THE STATE OF THE ENVIRONMENT (1972-1992)

SAVING OUR PLANET

CHALLENGES AND HOPES

NAIROBI 1992

UNITED NATIONS ENVIRONMENT PROGRAMME

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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."***

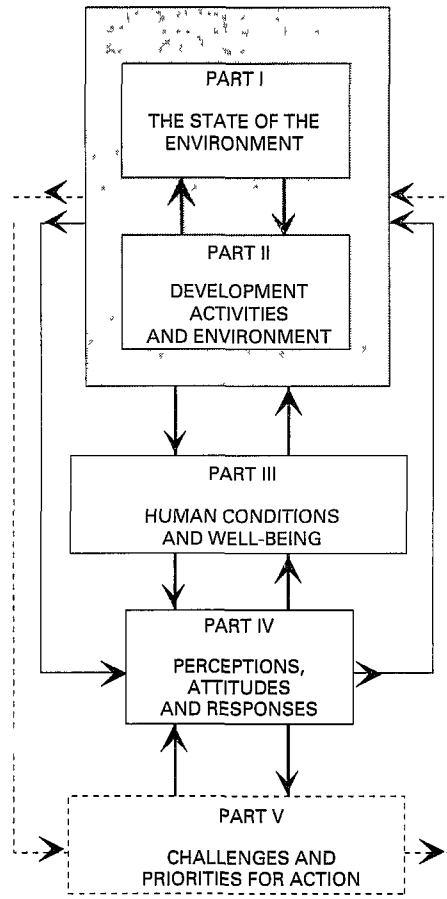
Accordingly, each year the United Nations Environment Programme issues a report on the state of the environment.

At its fourth session, the Governing Council decided that a comprehensive report on the state of the environment should be prepared every fifth year (decision 47 (IV), para. 10). In 1982, the United Nations Environment Programme issued, on the occasion of the tenth anniversary of the 1972 Stockholm Conference, the first comprehensive state-of-the-world-environment report, which covered the period 1972-1982 and dealt with the different changes that occurred in the environment in the decade that followed the Conference. In 1987, a brief report on the state of the world environment was published, covering the changes that occurred in the different components of the environment in the period 1981-1986.

At its fifteenth session, the Governing Council requested the Executive Director to prepare, for presentation to the United Nations Conference on Environment and Development to be convened in 1992, a brief analytical report on changes in the state of the world environment since 1972 (decision 15/13 A, para. 7b).

The present report has been prepared in compliance with that decision. It attempts to identify, analyse and interpret the different changes in various aspects of the environment and environmental situations that have taken place over the last two decades, according to available information.

The report is in five parts. The first (Chapters 1-10) is concerned with the state of the different components of the environment: the atmosphere, marine waters, fresh waters, land, forests, biological diversity, wastes and hazards. The second part (Chapters 11-15) deals with different development activities and highlights the environmental impacts of such activities. Both the state of the environment and the development activities affect human conditions and well-being. A description of how the latter have changed in the last two decades is given in Part III of the report (Chapters 16-19). Inevitably, people (and hence Governments and other bodies) respond to changes in the environment. The changes in perceptions and attitudes towards environmental issues, and the major responses undertaken at the national, regional and international levels are reviewed in Part IV (Chapters 20-21). The fifth part of the report (Chapter 22) outlines the major challenges that face the world community in the near future and presents a number of priorities for action. The relationships between the different parts of the report are illustrated in the following chart:



I hope that this report will be found to give a balanced analysis of the changes in the world environmental situation since the Stockholm Conference, and of the relationships between environment and development.

Mostafa K. Tolba
Executive Director
United Nations Environment Programme

Nairobi, December 1991

Acknowledgements

I wish to extend my great and sincere gratitude to my colleague, Professor Essam El-Hinnawi of the Egyptian National Research Centre, for his untiring efforts in putting all this material together and for his unfailing checking and rechecking of each piece of the data and facts presented in this document.

PART I

THE STATE OF THE ENVIRONMENT

Chapter 1

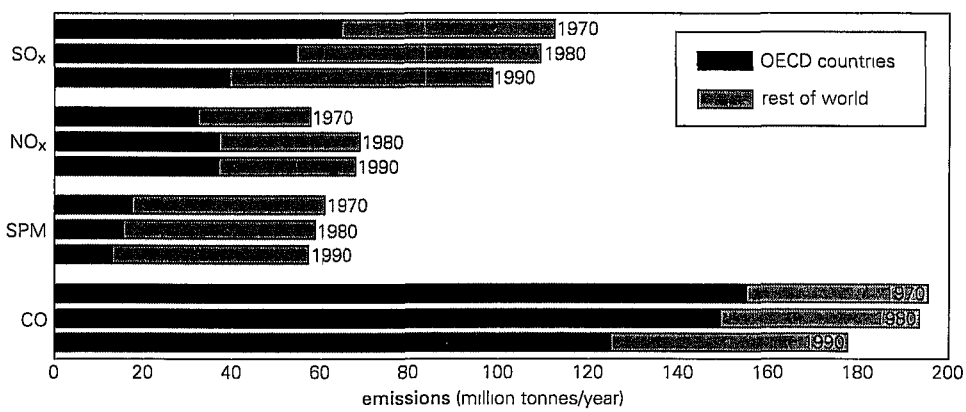
ATMOSPHERIC POLLUTION

1.1 Atmospheric pollution is a major problem facing all nations of the world. Various chemicals are emitted into the air from both natural and man-made sources. Emissions from natural sources include those from living and non-living sources (e.g. plants, radiological decomposition, forest fires, volcanic eruptions and emissions from land and water). These emissions lead to a natural background concentration that varies according to the local source of emission and the prevailing weather conditions. People have caused air pollution since they learned how to use fire, but man-made air pollution (anthropogenic air pollution) has rapidly increased since industrialization began.

1.2 Research over the past two decades has revealed that, in addition to the previously known common air pollutants (sulphur oxides, nitrogen oxides, particulate matter, hydrocarbons and carbon monoxide), many volatile organic compounds and trace metals are emitted into the atmosphere by human activities. Although our knowledge of the nature, quantity, physico-chemical behaviour and effects of air pollutants has greatly increased in recent years, more needs to be known about the fate and transformation of different pollutants and about their combined (synergistic) effects on human health and the environment.

1.3 World-wide, 99 million tonnes of sulphur oxides (SO_x), 68 million tonnes of nitrogen oxides (NO_x), 57 million tonnes of suspended particulate matter (SPM), and 177 million tonnes of carbon monoxide (CO) were released into the atmosphere in 1990 as a result of human activities, from stationary and mobile sources. (1) The OECD countries accounted for about 40 per cent of the SO_x, about 52 per cent of the NO_x, 71 per cent of the CO, and for 23 per cent of the SPM emitted into the global atmosphere, the rest of the world accounted for the remainder (Figs. 1.1

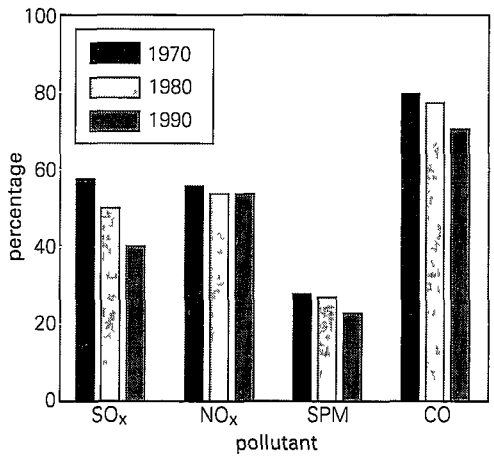
Figure 1.1
MAN-MADE EMISSIONS OF COMMON AIR POLLUTANTS



Source: Based on data by OECD (1, 32) and (33).

and 1.2). Time-series data (Fig. 1.1) show that, although the amount of SO_X emissions peaked in 1970 to a high of about 115 million tonnes, it dropped to 99 million tonnes in 1990 as a result of marked reduction in SO_X emissions in OECD countries (Fig. 1.2). These reductions have been achieved mainly by stricter regulations of emis-sions, changes in energy structures and fuel prices and introduction of more efficient technologies. Between 1970 and 1990, SO_X emissions in the OECD region decreased from about 65 million tonnes to about 40 million tonnes. In contrast, SO_X emissions in the rest of the world increased from 48 million tonnes to 59 million tonnes over the same period. From 1970 to 1990, there were no marked changes in NO_X and SPM emissions. There was, however, a marked decrease in CO emissions in the OECD region, from 155 million tonnes to 125 million tonnes; in the rest of the world CO emissions in-creased from about 40 million tonnes in 1970 to 52 million tonnes in 1990, mainly due to an increase in auto-mobile traffic.

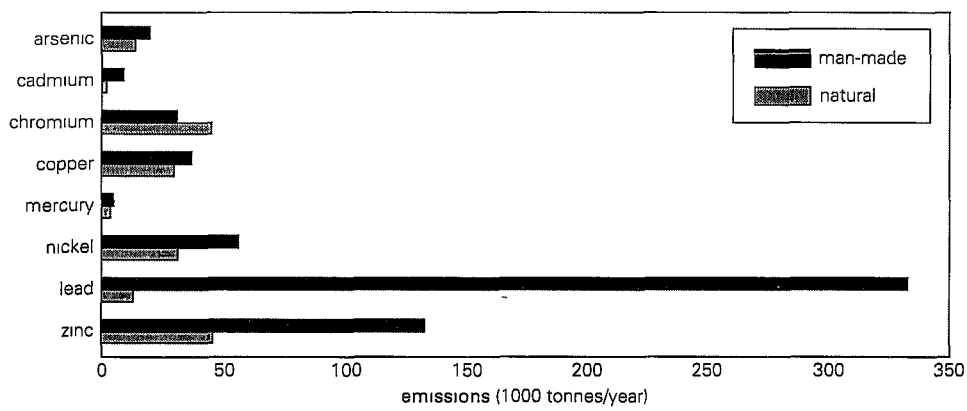
Figure 1.2
CONTRIBUTION OF OECD COUNTRIES TO GLOBAL AIR EMISSIONS (%)



Source Based on data by OECD (1, 32) and (33)

1.4 In the past two decades, and especially in the 1980s, increasing attention has been given to the emission into the atmosphere of hundreds of trace compounds – organic and inorganic. Some 261 volatile organic chemicals (VOCs) have been detected in ambient air (2). In most cases, the concentrations are quite low, with a majority of chemicals at sub-part per billion by volume (ppbv) levels.

Figure 1 3
GLOBAL NATURAL AND MAN-MADE EMISSIONS OF SOME TRACE ELEMENTS



Source Based on data from (34, 35)

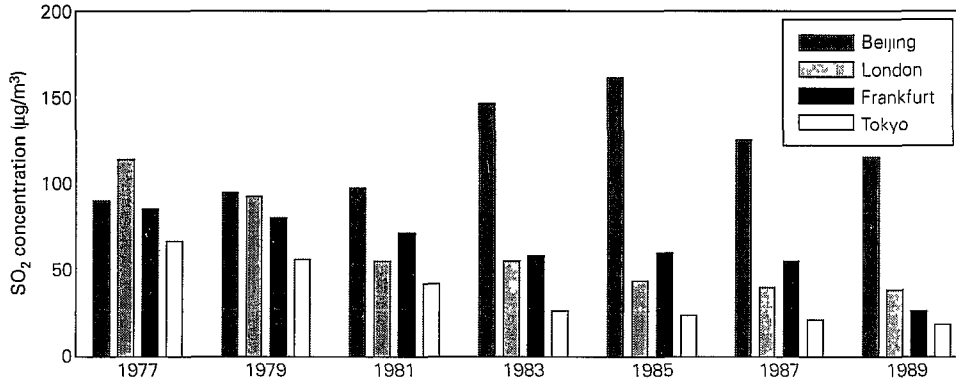
Some of these VOCs are highly reactive, even at such low concentrations, and are suspected of playing a considerable role at least in the formation of photochemical oxidants. Another group of compounds that has received attention in recent years is trace metals, such as cadmium, mercury, zinc, copper, etc. (Fig. 1.3). Lead is the best studied of these metals. An estimated 80-90 per cent of lead in ambient air derives from the combustion of leaded petrol (Chapter 14).

1.5 Because of growing concern about air pollution, programmes were initiated in some developed countries in the 1960s to monitor the common pollutants and assess changes in air quality. In 1973, WHO set up a global programme to assist countries in operational air pollution monitoring. This project became a part of UNEP's Global Environmental Monitoring System (GEMS) in 1976. Some 50 countries now participate in the GEMS/AIR monitoring project and data are obtained at approximately 175 sites in 75 cities, 25 of them in developing countries. Data from GEMS/AIR for the period from 1980-1984 indicate that of 54 cities, 27 have acceptable air quality (e.g. Auckland, Bucharest, Bangkok, Toronto, Munich) with sulphur dioxide concentrations below 40 micrograms/cubic metre (WHO established a range of 40-60 micrograms/cubic metre as a guideline for exposure to avoid increased risk of respiratory diseases). Eleven cities have marginal air quality (e.g. New York, Hong Kong and London) with sulphur dioxide concentrations between 40 and 60 micrograms/cubic metre. The other 16 cities have unacceptable air quality (e.g. Rio de Janeiro, Paris and Madrid) with sulphur dioxide concentrations exceeding 60 micrograms/cubic metre. (3, 4) Data for 41 cities indicate that 8 of them have acceptable air quality with respect to SPM (e.g. Frankfurt, Copenhagen and Tokyo), with SPM concentrations below 60 micrograms/cubic metre (the WHO range is 60-90 micrograms/cubic metre). Ten cities have borderline concentrations of SPM, between 60 and 90 micrograms/cubic metre (e.g., Toronto, Houston and Sydney), and 23 cities have SPM concentrations exceeding 90 micrograms/cubic metre (e.g. Rio de Janeiro, Bangkok and Tehran). 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-fuelled 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.

1.6 In some cities (e.g. Tokyo, Frankfurt, London) air quality has improved, with a marked fall in the average annual concentration of sulphur dioxide and in the number of days in which air quality guidelines are exceeded. However, in several cities, especially in the developing countries the sulphur dioxide concentration still exceeds the WHO guideline (e.g. Beijing) (Fig. 1.4). Suspended particulate matter also declined in most OECD cities in the 1970s and has since levelled off. (1) On the other hand, there has been no marked trend in the concentration of ambient nitrogen oxides over the past two decades.

1.7 Ozone and other photochemical oxidants, such as peroxyacetyl nitrate (PAN), are typically formed in the lower atmosphere from NO_x and hydrocarbon emissions in the presence of sunlight during stagnant, high-pressure weather conditions. This occurs most often during summertime, and leads to the well-known photochemical smog

Figure 1.4
TREND OF SULPHUR DIOXIDE IN THE AIR OF SOME CITIES



Source: Based on data from (16)

episodes, characterized by a thick layer of brown haze. Ozone concentrations in OECD countries, where time-series data are available, have not shown a clear trend; the principal reason is that they depend largely on prevailing weather conditions, which can change considerably from year to year. In many OECD countries, ozone levels exceed recommended standards. In the United States, the limit of exposure of 235 micrograms/cubic metre (for one hour/day as a maximum) is often exceeded, and it has been estimated that some 75 million people are exposed to higher levels of ozone. (1, 5)

1.8 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 the air, as another oxidant that may significantly degrade air quality. (6) Measurements of hydrogen peroxide carried out at various locations in Brazil, Canada, Europe, Japan and the United States show concentrations generally less than 10 parts per billion (ppb) by volume. No guidelines have yet been established for exposure to ambient hydrogen peroxide.

1.9 Air pollution is not only restricted to the outdoor environment. Although indoor air pollution has been known since prehistoric times, and elevated concentrations of air pollutants continue to be a fact of life for people who live in impoverished areas and cook over open fires fuelled by charcoal, coal, wood, dung and agricultural residues, the problem of indoor air pollution has recently become a matter of concern. The expression "sick building syndrome" has been used to describe buildings in which the air causes a number of symptoms (e.g. eye, nose and throat irritation; mental fatigue; headache; nausea; dizziness; airway infection; sensation of dry mucous membranes, etc). Such symptoms have been epidemiologically related to sealed buildings, non-openable windows, tight-enclosure dwellings, increased temperature and dust levels, and passive cigarette smoking. (7, 8)

1.10 Indoor air pollution in residences, public buildings and offices is created for the most part by the occupants' activities and their use of appliances, power equipment and chemicals; by emissions from some structural or decorative material; by thermal factors; and by the penetration of outdoor

pollutants. (9, 10, 11, 12) The most important indoor contaminants are tobacco smoke, radon decay products, formaldehyde, asbestos fibres, combustion products (such as NO_X, SO_X, CO, carbon dioxide and polycyclic aromatic hydrocarbons), and other chemicals arising from use in the household. WHO (7) has indicated that several microbiological air contaminants are encountered in the indoor environment. These include molds and fungi, viruses, bacteria, algae, pollens, spores and their derivatives. Recently, more than 66 volatile organic chemicals have been identified in indoor air. (2, 13) Several studies (11, 12, 14) have pointed out that many pollutants are more concentrated in the indoor environment than in the outdoor. Respirable particulate matter, NO_X, carbon dioxide, CO, formaldehyde and several other compounds and radon are higher indoors than outdoors.

1.11 The pollutants emitted into the atmosphere do remain confined to the area near the source of emission or to the local environment. They can be transported over long distances, cross frontiers and create regional and global environmental problems. Acidic deposition is one of these problems (for ozone depletion and the effect of greenhouse gases, see Chapters 2 and 3). World-wide monitoring of precipitation chemistry has clearly established that precipitation in extensive areas of North America and Europe is about 10 times more acidic than normal. (15) Large-scale acidification due to man-made emissions of sulphur and nitrogen is not considered to be a significant problem in other world regions at present. (16) However, there are indications that certain tropical regions, for example, south-eastern Brazil, southern China, south-western India, Jamaica, northern Venezuela and Zambia, may experience problems relating to acidification in the future if current trends in urbanization and industrialization continue into the 21st century. (15)

1.12 The mechanisms by which the emitted pollutants, mainly sulphur dioxide and nitrogen oxides, are transformed into acidifying substances in both the gaseous and liquid phases are complex and incompletely understood. The concentration and distribution of acidic deposits, wet and dry, are determined by many interacting processes, e.g. the transport and dispersal of the parent pollutants, the role of oxidizing agents such as hydrocarbon derivatives and ozone, and meteorological factors. The basic physical and chemical processes involved in the washout of soluble gases and aerosol species are not limited to sulphur and nitrogen oxides. Most atmospheric trace gases are likely to be highly soluble in precipitation. In fact, measurements have recently shown that precipitation contains hundreds of organic compounds (17) and many trace metals. (18, 19) Acid fog recently reported in the United States and other countries contains carbonyl compounds, alkyl sulphonate and pesticides, in addition to sulphates and nitrates. (20, 21, 22, 23)

1.13 Measurement of precipitation chemistry on a global scale is conducted as part of work of WMO's Background Air Pollution Monitoring Network (BAPMoN). First established in 1969, the BAPMoN network, currently a WMO/UNEP joint effort, comprises some 196 stations, 152 of which have the capability to carry out sampling for measurements of precipitation chemistry. Data from BAPMoN show that between 1972 and 1984 there has been a downward global trend of sulphur in precipitation. (4) This trend is due to the decrease in global emissions of sulphur oxides (Fig. 1.1).

1.14 On a regional basis, the Cooperative Programme for Monitoring and Evaluation of Long-range Transmission of Air Pollution in Europe (EMEP) was established in 1977 as a joint ECE/WMO/UNEP venture. EMEP

is responsible for coordination of routine measurements of air and precipitation quality at a network of 102 sites located throughout the European region. A number of EMEP stations are also BAPMoN stations. Recent results from EMEP show that much of central and eastern Europe receives rainfall containing sulphate in excess of 1 mg S/litre. The highest concentrations, over 1.5-2.0 mg S/litre are recorded in eastern Europe. However, in 1983-1987 the size of the area receiving precipitation with sulphate concentrations over 1.5 mg S/litre was reduced compared with that for the period 1978-1982, (16) mainly because of reduction in SO_X emissions. Nitrate in precipitation is greatest over northern Poland, eastern Germany and the Baltic Sea. Concentration of ammonia in precipitation is high over parts of Belgium, France and the Netherlands and also over an area in eastern Europe (the Poland-Czechoslovakia-USSR border).

Impacts of Atmospheric Pollution

1.15 Air pollution affects human health, vegetation and various materials. The notorious sulphurous smog which occurred in London in 1952 and 1962 and in New York in 1953, 1963 and 1966 clearly demonstrated the link between excessive air pollution and mortality and morbidity (Chapter 18). Such acute air pollution episodes occur from time to time in some urban areas. In January 1985, an air pollution episode occurred throughout western Europe. Near Amsterdam, the 24-hour average SPM and SO_X concentrations were each in the range of 200-250 micrograms/cubic metre (much higher than the WHO guideline values). During the episode, several people were affected; pulmonary functions in children were 3 to 5 per cent lower than normal. This dysfunction persisted for about 16 days after the episode. (24) Athens is known for the frequent occurrence of such acute air pollution episodes. But even in the absence of such episodes, long-term exposure to air pollution can affect several susceptible groups (the elderly, children and those with respiratory and heart conditions).

1.16 Air pollution can cause substantial damage to many materials. (25) The most striking examples of such damage are illustrated by the effects of air pollutants (especially SO_X) on historical buildings and monuments. The Acropolis in Greece, the Coliseum in Italy, and Taj Mahal in India have withstood the influence of the atmosphere for hundreds or even thousands of years without any great damage. Yet in the past few decades their surfaces have suffered increasing damage because of increased air pollution.

1.17 Indoor air pollution has a number of effects. Reference has already been made to the sick building syndrome, which causes a substantial portion of disease and absenteeism from work or school. (8) Recently, attention focused on the possible health hazards of radon emissions at home. In the United States, it has been found that the concentration of radon indoors is about 6 times higher than that outdoors (26) and that the current annual mortality rate from lung cancer attributable to indoor radon exposure is about 16,000 cases. However, it was found that only 3 per cent of this mortality occurred among individuals who never smoked tobacco. Thus, more than 90 per cent of the lung cancer risk associated with radon could be controlled by eliminating smoking. The penetration of outdoor pollutants into buildings has also been a cause of concern. High ozone levels have been found in some museums and art galleries and there are fears that ozone – a highly reactive gas – could cause the fading of colours of art work. Several museums and art galleries have taken costly precautions to monitor ozone levels indoors and to shield paintings and other art work tightly.

1.18 Emissions from burning biomass fuels, especially in rural areas of developing countries, are a major source of indoor air pollution. The most important identified adverse effects are chronic obstructive pulmonary disease and nasopharyngeal cancer. (27, 28) When infants are exposed to such pollution acute bronchitis and pneumonia occur because respiratory defenses are impaired. Emissions from biomass and coal burning at home contribute significantly to outdoor air pollution in some areas. It has been found that indoor emissions create a visible haze in certain parts of the Himalayas, which may have effects on visibility and on vegetation in that mountain ecosystem. (14)

1.19 Considerable evidence has accumulated over the past two decades to show that acidic deposition poses a threat to various resources: lakes and their aquatic life, forestry, agriculture and wildlife. (29) Thousands of lakes in parts of Scandinavia, the north-east United States, south-east Canada and south-west Scotland have been affected by acidic deposition to varying degrees, and many lakes (especially in Norway and Sweden) have lost their fish partly or totally. Acidic deposition has also caused excessive leaching of some trace metals from bottom sediments of lakes and soils, resulting in high concentrations of these elements in lake and groundwater. The effects of acidic deposition on the degradation of forests in Europe and in North America are also well documented (Chapter 7).

Responses

1.20 Although it was thought that urban (and rural) air pollution problems were local problems, it has become increasingly evident that urban emissions lead to the regional and global distribution and deposition of pollutants. These scales are not isolated from one another, and solutions to problems in one may lead to new problems from another. For example, the use of tall stacks to disperse pollutants may abate local air pollution, but it causes regional and global distribution and deposition of primary pollutants and their reaction products. Therefore, in the past two decades it became evident that countries have to work in concert to reduce air pollution.

1.21 Several countries have had marked success in reducing emissions into the atmosphere by implementing stricter control regulations, switching to low-sulphur fuels and installing air pollution control equipment at enterprises. In Bulgaria, for example, emissions of suspended particulate matter were reduced by 1.6 million tonnes a year in the years 1976 to 1980. (29) Comparable reductions in air pollutants have been recorded in OECD countries (1) and in a few developing countries (e.g. Singapore). An indicator of the efforts to reduce air pollution is the growth in sales of air pollution control equipment (e.g. flue gas desulphurization equipment, electrostatic precipitators, etc). A recent market survey (30) indicates that the total orders for such equipment world-wide reached $12.7 billion in 1991 ($4.0 billion in North America, $4.2 billion in Europe, and $4.5 billion for the rest of the world). This is more than double the orders a decade ago.

1.22 The signing of the ECE Convention on Long-range Transboundary Air Pollution in 1979 demonstrated the determination of European and North American countries to work together to cut back sulphur and nitrogen oxide emissions 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 pledges to bring sulphur dioxide levels down to less than half of 1980 levels by 1995. Austria, Germany and Sweden have committed themselves to reducing sulphur dioxide levels 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. (5)

1.23 To rehabilitate areas acidified by acidic deposition, liming programmes have been undertaken in some countries, especially in Sweden. More than 3,000 lakes have been limed in Sweden since 1976. (31) Liming is also used to reduce the acidity of soils in forests. However, the most effective way of preventing acidification is to reduce emissions at the source. Several technologies are now available to reduce the sulphur content of coal or to eliminate SO_X emissions from stack gases (Chapter 13).

1.24 The regulation of indoor air quality is much more complex than the regulation of outdoor air quality. Outdoor air is a public good in the sense that members of a community breathe the same ambient air. The rationale for government regulation of outdoor air pollution is the protection of the health of the members of the community on an equal basis. The situation is quite different for some indoor environments, especially private residences. If occupants foul the air in their own home, they are forced to breathe it. If they attempt to improve its quality, by increasing ventilation for example, they bear the costs and enjoy the benefits. The problem of regulating indoor air quality is, therefore, highly dependent on public perception and awareness of the different risks involved.

Chapter 2

OZONE DEPLETION

2.1 In contrast to the harmful ozone formed as a photochemical oxidant at ground level (tropospheric ozone, see Chapter 1), ozone in the stratosphere, between 25 and 40 km above the earth's surface, is the natural filter that absorbs and blocks the sun's short-wavelength ultraviolet radiation (UV-B) that is harmful to life.

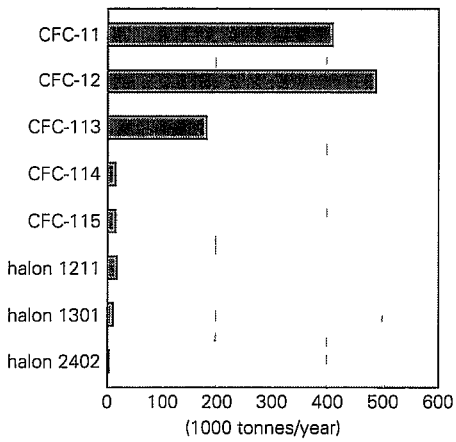
2.2 Ozone exists in equilibrium in the stratosphere, balanced between formation from molecular oxygen and destruction by ultraviolet radiation. The presence of reactive chemicals in the stratosphere, such as the oxides of hydrogen, nitrogen and chlorine, can accelerate the process of ozone destruction and therefore upset the natural balance, leading to a net reduction of the amount of ozone. These chemicals can participate in many ozone-destroying reactions before they are removed from the stratosphere.

2.3 Concern about the depletion of stratospheric ozone by man's activities began in the late 1960s over emissions of nitrogen oxides by high-flying supersonic aircraft. The high temperatures of the engines convert atmospheric nitrogen and oxygen into nitrogen oxides (NO_X) and deposit these in the stratosphere at flight altitudes of 17 to 20 km. The NO_X then act as a catalyst destroying ozone in the stratosphere. (1, 2) Later, in 1974, it was found that man-made chlorofluorocarbons (CFCs), although inert in the lower atmosphere, can survive for many years and migrate into the stratosphere. There, CFCs are destroyed by ultraviolet radiation, releasing atomic chlorine which attacks stratospheric ozone, with the formation of the free radical ClO which reacts further to regenerate atomic chlorine. This chain reaction can cause the destruction of as many as 100,000 molecules of ozone per single atom of chlorine. (3, 4, 5, 6, 7)

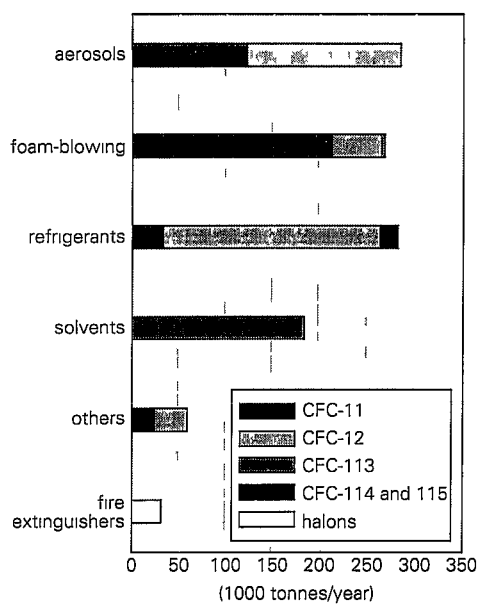
2.4 Chlorofluorocarbons are compounds used as propellants and solvents in aerosol sprays, fluids in refrigeration and air-conditioning equipment; foam-blowing agents in plastic foam production; and solvents, mainly in the electronics industry. Although there is a range of compounds called chlorofluorocarbons, CFC-11 (trichlorofluoromethane) and CFC-12 (dichlorodifluoromethane) are the most commonly used (Fig. 2.1). Studies in the 1980s have shown that emissions of bromine could also lead to a significant reduction in stratospheric ozone. (8) Bromofluorocarbons (Halons 1211 and 1301) are widely used as fire extinguishers, and ethylene dibromide and methylbromide are used as fumigants.

2.5 The concentration of chlorine in the stratosphere is set mainly by anthropogenic sources of CFC-11, CFC-12, carbon tetrachloride and methyl chloroform. Methyl chloride is the only natural organochlorine compound found in the atmosphere. The concentration of Cl in the atmosphere due to methyl chloride has remained unchanged perhaps since 1900. The major additions of Cl to the atmosphere have mainly occurred since 1970 and have been attributed to anthropogenic sources (Fig. 2.2). At present

Figure 2.1
ESTIMATED WORLD CONSUMPTION OF MAIN CFCs AND HALONS (1986)



WORLD USE OF MAIN CFCs AND HALONS (1986)



Source Based on data from (19)

the total Cl in the atmosphere due to organochlorine compounds is approaching 4.0 ppbv, i.e. an increase by a factor of 2.6 in only 20 years.

2.6 The capability to destroy ozone is a combination of the percentage of chlorine released from the organochlorine compounds and the lifetime of these compounds in the atmosphere. This determines the ozone depletion potential (ODP). ODP is measured relative to CFC-11, which has been given an ODP of 1.0 (Fig. 2.3).

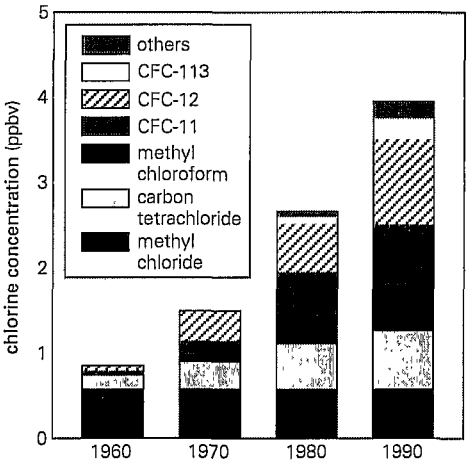
Has the Ozone Layer been depleted?

2.7 Observing changes in the chemistry of the stratosphere caused by the release of trace gases is difficult. Therefore, theoretical models have been developed to estimate such changes. The models developed in the 1970s estimated that continued release of chlorofluorocarbons at late 1970s rates, if continued indefinitely, would deplete stratospheric ozone by about 15 per cent, with an uncertainty range of 6 to 22 per cent. (9, 10, 11) Later models (12, 13, 14) indicate that if production of CFCs were to continue into the future at the 1980 rate, the steady-state reduction in total global ozone could be about or less than 3 per cent over the next 70 years. If the release rate of CFCs should become twice the level of 1980 or if stratospheric chlorine reaches 15 ppbv, it has been predicted that there will be a 3 to 12 per cent reduction of the ozone column, assuming that the annual rates of increase in the atmospheric concentration of carbon dioxide, nitrous oxide and methane continue at their present rate. There are several limitations to these theoretical models and it has been pointed out that such models might be underestimating the adverse impact of CFCs on ozone, especially at high latitudes in winter. (15)

2.8 World-wide ozone monitoring (ground-based total ozone monitoring) began during the International Geophysical Year in 1957, but only a very few stations have continuous records from 1957 to the present day. One of these stations is Halley Bay, Antarctica. Records from Halley Bay show that the total ozone levels above the station in

1984 were only about 60 per cent as large as those obtained in the late 1950s and early 1960s. (16) The changes were most pronounced in October. Recent studies (15, 17, 18) have indicated an average decrease of 30-40 per cent in the total column of ozone in the lower stratosphere between 15 and 20 km. above Antarctica (referred to as the ozone hole); at some altitudes the ozone loss may reach as much as 95 per cent. (18) The data indicate that the decrease in ozone occurs in springtime (September-October) and recovers in summer (January-February). Although different theories have been put forth to explain the massive Antarctic ozone depletion, (6) scientific evidence strongly indicates that man-made chlorinated and brominated chemicals are primarily responsible for this depletion. Under the special meteorological conditions of the Antarctic winter stratosphere (very low temperatures and abundant polar stratospheric clouds) chlorine and nitrogen chemistry occur which permit massive ozone depletion in the lower stratosphere when sunlight returns in the spring. Similar chemistry has also been identified in the Arctic stratosphere. However, at present, ozone changes over the Arctic are not comparable to those over the Antarctic. 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.

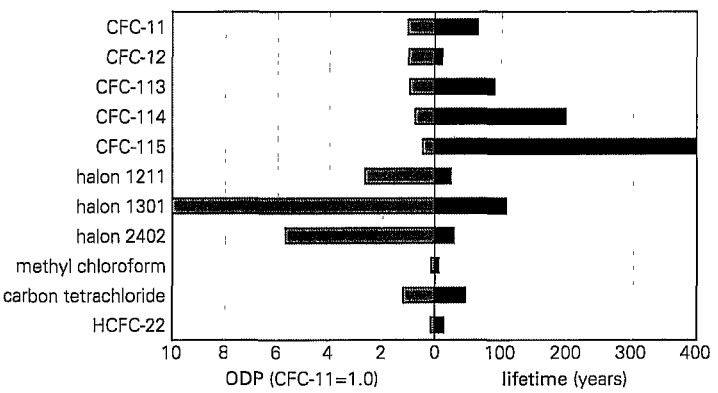
Figure 2.2
ORGANOCHLORINE CONCENTRATION IN THE ATMOSPHERE (ppbv Cl)



Source: Based on data from (7).

2.9 An analysis of the total-column ozone data from ground-based instruments has shown measurable downward trends from 1969 to 1988 of 3 to 5.5 per cent in the northern hemisphere, latitudes 30 to 64N. (19) Recent analyses of TOMS (Total Ozone Mapping Spectro-meter) satellite data by the National Aeronautics and Space Administration (NASA) of the United States indicate that total ozone between 65N and 65S has been decreasing at an average rate

Figure 2.3
OZONE DEPLETION POTENTIAL (ODP) AND LIFETIME OF HALOCARBONS



Source: Based on data from (19, 24).

of about 0.26 per cent per year. Statistically meaningful ozone depletions of 3 to 5 per cent are indicated north of 35N in springtime and may reach 9 per cent at 45N in winter. A 4-per cent or greater ozone depletion is indicated at all latitudes south of about 40S throughout the year. No statistically significant ozone trends were found between 30N and 30S throughout the year. (20) While the cause of the observed ozone depletion has not been unequivocally identified, the ozone changes coupled with other atmospheric data are strongly suggestive of a chlorine-induced effect.

Impacts of Ozone Depletion

2.10 The depletion of the ozone layer will increase the intensity of ultraviolet (UV-B) radiation reaching the earth's surface. It has been predicted that a 1-per cent reduction in the amount of stratospheric ozone will lead to an increase of approximately 2 per cent in UV-B radiation reaching the ground. UV-B radiation is known to have a multitude of effects on humans, animals, plants and materials. Most of these effects are damaging.

2.11 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, leishmaniasis 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. It has been estimated that each 1-per cent decrease in total column ozone is expected to lead to an increase of 0.6 per cent in the incidence of cataracts (or an estimated world-wide increase of 100,000 blind persons per year due to UV-B induced cataracts). In addition, every 1-per cent decrease of total column ozone is predicted to lead to a 3-per cent rise of the incidence of non-melanoma skin cancer (or an estimated worldwide increase of 50,000 cases per year). There is also concern that an increase of the more dangerous cutaneous malignant melanoma could also occur. A recent study has shown that a 1-per cent reduction in ozone will result in a 1.6 per cent increase in male death rates and a 1.1-per cent increase in female death rates due to melanoma. (21)

2.12 Plants vary in their sensitivity to UV-B radiation. Some crop species such as peanut and wheat prove fairly resistant, while others such as lettuce, tomato, soybean and cotton are sensitive. UV-B radiation alters the reproductive capacity of some plants and also the quality of harvestable products. This could have serious effects on food production in areas of already acute shortage. (19)

2.13 Increased UV-B radiation has negative effects on aquatic organisms, especially small ones such as phytoplankton, zooplankton, larval crabs and shrimp, and juvenile fish. Because many of these small organisms are at the base of the marine food web, increased UV-B exposure may have a negative effect on the productivity of fisheries. Increased levels of UV-B radiation may also modify freshwater ecosystems by destroying micro-organisms, thus reducing the efficiency of natural water purification.

2.14 Substantial reductions in upper stratospheric ozone and associated increases in ozone in the lower stratosphere and upper troposphere might lead to undesirable global perturbations in the earth's climate. The vertical redistribution of ozone may warm the lower atmosphere and reinforce the greenhouse effect associated with an increase in carbon dioxide. In addition, chloro-fluorocarbons are among the potential greenhouse gases (see Chapter 3).

Responses

2.15 Ozone depletion is a global problem that requires global action. International efforts, coordinated and catalysed by UNEP since 1977, in full cooperation with WMO, the scientific community and industry, led to the development of the Vienna Convention for the Protection of the Ozone Layer which was adopted in March 1985. The purpose of the Convention was to promote information exchange, research and systematic observations to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer. The convention was designed so that protocols requiring specific control measures could be added, and in September 1987 the Montreal Protocol on Substances that Deplete the Ozone Layer was signed. The Protocol set limits for production and consumption of the damaging CFCs and halons, so it will curb the levels of chlorine and bromine reaching the stratosphere and damaging the ozone layer (Box 2.1). The Montreal Protocol entered into force on 1 January 1989.

2.16 According to the Montreal Protocol, the Parties to the Protocol established four review panels in 1989 to prepare assessments on various aspects of the ozone problem (scientific assessment, environmental effects, technological aspects, and economic assessment). The results of these and other studies (6, 19, 22, 23) 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. At their second meeting, in June 1990, in London, the Parties to the Montreal Protocol agreed to phase out CFCs and halons by 2000 and set a timetable to phase out other compounds (Box 2.2 and Box 2.3). A Multilateral Fund involving

BOX 2.1

THE MONTREAL PROTOCOL

The Montreal Protocol on Substances that Deplete the Ozone Layer was adopted in September 1987. The Protocol entered into force on 1 January 1989. As of 31 August 1991, 73 countries and the EEC had become Parties to the Protocol.

THE CONTROLS

CFC-11, CFC-12, CFC-113, CFC-114 and CFC-115:

* *As of 1 July 1989, and within 12 months, and thereafter, the level of consumption and production should not exceed the 1986 level.*

* *As of 1 July 1993, and within 12 months, and thereafter, the level of consumption and production should not exceed 80 per cent of the 1986 level.*

* *As of 1 July 1998, and within 12 months, and thereafter, the level of consumption and production should not exceed 50 per cent of the 1986 level.*

Halons 1301, 1211 and 2402:

* *As of 1 February 1992, and within 12 months, and thereafter, the level of consumption and production should not exceed the 1986 level.*

BOX 2.2

ADJUSTMENTS TO THE MONTREAL PROTOCOL (LONDON, 1990)

CFC-11, CFC-12, CFC-113, CFC-114 and CFC-115:

* *From 1 July 1991 to 31 December 1992, and thereafter, the annual level of consumption and production should not exceed 150 per cent of the 1986 level.*
* *As of 1 January 1995 and within 12 months, and thereafter, the annual level of consumption and production should not exceed 50 per cent of the 1986 level.*
* *As of 1 January 1997 and within 12 months, and thereafter, the annual level of consumption and production should not exceed 15 per cent of the 1986 level.*
* *As of 1 January 2000 and within 12 months, and thereafter, the consumption and production should be zero.*

Halons 1301, 1211 and 2402:

* *As of 1 January 1992 and within 12 months, and thereafter, the annual level of consumption and production should not exceed the 1986 level.*
* *As of 1 July 1995 and within 12 months, and thereafter, the annual level of consumption and production should not exceed 50 per cent of the 1986 level.*
* *As of 1 January 2000 and within 12 months, and thereafter, consumption and production should be zero.*

UNEP, UNDP and the World Bank was established. Contributions to the Fund are allotted to industrialized countries Parties to the Protocol and those developing countries with per capita consumption of more than 0.3 kg of the controlled substances per year. The Fund is to help developing countries meet the costs of complying with the revised Montreal Protocol and to provide for the necessary transfer of technology. The Parties also agreed on a mechanism for decision-making regarding the Fund, in which developed and developing countries have equal representation.

2.17 Measures have already been taken in some countries to reduce or ban the use of the controlled CFCs in all or some products (e.g. non-essential aerosols). The United States of America took such restrictive measures long before the adoption of the Montreal Protocol. Canada, Sweden, Norway, Switzerland and Belgium have banned or drastically restricted the use of CFCs in non-essential aerosols. Several Governments have followed suite, and some (e.g. Germany and the Nordic countries) are now advocating much higher targets for reduction of the production and use of the ozone-depleting substances over the next few years. At the London meeting in 1990, Australia, Austria, Belgium, Canada, Denmark, Finland, Federal Republic of Germany, Liechtenstein, Netherlands, New Zealand, Norway, Sweden and Switzerland declared their firm determination to take all appropriate measures to phase out the production and consumption of all fully halogenated chlorofluorocarbons controlled by the Montreal Protocol, as adjusted and

amended, as soon as possible, but not later than 1997.

2.18 Industries and financial institutions also are working to reduce the production and use of CFCs and halons. The major chemical industries have announced policies to phase out production of CFCs as soon as safer alternatives are available. Some have set a goal of 1995 for halting CFC production, others will phase out production by 2000. These phase-out policies send customers a strong message to seek alternatives and substitutes. Some industry associations and individual companies have already phased out the use of controlled ozone-depleting substances. Many industry associations are engaged in extensive education, training and public awareness programmes (especially through voluntary labelling of products as "ozone-friendly", etc.). In addition, the major chemical manufacturers of CFCs and Halons have pledged not to sell or license CFC or halon manufacturing technology to countries that are not parties to the Montreal Protocol.

BOX 2.3

AMENDMENT TO THE MONTREAL PROTOCOL (LONDON, 1990)

CFC-13, 111, 112, 211 to 217:

* *As of 1 January 1993 and within 12 months, and thereafter, the annual level of consumption and production should not exceed 80 per cent of the 1989 level.*
* *As of 1 July 1997 and within 12 months, and thereafter, the annual level of consumption and production should not exceed 15 per cent of the 1989 level.*
* *As of 1 July 2000 and within 12 months, and thereafter, consumption and production should be zero.*

Carbon Tetrachloride:

* *As of 1 January 1995 and within 12 months, and thereafter, the annual level of consumption and production should not exceed 15 per cent of the 1989 level.*
* *As of 1 January 2000 and within 12 months, and thereafter, consumption and production should be zero.*

Methyl Chloroform:

* *Phase out production and consumption by 2005, with intermediate cuts of 30 per cent by 1995 and 70 per cent by 2000 of the 1989 level.*

All CFC substitutes (HCFC-21, 22, 31, 121-124, 131-133, 141, 142, 151, 221-226, 231-235, 241-244, 251-253, 261, 262, 271) 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 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.

Chapter 3

CLIMATE CHANGE

3.1 Weather (the day-to-day fluctuations of the atmosphere) and climate (normally taken as a moving 30-year average of weather) are important determinants of a region's energy use, its growth of vegetation, its means of transportation, its water supplies and its pattern of habitation and development. Periodic events, such as several years of dry or wet conditions, constitute variation in climate. Climate change, on the other hand, refers to shifts in normal climate – generally in the same direction – lasting over decades.

3.2 A primary descriptor of climate is temperature. Sunlight heats up the sea and land. The warmed surface of the earth then radiates heat back towards space. On its way out, some of this heat (infra-red radiation) is absorbed by trace gases – notably carbon dioxide and water vapour – in the atmosphere and thereby keeps the earth's temperature suitable for life. Without this natural greenhouse effect of carbon dioxide and water vapour, the temperature at the earth's surface would be some 33°C lower than it is today, i.e. below freezing point. The natural concentration of carbon dioxide in the atmosphere is controlled by the interactions of the atmosphere, oceans and the biosphere in what is known as the geochemical carbon cycle. Human activities can disturb this cycle by injecting carbon dioxide into the atmosphere. This leads to a net increase in carbon dioxide concentration in the atmosphere which "enhances' the natural greenhouse effect.

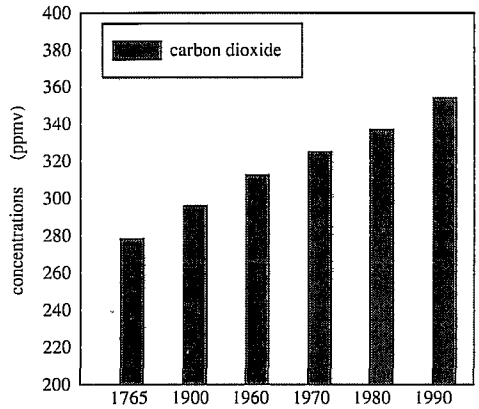
3.3 Although the greenhouse effect has been known for more than a century, it was not until the late 1960s that concern was voiced about the implications of such possible global warming. Studies for the climate published in the early 1970s (1, 2) warned of the long-term potential consequences of carbon dioxide accumulation in the atmosphere. The World Climate Conference, convened in 1979, (3) pointed out that some effects of climate change on a regional and global scale may be detectable before the end of this century and may become significant before the middle of the next century. The extensive studies carried out in the 1980s contributed a great deal to our understanding of the problem of climate change.

The Greenhouse Gases

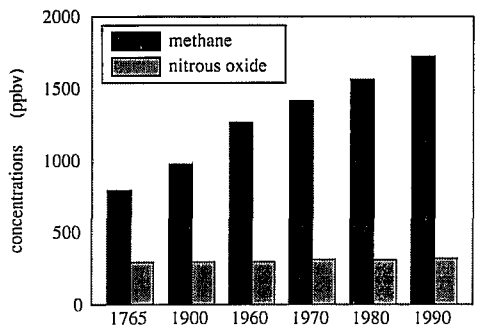
3.4 It has been thought that carbon dioxide was the only greenhouse gas. However, research over the last two decades has identified other gases such as nitrous oxide, methane, chlorofluorocarbons and tropospheric ozone as potential greenhouse gases.

3.5 The atmospheric carbon dioxide concentration is now 353 ppmv, 25 per cent greater than the pre-industrial (1750-1800) value of about 280 ppmv, (4, 5) and it is currently rising at a rate of about 0.5 per cent per year due to anthropogenic emissions (Fig. 3.1). The latter are estimated to be about 5,700 million tonnes of carbon per year due to fossil fuel burning, plus 600 to 2,500 million tonnes of carbon per year due to deforestation. (5, 6) About 40-60 per cent of the carbon dioxide emitted into the

Figure 3.1
INCREASE OF CARBON DIOXIDE IN THE ATMOSPHERE SINCE 1765



INCREASE OF METHANE AND NITROUS OXIDE CONCENTRATION IN THE ATMOSPHERE SINCE 1765



Source: Based on data from (5).

atmosphere remains there, at least in the short term; the rest is taken up by natural sinks, particularly the ocean. Future atmospheric carbon dioxide concentrations depend on the amounts of carbon dioxide released from future fossil fuel burning (which are determined by the amount and type of energy sources to be used), the carbon dioxide released from biotic sources (which is determined by the rate of future deforestation and changes of other vegetative cover), and the uptake of carbon dioxide by various natural sinks. The Intergovernmental Panel on Climate Change (IPCC) has estimated that if anthropogenic emissions of carbon dioxide could be kept at present day rates, atmospheric carbon dioxide would increase to 460-560 ppmv by the year 2100 (5) because of the long residence time of carbon dioxide in the atmosphere and the long lead time for its removal by natural sinks.

3.6 The current atmospheric methane concentration is 1.72 ppmv, more than double the pre-industrial value of about 0.8 ppmv, and is increasing at a rate of about 0.9 per cent per year. Methane is produced by anaerobic bacteria in natural wetland ecosystems, but the bulk of methane is produced through human activities such as rice cultivation, domestic ruminant rearing, biomass burning, coal mining and natural gas venting. The total annual flux to the atmosphere is between 400 and 600 million tonnes of methane a year. (5, 7, 8, 9) Of this amount, natural wetland ecosystems account for 100-150 million tonnes; rice paddies contribute an average of about 110 million tonnes of methane per year. (5) Recently, a similar figure of 100 million tonnes of methane per year has been given, (10) about half of this amount is due to rice cultivation in China alone.

3.7 The mean atmospheric concentration of nitrous oxide in 1990 was about 310 ppbv, about 8 per cent greater than the pre-industrial value of about 285 ppbv. (5) Nitrous oxide emissions result naturally from microbial processes in soil and water (about 4.3 to 7.8 million tonnes of nitrogen per year). Human activities add to them about 0.1 to 2.7 million tonnes of nitrogen per year by burning biomass and fossil fuels. The atmospheric nitrous oxide concentration is increasing at a rate of about 0.2-0.3 per cent per year.

3.8 Most halocarbons, with the exception of methyl chloride, are exclusively of

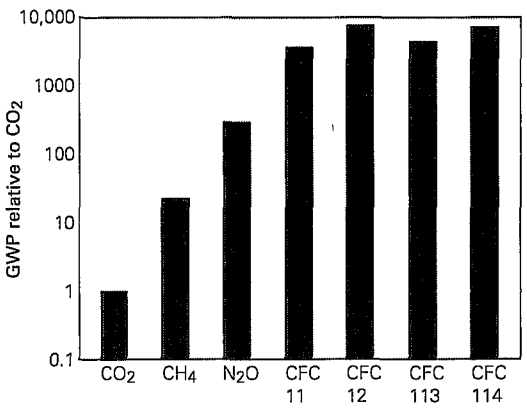
industrial origin. The atmospheric concentration of methyl chloride is about 0.6 ppbv, and is primarily released from the oceans. The atmospheric concentrations of the other halocarbons (especially CFC-11, 12 and 113, and methyl chloroform) have rapidly increased over the past few decades (see Chapter 2). Future emissions of most halocarbons will be very much reduced by the year 2000, according to the amended and adjusted Montreal Protocol (Chapter 2). However, the atmospheric concentrations of CFC-11, 12 and 113 will still be significant (about 30-40 per cent of current concentrations) for at least the next century because of their long atmospheric lifetimes.

3.9 The contribution of the above-mentioned trace gases to the greenhouse effect depends on the amount of the gas released into the atmosphere, its net concentration in the atmosphere, its lifetime, and its radiative forcing. The global warming potential (GWP) – defined as the time-integrated warming effect due to a release of 1 kg of a given greenhouse gas in today's atmosphere, relative to that of carbon dioxide – shows that carbon dioxide is the least effective greenhouse gas per kilogramme emitted (Fig.3.2). However, its contribution to global warming, which depends on the product of the GWP and the amount emitted, is the largest.

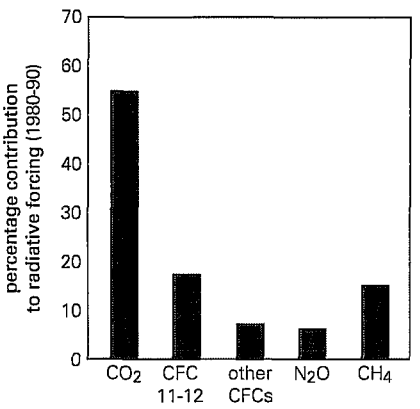
Scenarios of Climate Change

3.10 The task of predicting future climate change is extremely complex. The effects of the buildup of greenhouse gases in the atmosphere cannot be studied directly. Over the past two decades, a hierarchy of climate models (mathematical representations of the atmosphere used to simulate climate change under different scenarios) has been developed to estimate climate change. Early estimates made during the late 1960s predicted that a doubled carbon dioxide concentration in the atmosphere should raise the average temperature 1.5 to 3.0°C. (11) More than 100 independent estimates of average surface temperature increase have since been made. Almost all of these estimates lie in the range of 1.5 to 4.5°C, with values near 3.0°C tending to be favoured. (12, 13) IPCC has

Figure 3.2
GLOBAL WARMING POTENTIAL OF GREENHOUSE GASES *



CONTRIBUTION OF GREENHOUSE GASES TO RADIATIVE FORCING (1980-1990)



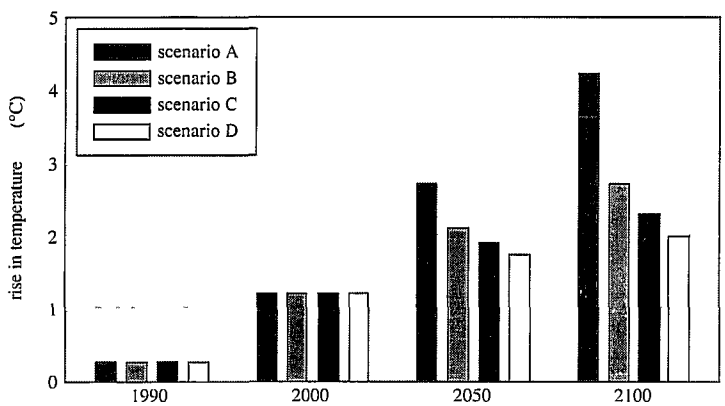
* Integrated 100 years time horizon
Source: Based on data from (5).

recently predicted that under the "business-as-usual" scenario (without actions to reduce emissions of greenhouse gases) global warming could reach 2 to 5° over the next century (with the best estimate around 3°), a rate of change unprecedented in the past 10,000 years. (5) The rate of increase of global mean temperature during the next century would be about 0.3° per decade (Fig.3.3). Uncertainties in predictions of climate change revolve around the timing and regional patterns and impacts of climate change.

Has the Climate Actually Changed?

3.11 Over the past 100 years, the atmospheric carbon dioxide concentration has increased by about 25 per cent. A range of model calculations suggests that the corresponding equilibrium temperature rise should be 0.5 to 1.0°. If this is corrected for the effects of the thermal inertia of the oceans (which slows down climate change for a period of 10-20 years), the changing composition of the atmosphere should have produced a warming of 0.35-0.7° superimposed on the natural fluctuations of the atmosphere. (14)

Figure 3.3
PROJECTED RISE IN TEMPERATURE ABOVE PRE-INDUSTRIAL (1765)



Source: Based on data from (5).

Scenarios as defined by IPCC

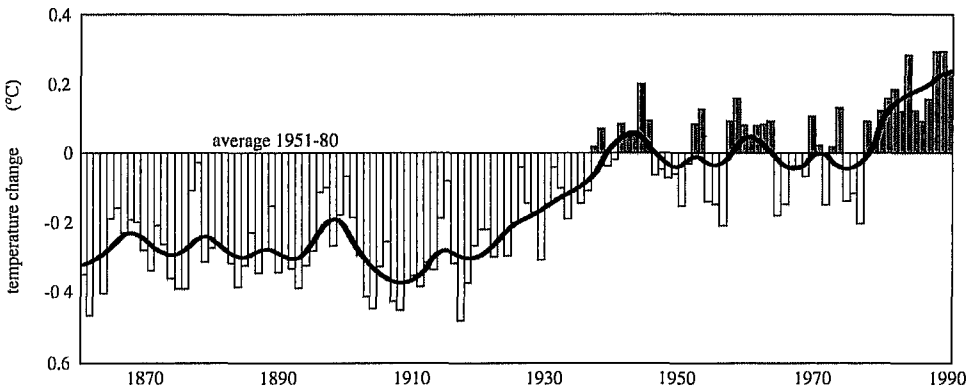
Scenario A:	Energy supply and demand continue as they are. Deforestation continues at present rate. Partial implementation of Montreal Protocol (business-as-usual).
Scenario B:	Energy supply mix shifts towards low-carbon fuels and natural gas. More energy efficiency. Deforestation reversed. Full imple mentation of Montreal Protocol.
Scenario C:	Shift towards renewable sources of energy and nuclear power in second half of the next century.
Scenario D:	Shift towards renewable energy and nuclear power in first half of the next century.

3.12 Detailed analysis of temperature records of the past 100 years indicates that global mean temperature has risen by 0.3-0.6° (Fig. 3.4). Much of the warming since 1900 has been concentrated in two periods, the first between about 1910 and 1940 and the other since 1975; the five warmest years on record have all been in the 1980s. (5, 15) The size of the warming over the last century is broadly consistent with the predictions of climate models, but is also of the same magnitude as natural climate variability.

Impacts of Climate Change

3.13 Sufficient evidence is now available to indicate that changes in climate would have an important effect on agriculture and livestock.

Figure 3.4
GLOBAL CHANGE IN TEMPERATURE (1861-1989)



Source: Based on data from (5)

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. (5)

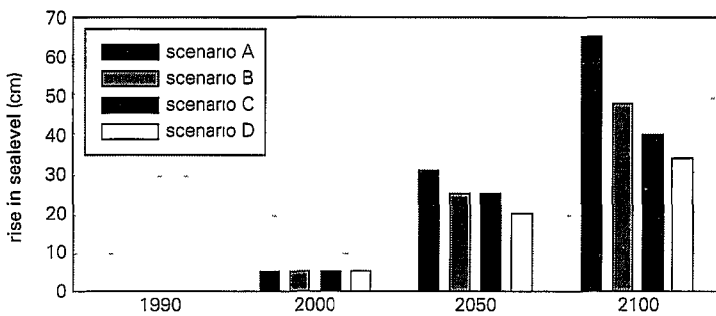
3.14 Natural terrestrial ecosystems could face significant consequences as a result of the global increases in the atmospheric concentrations of greenhouse gases and the associated climatic changes. Projected changes in temperature and precipitation suggest that climatic zones could shift several hundred kilometres towards the poles over the next 50-100 years. Flora and fauna would lag behind these climatic shifts, surviving in their present location and, therefore, they 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.

3.15 Relatively small changes in climate can cause large water resource problems in many areas, especially in 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.

3.16 Global warming will accelerate sealevel rise (Fig. 3.5), modify ocean circulation and change marine ecosystems, with considerable socio-economic consequences. IPCC predicted that under the "business-as-usual" scenario an average rate

of global mean sealevel rise of about 6 cm per decade could occur over the next century. The predicted rise is about 20 cm in global mean sealevel by 2030, and 65 cm by the end of the next century, and there will be significant regional variations. (5) A sealevel rise of this magnitude will threaten low-lying islands and coastal zones. It will render some island countries uninhabitable, displace tens of millions of people, seriously threaten low-lying urban areas, flood productive lands, contaminate freshwater supplies and change coastlines. In coastal lowlands such as in Bangladesh, China and Egypt, inundation due to sealevel rise and storm surges could lead to significant social disruption and economic losses.

Figure 3.5
PROJECTED SEALEVEL RISE



Source: Based on data from (5).
See Fig. 3.3 for definition of scenarios.

Responses

3.17 The prospective global warming and the forces driving it are now broadly understood. A clear scientific consensus has emerged on estimates of the range of global warming which can be expected during the 21st century, notwithstanding uncertainties about its precise regional distribution and its environmental consequences. Based on current scientific findings, the world community has two options. The first is to consider the issue academic and to let things go on as at present. If this happens, eventually the world will suddenly have to adapt its socio-economic structure to the changing climate, and face possibly catastrophic consequences. This is clearly unviable. The second option is to apply the anticipatory principle and take immediate measures to slow down the build-up of greenhouse gases in the atmosphere, and hence minimize the warming and its potential undesirable consequences. The Second World Climate Conference (1990) concluded that "nations should now take steps towards reducing sources and increasing sinks of greenhouse gases through national and regional actions, and negotiation of a global convention on climate change and related legal instruments. The long-term goal should be to halt the build-up of greenhouse gases at a level that minimizes risks to society and natural ecosystems".

3.18 The Montreal Protocol on Substances that Deplete the Ozone Layer (Chapter 2) is a step in the right direction. It calls for a complete phase-out of the main halocarbons by the year 2000. But alone it is insufficient to deal with the problem of global warming. Carbon dioxide and methane account for 70 per cent of the increased radiative forcing produced by greenhouse gases from human activities, and focus should be on strategies and tools that would freeze or reduce the rate of their emission into the atmosphere.

3.19 The Second World Climate Conference (1990) concluded that "technically

feasible and cost-effective opportunities exist to reduce carbon dioxide emissions in all countries". Increasing the efficiency of energy use, and employing environmentally-sound alternative energy sources, especially renewable sources of energy, will contribute significantly to the reduction of carbon dioxide emissions. In addition, reversing the current net losses of forests would increase storage of carbon. The decisions and commitments undertaken by the European Community member States, and by Australia, Austria, Canada, Finland, Iceland, Japan, New Zealand, Norway, Sweden, Switzerland, and other developed countries to take actions aimed at stabilizing their emissions of carbon dioxide, or carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol, by the year 2000 in general at the 1990 level are encouraging signs of a concerted global effort to control greenhouse gases.

3.20 Although a number of international legal mechanisms exist which have a bearing on the climate change issue, they are insufficient to meet the challenge. An international consensus 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 with specific commitments. This consensus has been reiterated by the Ministerial Declaration of the Second World Climate Conference in 1990. IPCC suggested that 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. A global climate convention should establish global goals regarding future emissions of greenhouse gases. This agreement should also address other institutional issues, such as cooperation 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 the global targets set out in the convention should be negotiated simultaneously with the convention. (5, 16) Rounds of negotiations are under way to draft such a global climate convention, and it is hoped that the convention will be ready for signature at the time of the United Nations Conference on Environment and Development, to be convened in Brazil in June 1992.

Chapter 4

MARINE POLLUTION

4.1 The oceans cover 71 per cent of the earth's surface and through their interactions with the atmosphere, lithosphere and biosphere in what is known as the geo-chemical cycles, they have played a major role in shaping the conditions which have made life possible on earth. 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 30 per cent or more of their animal protein from marine fish (Chapter 11).

4.2 For geological ages, the oceans have received natural dissolved and suspended matter, especially from continents. Rivers have delivered to the oceans annually about 35 trillion tonnes of water, 3.9 billion tonnes of dissolved matter and from 10 to 65 billion tonnes of suspended particulate matter. (1) Additional input sources are groundwater discharging through the continental shelf, submarine springs of volcanic and deeper crustal origin, and the atmosphere, through which airborne gases and particulates reach the oceans. The volume and composition of oceans have remarkably remained stationary for a geologically long period of time through the balance of various geochemical cycles.

4.3 Human activities on land and in the sea are disturbing this balance and changing the composition of sea water. This is most marked along coastal and near-shore areas, which are among the most intensively used parts of the earth. About 60 per cent of the world's population, or nearly 3 billion people, live on or within some 100 km of the shoreline. The coastal zones are sites for large-scale industrial development, and are a major recreational ground. Harbours are essential centres for national and international trade and transport. 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 95 per cent of world fisheries catch comes from the near-shore areas.

4.4 Although the open oceans still seem to be largely unaffected by human activities, the state of the marine environment in coastal areas and enclosed and semi-enclosed seas is declining. The malaise is indicated by spread of algal blooms, coral bleaching, epidemics, oil pollution, and by the decline in the quality and quantity of marine food resources. In general, the state of the marine environment in these areas has deteriorated over the past two decades, in spite of local improvement here and there.

Sources of Marine Pollution

4.5 The two dominant pathways by which potential pollutants reach the oceans from the continents are the atmosphere and rivers. The atmospheric pathway accounts for more than 90 per cent of the lead, cadmium, copper, iron, zinc, arsenic, nickel, PCBs, DDT and HCH found in the open oceans water. (2) River inputs are generally more important than those from the atmosphere in coastal

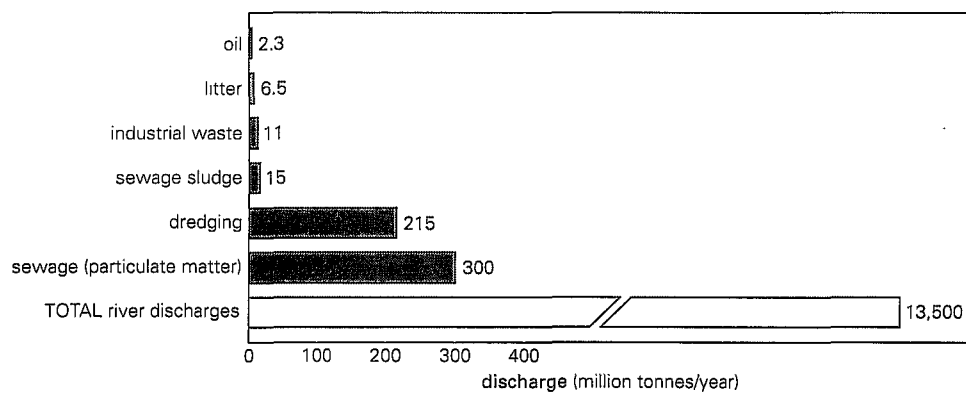
zones, although in certain areas and for some substances (e.g. lead and HCH in the North Sea, and nitrogen in the Mediterranean) atmospheric inputs are similar or even dominant.

4.6 Aside from physical degradation of the coastal and near-shore zones, pollution is the major problem affecting these zones. Most of the liquid wastes and a growing fraction of solid wastes resulting from man's activities on land are introduced into the oceans through the land/sea interface. Coastal areas receive direct discharges from rivers, surface run-off and drainage from the hinterland, domestic and industrial effluents through outfalls, and various contaminants from ships (Fig.4.1).

4.7 Some 6.5 million tonnes of litter find their 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 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; it has been estimated that more than 150,000 tonnes of fishing gear made of plastic is lost (or discarded) in the oceans each year. (2) 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. (3)

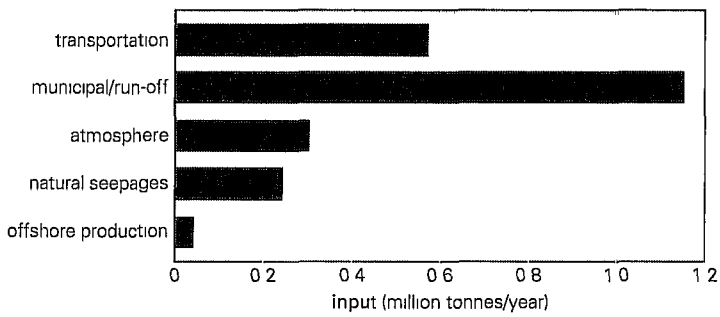
4.8 In 1985, the National Research Council (4) estimated that the amount of petroleum from all sources entering the marine environment was 22.3 million barrels (3.2 million tonnes) annually. Of this amount, municipal wastes and runoff accounted for 8.1 million barrels (1.16 million tonnes), and maritime transportation activities for about 10.1 million barrels (1.47 million tonnes). However, recent data (5) indicate that the amount of oil entering the world's oceans as a result of shipping operations has been cut by 60 per cent since 1981. In 1989, it was estimated that maritime transportation

Figure 4.1
DISCHARGES IN THE MARINE ENVIRONMENT



Source: Based on (5, 16)

Figure 4.2
INPUT OF PETROLEUM IN THE MARINE ENVIRONMENT



Source. Based on data from (4, 5)

activities accounted for about 4 million barrels (568,800 tonnes) of oil annually (Chapter 14). Tanker accidents accounted for about 20 per cent of the oil spilled from transportation activities (Chapter 9). Fig. 4.2 gives estimates of the quantities of oil entering the marine environment. A major reason for the improvement in the pollution figures has been the entry into force of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78), in 1983. The Convention now applies to more than 85 per cent of the world fleet of merchant ships.

Impacts of Marine Pollution

4.9 Most types of wastes, once introduced into the sea, cannot be removed from there. Their fate is determined by their chemical composition and by the physical transport processes (e.g. mixing, sea currents) of the recipient waters. The distance they can reach depends on these processes and on the rate of their decomposition, with the non-degradable wastes having the ability to travel for long distances.

4.10 Some wastes are easily decomposed into harmless substances, although their end products, if excessively concentrated, may lead to serious disturbances of ecosystems (e.g. eutrophication, due to excess of nutrients). Other wastes, such as metals and persistent organic compounds, cannot be degraded; they usually remain adsorbed to the bottom sediments near the sources of discharges. Some marine organisms have a remarkable ability to accumulate such substances from sea water, 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 methylmercury, which caused the outbreak of Minamata disease in Japan in the 1950s and 1960s.

4.11 The principal problem for human health on a world-wide scale is the existence of pathogenic organisms discharged with domestic sewage into coastal waters. Bathing in sea water 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 sea water have an above-normal incidence of gastric disorders. (2) 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.

4.12 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. Algal 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. The incidence of PSP is increasing globally. (6) The term "red tide" is in general used to describe the discoloration 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 increased from two in 1977 to 19 in 1987. (7) Blooms of toxic species occurred in the North Sea with increasing frequency in the 1970s and 1980s. (8) In 1988, a massive bloom occurred in the seas around southern Scandinavia, damaging marine life in some seas and some fish farms along the coast of Norway. (8) 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.

4.13 Many compounds discharged into the sea tend to accumulate in various organisms. Halogenated hydrocarbons accumulate in fatty tissues, the amount accumulated may increase 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 Wadden Sea, the reproductive capacity of marine mammals and birds has been affected. (2) Polychlorinated biphenyls (PCBs) accumulated in seafood can reach levels unacceptable for marketability. Tributyltin (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.

4.14 Oil in the sea is normally found in concentrations too low to pose a threat to marine organisms. However, oil spills, especially major ones, may cause excessive damage, especially in coastal areas (Chapter 9).

4.15 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 and fish ponds has eliminated natural barriers to flooding from storms. In 1980 the Philippines had 146,000 ha of mangrove forests, today it has a mere 38,000 ha. (9) 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 countries by excessive uncontrolled tourism or by near-shore human activities. In the Philippines,

only 10 per cent of the country's coral reefs are in good condition, the rest has been damaged to varying degrees. (10) Many of the world's coastal wetlands have diminished over the past decades as a result of drainage and reclamation schemes to increase land for agriculture and industries and urban growth. Many of the valuable habitats of these wetlands have been lost as a result of these activities (Chapter 8).

Over-exploitation of Living Marine Resources

4.16 The world marine fish catch (including aquatic plants) rose from 60 million tonnes in 1970 to 91 million tonnes in 1989. (11, 12) 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 has led to a sharp drop in catches of cod and herring, 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.

4.17 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. In 1985, the International Whaling Commission imposed a five-year moratorium on commercial whaling. But since then more than 11,000 whales have been killed. (9)

Responses

4.18 Several measures have been taken to control marine pollution. They range from isolated national actions to control pollution in specific sites from easily identifiable sources to measures to curb pollution at regional levels and to global approaches to controlling pollution through the general provisions of international agreements.

4.19 Historically, international marine agreements dealt with the regulation of navigation and fishing. Only recently has it been recognized that the world oceans should be regulated and protected as a natural resource. This important change from "a user-oriented" to a "resource-oriented" approach became most marked in the last two decades. Most legal regimes that have been adopted since 1970 have encompassed the protection, conservation and management of the marine and coastal environment and their resources. The most significant of these are: Convention on Wetlands of International Importance, Ramsar, 1971; Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London, 1972; International Convention for the Prevention of Pollution from Ships, London, 1973; United Nations Convention on the Law of the Sea; and the several regional seas conventions. UNEP's 1991 register of international legislations lists all those related to the marine environment.

4.20 Although the importance of reducing maritime sources of ocean pollution had led to action in the 1960s, it was not until the early 1970s that land-based activities were recognized as the most significant source of marine pollution. The Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki, 1974) and the Convention on the Prevention of Marine Pollution from Land-based Sources (Paris, 1974) were among the first conventions

formulated to control pollution from land-based sources.

4.21 Under the catalytic and coordinating role of UNEP, the "regional seas" programme started in the mid-1970s. In 1975, the Mediterranean states agreed on an Action Plan for the Protection of the Mediterranean Environment (MAP). In the following year, the Barcelona Convention for the Protection of the Mediterranean Sea Against Pollution, plus two protocols, were signed. In the same year, a regional oil-combating centre was established in Malta as part of the MAP. In 1979, a "Blue Plan" for the long-term management of the Mediterranean Sea was launched as part of the socio-economic component of the MAP. It was intended to integrate development plans with environmental protection measures in the Mediterranean Basin. In 1980, the Mediterranean States moved a step forward by adopting the Protocol for the Protection of the Mediterranean Sea Against Pollution from Land-Based Sources. This agreement identifies measures to control coastal pollution from municipal sewage, industrial wastes and agricultural chemicals. Two years later, the Mediterranean Governments also approved a protocol providing special protection for endangered species of fauna and flora, as well as critical habitats. In 1985, the Mediterranean countries established ten priority targets for the decade 1985-1995. In addition to the MAP, action plans for eight other regions have been adopted: the 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. An action plan was recently drafted for the South Asian region, and is under consideration for approval by the concerned Governments. Other action plans for the Black Sea and the Atlantic are being developed. All in all, the regional seas programme involves some 130 countries, 16 United Nations agencies and more than 40 other international and regional organizations, all working with UNEP to improve the marine environment and make better use of its resources (see (10) for a description of the regional seas programmes).

4.22 The adoption of the United Nations Convention on the Law of the Sea in 1982 (as of 31 December 1990, 160 countries had signed the Convention) set up a comprehensive new legal regime for the sea and oceans and, as far as environmental provisions are concerned, established material rules concerning environmental standards as well as enforcement provisions dealing with the pollution of the marine environment. Although the Law of the Sea has not yet entered into force, the concept of the 200-mile exclusive economic zone is already effectively in operation, and the Law may play a key role in the management of the ocean's resources.

4.23 The physical and biotic features of Antarctica represent, for the most part, extreme conditions - isolation, cold, windness, extensive glacial ice and sea ice, impoverished terrestrial biota and abundant marine biota. Antarctica was untouched by man until the last two centuries and is still almost pristine. The Antarctic Treaty, Washington, 1959, seeks to ensure, *inter alia*, that the continent is used for international cooperation in scientific research. The Treaty bans military activity, nuclear explosions and the disposal of radioactive waste in the region. In the 1960s and 1970s the Parties to the Treaty agreed on measures for the conservation of fauna and flora, seals and marine living resources of the region. There is growing concern, however, among several Governments and non-governmental organizations that the Antarctic Treaty may not be proving effective in protecting the antarctic environment, and that direct human activities like intensive exploration, research, and exploitation of living and mineral

resources in the region will have both direct and indirect impacts. (13, 14, 15) Recently, the Parties to the Antarctic Treaty reached an agreement on a 50-year prohibition of mining and mineral prospecting in the region.

4.24 In spite of the various efforts to protect the marine environment, progress has been rather slow, especially in the developing regions. The capabilities of most developing countries are still generally insufficient to cope adequately with the assessment of the problems facing their marine and coastal environment and the rational management of their resources. Weak institutional structures hamper the effective participation of many countries in international efforts designed to protect and develop the marine and coastal environment. The effectiveness of regional agreements to enable a rapid response to accidents involving ships and to combat ensuing environmental threats are constrained by available resources and capabilities. For countries that lack the necessary material resources and trained human resources, the agreements are consequently of limited use. Initiatives to improve this situation include the recently adopted International Convention on Oil Pollution Preparedness Response and Cooperation (OPRC Convention, 1990), which contains a mandatory requirement for oil pollution emergency plans.

4.25 The 1990 report of the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) emphasized that strong coordinated national and international action should be taken now to prevent the rapid deterioration of the marine environment. 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.

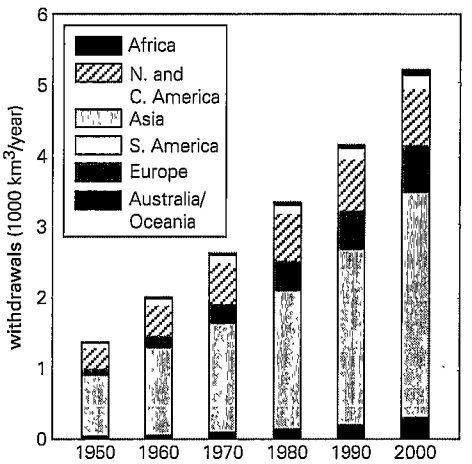
Chapter 5

FRESHWATER RESOURCES AND WATER QUALITY

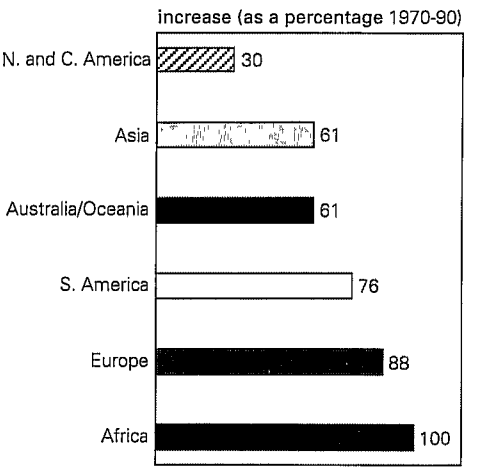
5.1 A number of estimates suggest that of all the water around the globe, 94 per cent is salt water in the oceans and 6 per cent is fresh. Of the latter, about 27 per cent is in glaciers and 72 per cent is underground. This leaves at any one time less than 1 per cent of the fresh water in the atmosphere or in streams and lakes. (1) This fresh water supply is continually replenished by precipitation as rain or snow. It has been estimated that the total annual runoff from continents is about 41,000 cubic kilometres. Of these, 27,000 cubic kilometres return to the sea as flood runoff, and another 5,000 cubic kilometres flow into the sea in uninhabited areas. This cycle leaves 9,000 cubic kilometres of water readily available for human exploitation world-wide. (2, 3) As both the world's population and usable water are unevenly distributed, the local availability of water varies widely. Much of the Middle East and North Africa, parts of Central America and the western United States are already short of water. By the year 2000, many countries will experience excessive scarcity of water due to increasing demand for water for agriculture, industry and domestic use.

5.2 The demand for water varies markedly from one country to another and depends on population and on the prevailing

Figure 5.1
TRENDS IN WATER WITHDRAWAL
(Cubic km/year)



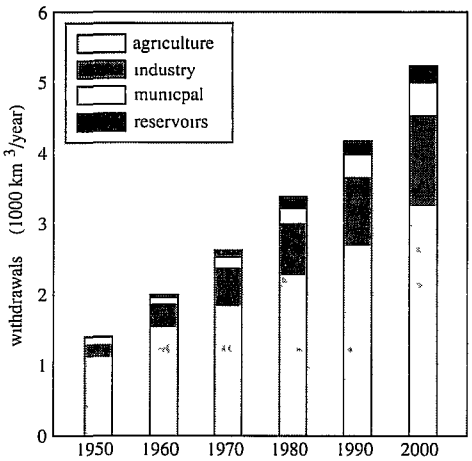
INCREASE IN WATER WITHDRAWAL



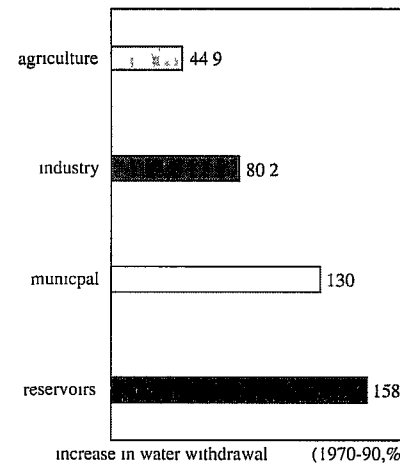
Based on data from (4).

Figure 5 2

WATER WITHDRAWAL BY SECTOR
(Cubic km/year)



INCREASE OF WATER USE IN DIFFERENT SECTORS (1970-1990)



Based on data from (4)

level and pattern of socioeconomic development. Marked differences exist between developed and developing countries. For example, the average per capita domestic use of water in the United States is more than 70 times that in Ghana. World-wide water use increased dramatically from about 1360 cubic kilometres in 1950 to 4,130 cubic kilometres in 1990 (Fig. 5.1) and is expected to reach about 5,190 cubic kilometres by 2000. (4) Although the uses to which water is put vary from country to country, agriculture is the main drain on the water supply. Averaged globally, 69 per cent of water withdrawn goes for that purpose, 23 per cent for industry and 8 per cent for domestic purposes (Fig. 5.2).

5.3 Assuring an adequate supply is not the only water problem facing many countries throughout the world: they need to worry about water quality. Concerns about water quality have been growing since the 1960s. At first, attention centred on surface water pollution from point sources, but more recently groundwater and sediment pollution and non-point sources have been found to be at least equally serious problems.

5.4 The basic type of pollution is that caused by the discharge of untreated or inadequately treated waste water into rivers, lakes and reservoirs. With the growth of industry, industrial waste waters discharged into water bodies have created new pollution problems. Another water quality problem is the increasing eutrophication of rivers and lakes caused mainly by the runoff of fertilizers from agricultural lands. Acidification of lakes by acidic deposition is common in some European countries and in North America (Chapter 1). Wastes can also be carried to lakes and streams along indirect pathways – for example, when water leaches through contaminated soils and transports the contaminants to a lake or river. Dumps of toxic chemical waste on land have become a serious source of groundwater and surface

water pollution (Chapter 10). In areas of intensive animal farming or where large amounts of nitrate fertilizers are used, nitrates in groundwater often reach concentrations that exceed guidelines established by WHO. The problem has become a cause of concern in some European countries and in the United States and is growing in magnitude in some developing countries (Chapters 11 and 18).

5.5 Water quality monitoring has been introduced in several countries. The GEMS global water quality monitoring project (UNEP/WHO/WMO/Unesco), launched in 1977, consists of 344 stations (240 river, 43 lake, and 61 groundwater stations) in 59 countries. 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 (BOD), fecal coliforms and nitrates, as well as analyses of chemical trace constituents and contaminants (heavy metals and organic micropollutants).

5.6 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. (5) 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 4,500 micrograms/l. In contrast, rivers monitored by the GEMS project outside Europe show a much lower median value of 250 micrograms/l. The median phosphate level in rivers monitored in the GEMS/WATER project is 2.5 times the average for unpolluted rivers (10 micrograms/1). As regards metals and toxic substances, regulatory measures have led to a marked decrease of lead in most OECD rivers since 1970. (6) Trends in other metals and toxic substances are less encouraging, despite efforts to reduce discharges. Such substances are often persistent, accumulate into bottom sediments and can be released over long periods of time once initially deposited. Organochlorine pesticides measured in some rivers from developing countries (e.g. in Colombia, Malaysia and the United Republic of Tanzania) are higher than those recorded in European rivers.

Impacts of mismanagement and pollution

5.7 Water use has not been efficient in many countries. Over-exploitation of groundwater (mostly a non-renewable source) has led to the depletion of resources in some areas and to increased encroachment of saline waters into aquifers along coastal zones in some countries (e.g. in North Africa and in the Persian Gulf). There are fears that the rapid expansion of agriculture in desert areas may lead to over-exploitation of groundwater for irrigation. (7) Excessive irrigation has also led to waterlogging and salinization, thereby accelerating, land degradation (Chapters 6 and 11). The lack of maintenance of water delivery systems and over-use of water for domestic, commercial and industrial purposes, especially in the developing countries, have caused a host of socio-environmental and economic problems. Pools of water around faulty standposts in rural areas and marginal settlements have become breeding grounds for various disease vectors. Water seepage has affected the interior and exterior of houses, historical buildings and monuments, and in some areas has caused occasional overflow of drainage and sewage systems. These and other losses, which in some cases amount to more than 70 per cent of water delivered, put increasing and costly pressures on the water works which have to meet the increasing demand for pure water.

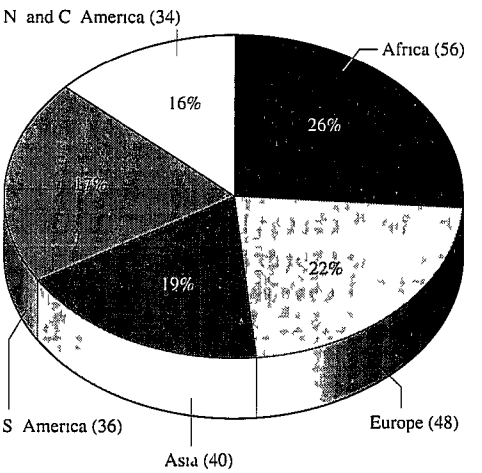
5.8 The quality of fresh water depends not only on the quality of waste entering the water but also on the decontamination measures that have been put into effect. Although organic waste is biodegradable, it nonetheless presents a significant problem especially in developing countries. Human excreta contain pathogenic micro-organisms as the water-borne agents of cholera, typhoid fever and dysentery, and contaminated water has caused the outbreak of epidemics of these diseases in several developing countries (Chapter 18). Industrial waste may include heavy metals and many other toxic and persistent chemicals not readily degraded under natural conditions or in conventional sewage-treatment plants. Unless these wastes are adequately treated at the sources or prevented from discharge into watercourses, the freshwater quality can be seriously impaired. The high content of nutrients in rivers and lakes has created eutrophication. Apart from ecological and aesthetic damage eutrophication brings increasing difficulties and costs for water treatment works which have to produce safe, palatable drinking water. Acidification of freshwater lakes has affected aquatic life to various degrees (Chapter 1). In most newly industrializing countries both organic and industrial river pollution are on the increase and decontamination efforts are often neglected. In these countries industrialization has had higher priority than reduction of pollution. As a consequence, in some regions (East Asia, for example) degradation of water resources is now considered the gravest environmental problem (3). In many of these countries aquatic life (especially fisheries) has been affected and the deterioration of water quality is a growing threat to aquaculture which provides a sizeable amount of fish for the population (Chapter 11).

Shared Water Resources

5.9 An important feature of the geographical distribution of freshwater resources in the world is that many of these

Figure 5 3
INTERNATIONAL RIVER BASINS

NUMBER OF RIVER BASINS



Source Based on data from (17)

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 (Fig. 5.3). 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. (8)

5.10 The joint use of international watercourses has always depended on cooperation among the riparian States. International treaties and organizations were created to regulate the use of some shared water bodies. Historically, these treaties dealt with issues such as allocation of water shares, regulation of navigation and fishing, and construction of public works such as barrages, etc. Only recently – especially since the early 1970s – have some of these treaties been revised to reflect the growing concerns about pollution of shared water resources. For example, 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. (2) 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 since 1980. The Sandoz-Basel accident that occurred in November 1986 (Chapter 9) 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.

5.11 The level of the Aral Sea, shared by three republics in the USSR is retreating because excessive irrigation withdrawals have been reducing inflow from the catchment area. The Aral Sealevel has dropped by 3 m since 1960 and, if the trend continues, will drop another 9-13 m by the year 2000. Reduced inflow, with enhanced salinity from irrigation 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. (5) This large-scale transfer of water will ameliorate a deteriorating environmental situation and will further agricultural and economic development in the area. However, not all large systems of water transfer have net beneficial effects, and the economic, social and environmental consequences of such transfer schemes should be carefully evaluated. (9)

Responses

5.12 The oldest approach to water management is the construction of dams and reservoirs of different sizes to control floods and to store water for use as the need arises. Hundreds of thousands of dams and reservoirs have been built world-wide, but only a few hundred large multi-purpose dams (for water management and electricity generation) have been built in the present century. Between 1950 and 1986 about 36,240 dams higher than 15 metres were constructed, 79 per cent of which are between 15 and 30 m high, 16 per cent between 30 and 60 m, 3.4 per cent between 60 and 100 m, 0.9 per cent between 100 and 150 m, and 0.28 per cent higher than 150 m. (10, 11) About half of these dams were constructed in China alone. Although these dams have provided several benefits, they have not been without environmental cost, and the past two decades witnessed wide discussions about the costs and benefits of large dams, such as the Aswan High Dam and others. (12, 13, 14) One important fact remains: the amount of stored water in man-made reservoirs in the world has been estimated at 3,500 cubic kilometres, nearly equal to the total annual water withdrawal in the world. In addition to such water management schemes, various measures have been taken by several countries to improve the efficiency of water use. Technical as well as regulatory measures (including pricing mechanisms, incentives and disincentives) have been introduced with varying degrees of success. In spite of these efforts, water use is still markedly inefficient, especially in developing countries, many of which provide water (especially for irrigation) either free or heavily subsidized. The past two decades also witnessed increasing efforts to recycle water for use in industry and agriculture (Chapters 11, 12).

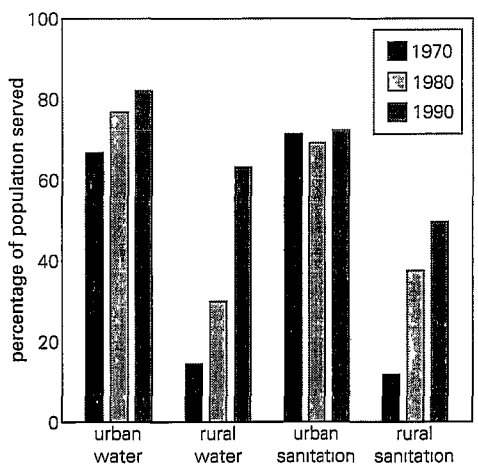
5.13 Global concern about the availability and quality of water was highlighted at the United Nations Water Conference held in Mar del Plata, Argentina, in 1977. The recommendations of the Conference covered 8 major areas: assessment of water resources;

water use and efficiency; environment, health and pollution control; policy, planning and management; natural hazards; public information, education, training and research; regional cooperation; and international cooperation. The implementation of the Mar del Plata Action Plan has been rather slow, but recently the United Nations embarked on the formulation of a global strategy to implement the Mar del Plata Action Plan in the 1990s.

5.14 The United Nations Conference on Human Settlements, held in Vancouver, Canada, in 1976 and the Mar del Plata Action Plan set the stage for the launching of the International Drinking Water Supply and Sanitation Decade (IDWSSD 1981-1990) by the General Assembly of the United Nations in 1980, at the recommendation of WHO. The main objective of the Decade was to bring about a substantial improvement in the standards and levels of services in drinking water supply and sanitation by the year 1990.

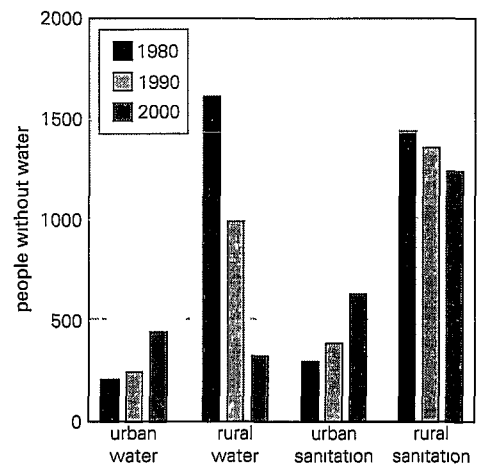
5.15 In 1970, 33 per cent of the population in urban areas of the developing countries did not have access to safe clean water and 29 per cent did not have access to sanitation services. At the same time, in those countries 86 per cent of the population in rural areas did not have access to clean water and 89 per cent did not have access to sanitation services. By the end of the IDWSSD, the percentage of people in urban areas without access to safe clean water had dropped to 18 per cent. Access to sanitation services did not improve – barely one per cent more were supplied with sanitation services during the decade. In rural areas, however, improvements were dramatic: the percentages fell to 37 without clean water and 51 without access to sanitation services (Figs. 5.4 and 5.5, and Box 5.1).

Figure 5.4
WATER SUPPLY AND SANITATION COVERAGE IN DEVELOPING COUNTRIES



Source Based on data from (15, 16)

Figure 5.5
NUMBER OF PEOPLE WITHOUT WATER SUPPLY AND SANITATION



Source Based on data from (15, 16)

BOX 5.1

IDWSSD AND BEYOND

From 1981 to 1990:

* *About 1,348 million people were provided with a safe drinking water supply in developing countries (368 million in urban areas and 980 million in rural areas).*

* *About 748 million people were provided with suitable sanitation services (314 million in urban areas and 434 million in rural areas).*

* *Overall, the number of people without safe water decreased from 1,825 million to 1,232 million, while the number of people without suitable sanitation remained virtually the same.*

The rate of progress achieved during the IDWSSD would be insufficient to reach the ultimate objective of services for all by the end of the century.

If programme implementation were to continue at the current rate, those in urban and rural areas without safe water by the year 2000 would decrease to around 767 million due to significant increases in coverage in rural areas. In percentage terms this would constitute a decrease from 31 per cent of the total population of the developing countries in 1990 to 16 per cent by 2000. Those without sanitation would rise to around 1,880 million, although the percentage of the population without services would decrease from 43 to 38 per cent due to a small decrease in the number of people in rural areas without coverage. The health and environmental consequences associated with these numbers of people without services would preclude the achievement of living conditions compatible with sustainable development.

Sources: (15, 16).

5.16 The slow progress towards achieving the goals of the IDWSSD (Box 5.1), particularly in urban areas, has been attributed to several factors, including population growth, rural-urban migration, 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 the century, provided adequate investment will be made available, coupled with the provision of appropriate low-cost technologies and wider public participation.

5.17 New and more comprehensive approaches to water management are needed to enhance socioeconomic and environmental development, especially in international basins (whether rivers, lakes, or groundwater aquifers). The Environmentally Sound

Management of Inland Waters (EMINWA) programme, launched by UNEP in 1986, is one of these comprehensive approaches. 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.

5.18 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. Eight countries (Angola, Botswana, Malawi, Mozambique, Namibia, United Republic of Tanzania, Zambia and Zimbabwe) are participating in 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. Other activities under way include the management of the Nile river basin.

Chapter 6

LAND DEGRADATION AND DESERTIFICATION

6.1 Of the total land area in the world (about 13,382 million hectares, 13,069 million of which are ice-free), only 11 per cent (about 1,475 million ha.) is currently under cultivation, while 24 per cent is permanent pasture, 31 per cent comprises forests and woodlands and 34 per cent is classified as "other land", which includes unused but potentially productive land, built-up areas, wasteland, parks, or other land not specified in the previous types. (1) The world's potentially cultivable land has been estimated at about 3,200 million ha, more than twice the area currently used as cropland. About 70 per cent of potentially cultivable land in the developed countries and 36 per cent in the developing countries is currently cultivated (Chapter 11). Data given by FAO (1) show that in the 15 years from 1973 to 1988 the total area of arable and permanent cropland in the world increased from 1,418 to 1,475 million ha. (i.e. by 4 per cent), that of permanent pastures decreased slightly from 3,223 to 3,212 million ha. (i.e. -0.3 per cent), that of forests and woodlands decreased from 4,190 to 4,049 million ha. (i.e. -3.5 per cent), and that of "other land" increased from 4,235 to 4,333 million ha. (i.e. by 2.3 per cent).

6.2 Human activities have radically reshaped the world's natural land cover. The often indiscriminate destruction of forests and woodlands (Chapter 7), the overgrazing of vegetation by increasing numbers of livestock, and the improper management of agricultural land have all resulted in the degradation of extensive land areas.

6.3 The productivity of farmland principally depends on the capacity of the soil to respond to management. Soil is not an inert mass, but a very delicately balanced assemblage of mineral particles, organic matter and living organisms in dynamic equilibrium. Soils are formed over very long periods of time, generally from a few thousand to millions of years. (2) Excessive human pressure or misguided human activity can destroy soils in a few years or decades, and the destruction is often irreversible.

6.4 Of all human activities, agricultural production has had the greatest impact on soil degradation. Traditionally, farming practices had been well balanced with soil sustainability. In recent decades, however, human management of agro-ecosystems has been steadily intensified, through irrigation and drainage, heavy inputs of energy and chemicals, and improved crop varieties increasingly grown as monocultures. Although bringing some general growth in agricultural production, this process has made agro-ecosystems more and more artificial and often unstable and more prone to rapid degradation (Chapter 11).

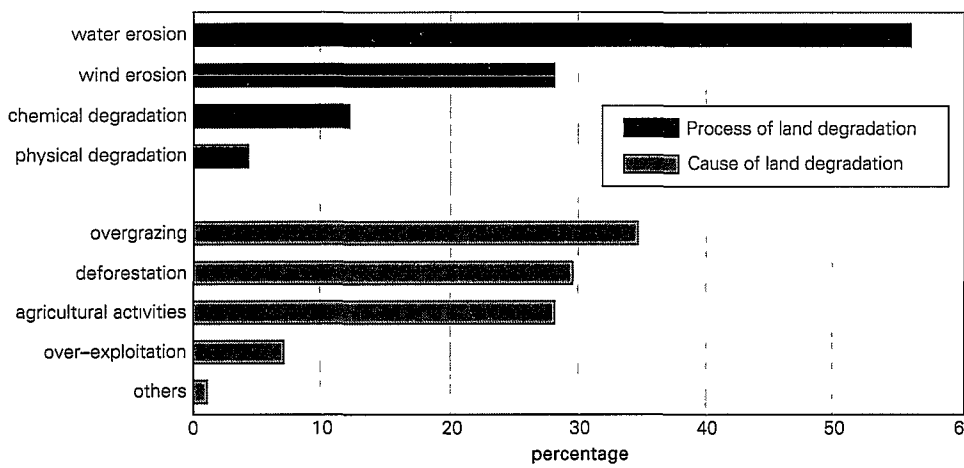
6.5 The pressure to expand the area under farming has resulted in more and more utilization of marginal land, most often with various detrimental consequences. Overgrazing and overcultivation on steep hillsides everywhere have led to serious soil erosion. Slash-and-burn agriculture has accelerated deforestation, which in turn has

led to increased soil erosion and floods (Chapter 7). As more land is used for housing, for commercial and industrial development and for transport, agricultural land areas suffer the consequences. In some countries, coastal and shore areas and wetlands are particularly vulnerable to such human activities (Chapter 4).

6.6 Soil degradation is a complex process, involving one or more of several agents: erosion and actual removal by water and wind and chemical, physical, and/or biological changes. (3) Although soil erosion is a natural process, its intensity has been greatly increased by human activities. The average rate of soil erosion is estimated to be about 0.5- 2.0 tonnes per hectare per year (4) depending on soil type, slope and the nature of the erosion processes. In the United States, 44 per cent of cropland is affected by erosion. (5) In El-Salvador, 77 per cent of the land area is suffering from accelerated erosion (6), and in the eastern hills of Nepal, 38 per cent of the land area consists of fields which have had to be abandoned because the topsoil has washed away. In India about 150 million ha out of 328 million ha of farmland are affected by erosion to varying degrees. (7) World-wide, it has been estimated that about 25,400 million tonnes of material are removed each year from topsoil by excessive erosion. (5) A decline in soil fertility or even a total loss of land to agriculture, caused by an increase in salinity or alkalinity, is a common problem in many parts of the world (Chapter 11).

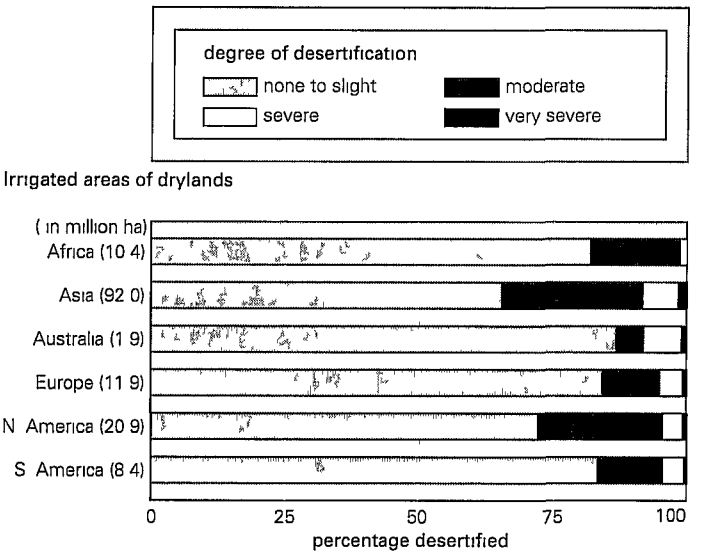
6.7 The recent Global Assessment of Soil Degradation (GLASOD), carried out by the International Soil Reference and Information Centre (ISRIC) at Wageningen, the Netherlands, (8) estimates that 15 per cent of the earth's land area has been degraded by human activities to varying degrees. Of this degraded land, 55.7 per cent has been degraded by water erosion, 28 per cent by wind erosion, 12.1 per cent by chemical means (loss of nutrients, salinization, pollution and acidification), and 4.2 per cent by physical means (compaction, waterlogging and subsidence). The main causes of such degradation are overgrazing, which accounts for 34.5 per cent of the degraded area; deforestation, 29.5 per cent; agricultural activities, 28.1 per cent; over-exploitation, 7 per cent; and bio-industrial activities (waste accumulation, excessive manuring, use of agrochemicals, etc.), 1.2 per cent (Fig. 6.1). GLASOD has

Figure 6.1
PROCESSES AND CAUSES OF LAND DEGRADATION



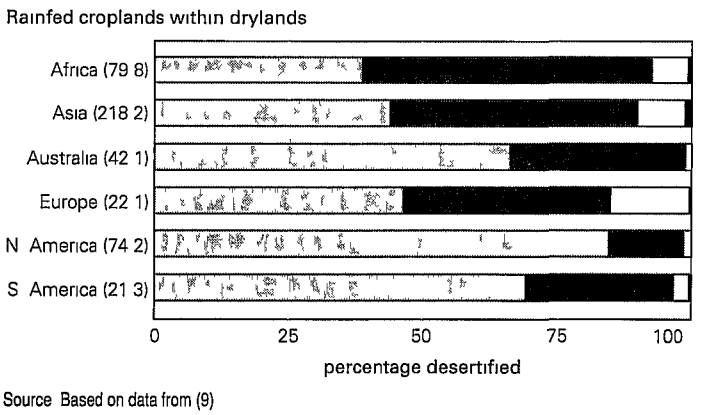
Source: Based on data from (8).

Figure 6 2
DESERTIFICATION IN IRRIGATED AREAS OF DRYLANDS



Source Based on data from (9)

Figure 6 3
DESERTIFICATION IN RAINFED CROPLANDS WITHIN DRYLANDS

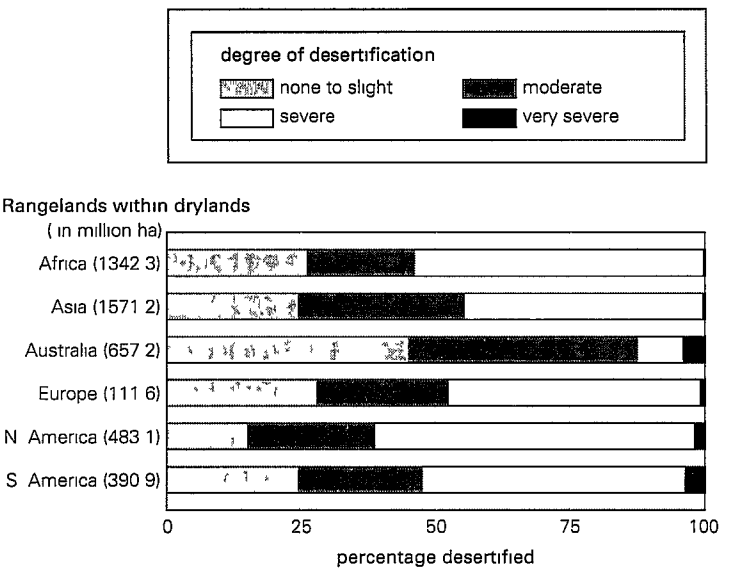


Source Based on data from (9)

classified the degree of land degradation into four categories: light, moderate, strong and extreme. According to FAO, (1) the total area of agricultural land (arable land, permanent pasture and grazing land) in the world in 1988 was about 4,687 million ha. The GLASOD figures indicate that around 1,230 million ha of these (or 26 per cent) have been degraded as a result of mismanagement.

6.8 World-wide, drylands (arid, semi-arid and dry subhumid areas) cover 6,150 million ha., or about 47 per cent of the total land area in the world. Drylands comprise 62 per cent of the total irrigated land area in the world, 36 per cent of the total rainfed cropland, and 68 per cent of the total rangeland. Desertification, defined as land degradation in drylands resulting mainly from adverse human impact, is common in many areas. The recent assessment by UNEP of the global status of desertification (9) shows that 30 per cent of irrigated areas within the drylands, 47 per cent of rainfed cropland and 73 per cent of rangeland are at least moderately affected (Figs. 6.2 to 6.5). About 43 million ha of irrigated land in the world's drylands are affected by various processes of degrada-tion, mainly waterlogging, salinization and alkalinization. It has been estimated that a total of 1.5 million ha. of irrigated land are lost every year world-wide, of which 1.0-1.3 million ha are in drylands. Nearly 216 million ha of rainfed croplands in the world's drylands are affected by water and wind erosion, depletion of nutrients and physical deterioration. About 7-8 million ha of rainfed croplands are currently lost every year throughout the world,

Figure 6.4
DESERTIFICATION IN RANGELANDS WITHIN DRYLANDS



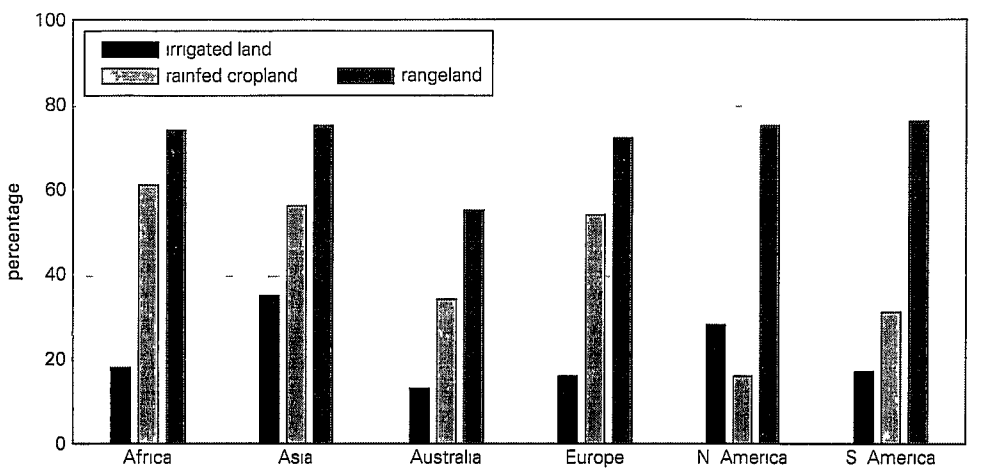
Source Based on data from (9)

of which 3.5-4.0 million ha are in drylands. About 3,333 million ha of rangeland in drylands are affected, mainly by degradation of vegeta-tion; erosion also affects some 757 million ha of this area. All in all, some 70 per cent of all agriculturally used drylands is affected to various degrees by desertification/land degradation. The worst affected are North America, Africa, South America and Asia. (9)

Impacts of Land Degradation and Desertification

6.9 While people are the main agents of land degradation and desertification, they are also the victims. Throughout the Third World, land degradation has been the main factor in the migration of subsistence farmers into the slums and shantytowns of major cities (looking for "better" opportunities), producing desperate populations vulnerable to disease and natural disasters and prone to participate in crime

Figure 6.5
PERCENTAGE OF DRYLANDS AFFECTED BY DESERTIFICATION



Source Based on data from (9).

and civil strife. Such an exodus from rural to urban areas has exacerbated the already dire urban problems in many developing countries. At the same time, it has delayed efforts to rehabilitate and develop rural areas through lack of manpower and increased neglect of the land. The effects of land degradation and desertification are compounded by recurrent droughts. The mass exodus that has been taking place in Africa since the late 1970s is a vivid illustration of the plight of people facing such intolerable environmental conditions. At the peak of the crisis, in 1984 and 1985, an estimated 30-35 million people in 21 African countries were seriously affected, of whom about 10 million were displaced and became known as "environmental refugees". (10) Death, disease, chronic malnutrition and disability haunt these millions of refugees because of the continuing intolerable living conditions.

6.10 Land degradation and desertification diminish the ability of affected countries to produce food and consequently entail the reduction of regional and global food-producing potential. They also cause food deficits in menaced regions with impacts on world food reserves and food trade. Since desertification entails the destruction of vegetation and the diminution of many plant and animal populations, it is an effec-tive cause of loss of bio-diversity in arid and semi-arid areas (Chapter 8), thereby limiting the opportunities for food production.

Responses

6.11 Preventing land degradation and desertifi-cation is certainly much more efficient and econo-mical than rehabilitating degraded land. The latter becomes more difficult and costly with the advanced degree of de-gradation. Many countries are undertaking costly operations. In the period from 1976 to 1980, more than 740,000 ha of land in Bulgaria were pro-tected from erosion, and over 1.4 million ha were treated to reduce soil pol-lution. (11) In Hungary, soil erosion has caused land degradation over a total area of about 2.3 million ha and efforts are under way to amelio-rate the situation. Exten-sive drainage networks have been constructed in several countries to reduce waterlogging and salinization. In Pakistan, 32 salinization control and reclamation projects were completed in the period 1960-1985. As a result of these projects, the extent of salinization has declined from 40 per cent to 28 per cent. On average, about 81,000 ha. of affected land are being brought back into full production every year. (12)

6.12 Efforts to re-habilitate degraded rangeland are under way in many countries. In the Syrian Arab Republic, range cooperatives have been established and regulations for the use of certain rangeland have been formulated. In Jordan priority is given to the establish-ment of permanent settlements for nomadic herdsmen. Several tech-nologies are being intro-duced to increase the carrying capacity of rangeland. For example, it has been demonstrated in Kuwait, Pakistan and Saudi Arabia that salt-tolerant grasses grow well under irrigation with brackish water. Annual medick pasture in rotation with cereals has been utilized with varying degrees of success in Iraq, Jordan, Libyan Arab Jamahiriya and the Syrian Arab Republic. Tropical pasture species have been introduced in Oman and Sudan, where environmental conditions allow. (13)

6.13 Reforestation and afforestation activities have been undertaken in several countries to stabilize soils, to halt the encroachment of sand dunes on agricultural land and to halt desertification. Marked progress has been achieved in this respect in China, Republic of Korea, etc. (Chapter 7). Agroforestry is also practiced in some countries. Farmers plant trees as windbreaks or as shade trees on pastures and fields. Trees

also provide fuelwood, poles, fruit, edible seeds and fodder. In North Africa a green belt has been planned as part of the effort to halt desertification. In spite of these efforts, the implementation of the Plan of Action to Combat Desertification, which was adopted by the United Nations Conference on Desertification in 1977, has been very slow due to several factors, the most important of which are institutional, administrative, technical as well as financial. A detailed evaluation of the progress achieved in the implementation of the Plan of Action to Combat Desertification is being published by UNEP within another comprehensive document on desertification for UNCED.

Chapter 7

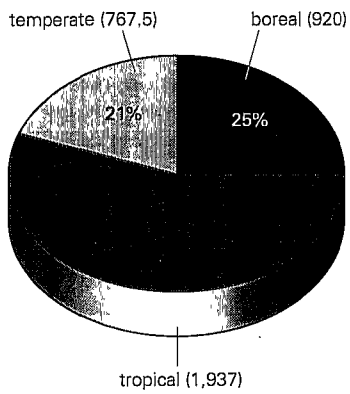
DEFORESTATION AND DEGRADATION OF FORESTS

7.1 Forest cover is of great importance from the ecological point of view. It protects and stabilizes soils and local climates as well as soil hydrology and the efficiency of the nutrient cycle between soil and vegetation. Forests are also the habitat of people and numerous plant and animal species. Virgin forests, especially those in tropical regions, are an irreplaceable repository of the genetic heritage of the world's flora and fauna (see Chapter 8). From the economic point of view, forests provide not only timber and firewood, but also medicinal and other plants of use to humankind. The role of forests as carbon sinks to reduce the effects of carbon dioxide in the atmosphere, thereby helping to contain global warming, is now well-established (Chapter 3).

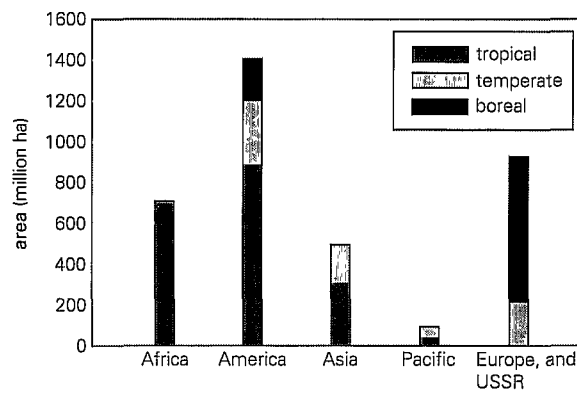
7.2 Forests now cover 3,625 million ha. or 27.7 per cent of the total ice-free land area of the world. (1) Of the total forest area, 25.4 per cent is covered by boreal forests; 21.2 per cent by temperate forests; and 53.4 per cent by tropical forests (Fig.7.1). In addition to these forests, some 650 million ha. are covered by "other wooded vegetation", which includes scrub, thickets, shrub vegetation, forest fallow, etc.

Figure 7.1

DISTRIBUTION OF FORESTS IN THE WORLD (million ha)



REGIONAL DISTRIBUTION OF FORESTS



Source: Based on data from (1).

7.3 The total stock of wood contained in forests has been estimated at about 315 billion cubic metres (as calculated from data given by OECD. (2) This is the resource base which will eventually be depleted if more than the annual increment from it, estimated at about 6 billion cubic metres, is consumed. In 1988, the total world consumption of roundwood was 2,972 million cubic metres (industrial roundwood, 1,535 million cubic metres - or 51.6 per cent – and fuelwood, 1,437 million cubic metres – or 48.4 per cent). (3) This figure is an underestimate, since many countries keep no accurate records of self-collected or self-produced wood. Although it seems that the annual increment of the forest resource base can meet the world demand for wood, forest resources are unevenly distributed in the world and not all the increment is being removed. Much of the latter is in the inaccessible northern forests of Alaska, Canada and USSR. This leads to increasing pressure on, and over-exploitation of, forest resources in certain regions, for example, in South-East Asia and Latin America. A recent forecast (2) indicates that the supply of industrial roundwood will not meet world demand in the year 2010.

7.4 Wood is the primary source of energy for domestic heating and cooking for well over 2,000 million people. Fuelwood and charcoal supplied 17 per cent of the total energy consumption in developing countries in 1990, (1) but their importance is even greater in rural areas where they constitute the main source of energy for most household and rural industry needs. For some countries, wood is the main source of energy. More than 80 per cent of energy use in such nations as Burkina Faso, Ethiopia, Mali, Nepal, Niger, Nigeria, Sudan and the United Republic of Tanzania comes from wood. (4) Current estimates indicate that on average every person in the developing countries consumes about 0.45 cubic metres of wood as fuelwood or charcoal per year, although values as high as 2.5 cubic metres may be encountered in rural areas. Because of the increasing demand for fuelwood and the rapid depletion of resources, in 1980 about 100 million people in the developing countries could not get sufficient fuelwood to meet their minimum energy needs, and close to 1,300 million consumed fuelwood resources faster than they were being replenished. Without remedial action to improve the situation, it is estimated that 2,400 million people will be either unable to obtain their minimum energy requirements or will be forced to consume wood faster than its being grown by the year 2000. (1) The world fuelwood deficit could reach 960 million cubic metres a year by 2000.

7.5 In all parts of the world, degradation of forests is caused by a number of natural and anthropogenic factors. Natural hazards like droughts, frosts, storms, etc. and the spread of certain pests and diseases degrade the quality of forests in some regions. Forest fires have caused serious damage to forests in France, Greece, Spain, the United States and other countries (Chapter 9). Air pollution (especially acidic deposition and oxidants) can affect forests directly, by acting on the foliages or indirectly by changing the properties of the soil supporting forest growth (Chapter 1). In 1988, it was estimated that in Europe (temperate forests) between 0.6 per cent (Portugal) and 5.4 per cent (Czechoslovakia) of all trees were severely defoliated or dead. In addition, between 0.7 per cent (Portugal) and 22 per cent (Czechoslovakia) of the trees were moderately defoliated. In 13 European countries, between 10 and 20 per cent and in three countries more than 20 per cent of the trees of all species are moderately to severely affected. (5) In general, it has been estimated that, of a total forest area of 141 million ha. in Europe, some 50 million ha. (or 35 per cent) are damaged to varying degrees. (6) This "die-back" of forests has been attributed

to different causes: acidic deposition, soil acidification, effects of atmospheric sulphur and nitrogen oxides, ozone (and possibly other photo-oxidants), climate change, pathogens and the effect of ammonium and other nitrogen compounds. (7, 8, 9, 10) Forest damage as a result of air pollution is also observed in North America and East Asia. In the tropics, deforestation has been increasing due to expansion of agricultural land, ranching, and over-exploitation for fuelwood. In 1980, FAO/UNEP estimated that 11.4 million ha. of closed and open forests in tropical areas were being cleared annually. (11) A recent reassessment by FAO indicates that between 1981-1990, the annual deforestation rate may have been as high as 16.8 million ha. (1) In contrast, in temperate and boreal zones deforestation is generally very limited and is often compensated by afforestation and reforestation.

Impacts of Deforestation

7.6 Deforestation and forest degradation have many negative consequences. Tropical forests are the richest biotic environments in terms of the numbers of plant and animal species (Chapter 8). The loss of tropical forests causes the extinction of increasing numbers of these species, and forest degradation leads to serious reductions in the genetic diversity of others. The loss of tropical forests already affects hundreds of millions of people through increased flooding, soil erosion and silting of waterways, drought, shortages of fuelwood and timber, and displacement of societies and cultures.

7.7 The destruction of forests undermines the basic operations of the ecosystem and may thus cause irreversible changes. The most serious of these appear to be due to the large-scale exposure of natural soil systems, leading to increased erosion and, in turn, indirectly affecting water resource development. In the past, when the Himalayas were covered with trees, Bangladesh used to suffer from overwhelming floods about once every half century. Growing populations have stripped the forests from the habitable areas on the southern slopes of the mountains. The slopes can no longer hold the rainwater and major floods are increasing throughout the Himalayan watershed. By the 1980s, Bangladesh was suffering from a major flood about every four years. India's flood-prone area increased from 25 million ha. in the late 1960s to 59 million ha. in the late 1980s. (12, 13)

7.8 Where deforestation has eliminated plants and animals and has degraded water supplies and soil fertility, families can no longer support themselves. Major deforestation can cause the displacement of whole communities. Such disruption can force people to flee and seek livelihoods elsewhere. Several million of these "environmental refugees" have left their home countries in Central America, the Caribbean, Africa and Asia to escape poverty and environmental deterioration related to deforestation. (12) In Haiti, where over 100,000 people have emigrated, the once abundant forests now cover less than 2 per cent of the land. In Indonesia over a million people have abandoned deforested and eroded areas of Java and migrated to Borneo and other islands. (14)

7.9 Deforestation has an important influence on regional and global climate. Deforestation affects regional climate by altering sensible and latent heat flux, precipitation and albedo. On a global level, deforestation has resulted in a net release of carbon dioxide and other greenhouse gases into the atmosphere. It has been estimated that tropical deforestation accounts for 26-33 per cent of carbon dioxide released annually into the atmosphere; for 38-42 per cent of methane, and for 25-30 of nitrous

BOX 7.1

IMPROVING FOREST MANAGEMENT

* *Bolivia has launched a five-year ecological "meratorium" which includes temporarily suspending logging concessions.*

* *Côte d'Ivoire, which lost two-thirds of its forests in 25 years, has announced a ban on timber exports to protect its remaining 400,000 ha.*

* *Traditional non-destructive uses of the rainforest, like tapping rubber and agroforestry, achieve much higher economic returns than logging, slash-and-burn agriculture or cattle ranching. Many local communities in Brazil, Kenya, Mexico, Philippines and Thailand practice and develop such systems.*

Sources: (13, 14, 21, 22).

oxide. (15) The potential for climate change (global warming) due to the increase of greenhouse gases is now well established (Chapter 3). Although, from the theoretical point of view, such global warming could enhance the growth of tropical and temperate forests, it may have devastating effects on boreal forests. (16, 17)

Responses

7.10 The logical immediate response to the growing problem of deforestation is to protect substantial areas of remaining tropical forests, to improve forest management, and to plant more trees. World-wide, less than 5 per cent of the remaining tropical forests is protected as parks or reserves. However, Brazil has established a system of forest parks and conservation areas covering nearly 15 million ha. while Costa Rica has protected 80 per cent of its remaining wildlands through parks, wildlife refuges and reserves. Some other countries in Latin America, Africa and Asia have established successful reserves. (14) Several countries have taken steps to improve forest management. Some have restricted the harvesting of timber, others have improved the harvesting technologies, etc. (see Box 7.1).

7.11 Reforestation and afforestation activities are under way in many countries. FAO estimates the annual rate of successful tree planting at 1.1 million ha. (1) The total area of man-made forests in the tropical countries alone is estimated to have reached 25 million ha. in 1990. On a large scale, China is one of the few countries that has had success in reforesting major areas of its land. Between 1979 and 1983, 4 million ha. were planted each year; in 1985 the area rose to 8 million ha. (14) Zambia has established enough plantations to meet all its needs for industrial timber until the end of the century. (13) In Cyprus, some 17,000 ha. were reforested to conserve endemic tree species. (18)

7.12 In the past two decades, some attempts have been made, with varying degrees of success, to establish "energy farms". Although the concept is not new (relatively large Eucalyptus energy farms, dedicated to charcoal production for steel mills, have been in operation since the early

1950s in Argentina and Brazil), it was thought that farms of fast growing trees could meet part of the energy needs in some countries. Ipil Ipil plantations in the Philippines were established to fuel power stations and projections made to the year 2000 were that 700,000 ha. of wood plantations would produce some 2,000 megawatts of electricity. (19) Other energy farms were established on smaller scale in India and other countries. However, many of these energy farms have not been successful. Some of the projects were discontinued due to a drop in oil prices in the 1980s and a lack of adequate funds; in others the trees were diverted and sold as timber for more profit.

7.13 Since the mid-1970s, several attempts have been made to increase the efficiency of fuelwood and charcoal utilization (which should lead to conservation of fuelwood resources). Modifications were made to wood stoves and other new designs were tested. (4, 20) However, the dissemination of efficient stoves has been slow and has encountered a number of economic, social and cultural problems.

7.14 At the regional and global levels, several actions have been taken to protect forests. The signing of the ECE Convention on Long-range Transboundary Air Pollution in 1979 and of the Protocols on sulphur and nitrogen oxides has led to cutbacks in sulphur and nitrogen oxides emissions (the main agents of acidic deposition) in Europe (Chapter 1). In 1985, a Tropical Forestry Action Plan (TFAP) was launched by FAO, the World Bank, UNDP and the World Resources Institute (WRI). The Plan provides a framework for environmental management and sustainable forest development at national, regional and global levels. So far, 81 countries have adopted the TFAP (1). An innovative approach introduced since 1987 has been the purchase of foreign debts of tropical countries in exchange for the creation of domestic forest reserves (Box 7.2).

BOX 7.2

DEBT-FOR-NATURE SWAPS

Foreign debt has been purchased at discounts of 50 to 90 per cent on the world market for several years. Generally, debt is purchased in exchange for other equity, usually funds in local currency, from the debtor Government.

An innovative approach introduced by non-governmental organizations is to purchase foreign debts in exchange for the creation of domestic forest reserves:

* *Conservation International helped to negotiate the purchase of $650,000 worth of Bolivian debt for $100,000. In exchange, the Bolivia Government committed 1.5 million ha. of land and maintenance funds to expand the Rio Beni reserve.*

* *The World-wide Fund for Nature purchased $1 million of Ecuador's debt, which will be converted into funds to maintain parks and wildlife reserves.*

* *Costa Rica has recently announced a programme to convert up to $5.4 million of its external debt, and at least other eight countries are considering similar plans.*

Sources: (13, 14, 21, 22).

7.15 The International Tropical Timber Agreement, which came into force in 1985 under the auspices of UNCTAD, is now implemented by the International Tropical Timber Organization (ITTO), established at Yokohama in Japan in 1987. ITTO's main objectives are to improve market intelligence, to assist producing countries to develop better techniques for reforestation and forest management, to encourage increased timber processing in producing countries, and to support research and development programmes to achieve these goals. One of the most encouraging aspects of ITTO is that producing and consuming countries are working together towards sustainable management of tropical forests. Ecological considerations have now been firmly embedded in ITTO's objectives and activities, largely due to the efforts of UNEP, the International Union for the Conservation of Nature and Natural Resources (IUCN), the World-wide Fund for Nature (WWF), and many environmental NGOs.

Chapter 8

LOSS OF BIOLOGICAL DIVERSITY

8.1 The earth's genes, species, and ecosystems are the product of hundreds of millions of years of evolution, and have enabled our species to prosper. But the available evidence indicates that human activities are leading to the loss of the planet's biological diversity (or biodiversity). With the projected growth in both human population and economic activity, the rate of loss of biodiversity is far more likely to increase than stabilize.

8.2 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, but the figure is most probably in the range of 30 million. 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. (1, 2)

8.3 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 also have the highest richness of mammal species per unit of area, and vascular plant species diversity is much richer at lower latitudes. (3) 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. (4) 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. These terrestrial and marine patterns of increasing diversity in the tropics reach their peak in tropical forests and coral reefs.

8.4 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 Botswana, Lesotho, Namibia, South Africa and Swaziland (which are temperate areas), 18,560 (i.e. 80 per cent) are endemic to the region. (5) 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 south-west Australia's 3,600 plants are endemic to those regions. (3)

8.5 Wetlands are among the most biologically productive ecosystems in the world, yet are often regarded as a nuisance, as wastelands, habitats for pests and threats to public health. In reality, wetlands help to regulate water flows and provide essential

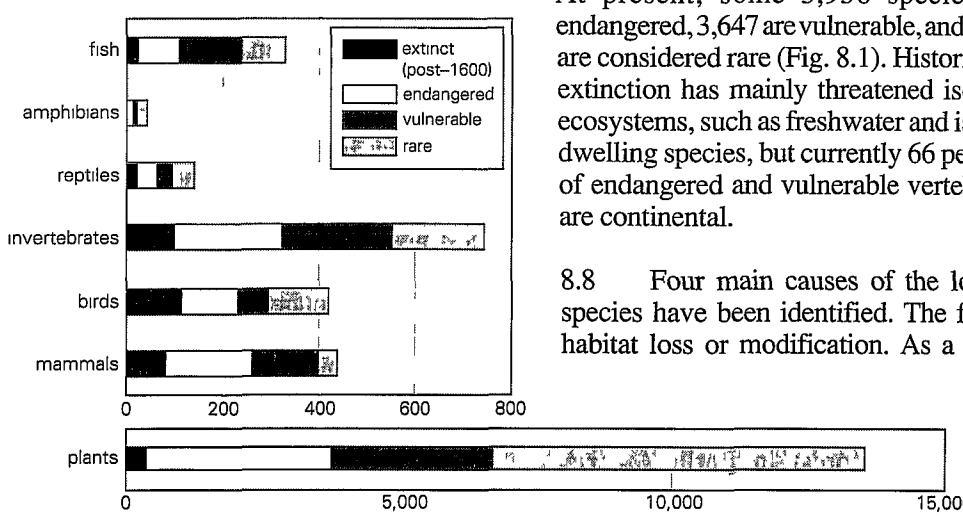
breeding habitats for many species of flora and fauna. Wetlands are in retreat nearly everywhere they are found. The United States has lost some 53 per cent of its coastal and freshwater wetlands; New Zealand has lost over 90 per cent of its natural wetlands; and many parts of Europe have lost nearly all natural wetlands. (6) In the tropics, countries such as Bangladesh, Cameroon, Chad, India, Niger, Thailand, and Viet Nam have lost over 80 per cent of their freshwater wetlands; (7) the effects of this loss are felt far beyond the boundaries of any individual wetland, through disruptions of the hydrological cycle, destruction of habitats for migratory birds, and reduction of productivity of fisheries.

Loss of Species

8.6 Throughout the geological history of the earth, species of plants and animals have been subjected to various evolutionary processes. Many species became extinct during the different geological periods, the length of which is measured in millions of years. Indeed, over 99 per cent of the species that have ever existed are now extinct. (8) In recent history, humans have had an increasing impact on species extinctions.

8.7 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 experts have concluded that perhaps a quarter of the earth's total biological diversity is in serious danger of extinction during the next 20-30 years. (9) Between 1990 and 2020, species extinctions caused primarily by tropical deforestation (tropical forests cover only 7 per cent of the earth's 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 40-140 species per day. (3) Data indicate that since 1600, 724 species have become extinct. (2) At present, some 3,956 species are endangered, 3,647 are vulnerable, and 7,240 are considered rare (Fig. 8.1). Historically, extinction has mainly threatened isolated ecosystems, such as freshwater and island-dwelling species, but currently 66 per cent of endangered and vulnerable vertebrates are continental.

Figure 8.1
NUMBER OF EXTINCT AND THREATENED SPECIES



Source: Based on data from (2)

8.8 Four main causes of the loss of species have been identified. The first is habitat loss or modification. As a broad

general rule, reducing the size of a habitat by 90 per cent will reduce the number of species which can be supported in the long run by about 50 per cent. The second reason for the loss of species is over-exploitation. 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. Pollution is the third reason for the growing loss of species. 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 die-backs in Europe and North America. Acid rain has resulted in the loss of a number of fish species in northern European lakes (Chapter 1). The fourth reason for the loss of species is the impact of introduced exotic species as they threaten natural flora and fauna by predation, competition or by altering the natural habitat.

Loss of Genes

8.9 A species consists of many genes; genetic diversity refers to the variation of genes within species, as expressed for example in the thousands of rice varieties in Asia. The genetic variability of many species is diminishing and hence reduces their ability to adapt to pollution, climate change, disease, or other forms of environmental adversity. The remaining gene pools in crops such as maize and rice amount to only a fraction of the genetic diversity they harboured only a few decades ago. Many agriculturalists argue that the loss of genetic diversity among domestic plants and animals looms as an even greater threat to human welfare than the loss of wild species, because diversity is what will enable crops to adapt to future environmental change.

Impacts of Loss of Biodiversity

8.10 Wild species and the genetic variation within them make substantial contributions to the development of agriculture, medicine and industry. Many species constitute the foundation of community welfare in rural areas by providing for food, feed, fuel and fibres. 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 that biological diversity provides, but the examples in Box 8.1 are illustrative. The loss of biodiversity will restrict all these socio-economic and environmental benefits and in the long run, will compromise the ability of future generations to meet their needs.

8.11 Recent advances in biotechnology research and development offer new possibilities of increasing the production of food, medicines, energy, speciality chemicals and other raw materials and of improving environmental management. This reinforces the need to maintain the richest possible pool of genes. The loss of biodiversity could cripple the genetic base required for the continued improvement and maintenance of currently utilized species and deprive us of the potential use of developments in biotechnology.

Responses

8.12 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 habitats as National Parks, Biosphere Reserves or other protected areas; (b) measures to protect

BOX 8.1

SOCIO-ECONOMIC BENEFITS OF BIODIVERSITY

* *About 4.5 per cent of the GDP in the United States (some $87 billion per year) is attributable to the harvest of wild species.*
* *In Asia, by the mid-1970s genetic improvements had increased wheat production by $2 billion and rice production by $1.5 billion a year by incorporating dwarfism into both crops.*
* *A "useless" wild wheat plant from Turkey was used to give disease resistance to commercial wheat varieties worth $50 million annually to the United States alone.*
* *One gene from a single Ethiopian barley plant now protects California's $160 million annual barley crop from yellow dwarf virus.*
* *An ancient wild relative of corn from Mexico can be crossed with modern corn varieties with potential world-wide savings to farmers estimated at $4.4 billion annually.*
* *World-wide, medicines from wild products are worth some $40 billion a year.*
* *In 1960, a child suffering from leukemia had only one chance in five of survival. Now the child has four chances in five, due to treatment with drugs containing active substances discovered in the rosy periwinkle, a tropical forest plant originating from Madagascar.*

Sources: (2, 11, 12).

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 Especially as Waterfowl Habitat (Ramsar, 1971), the Convention Concerning the Protection of the 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 (CITES – Washington, 1973) (Box 8.2), the Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979), etc. Although these conventions and programmes have provided important means of promoting the conservation of biological diversity, none has the explicit purpose of conservation of global biological diversity.

8.13 Protected areas provide a mechanism for conserving wild biodiversity and most countries today have established at least some protected areas. Nationally protected areas have increased from 1,478 sites in 1970 to 6,930 in 1990, i.e. about five-fold (Fig. 8.2). The total area of these sites was 164 million ha. in 1970 and 652 million ha. in 1990. The protected areas in the world covered 4.9 per cent of the earth's land surface area in 1990. (10)

BOX 8.2

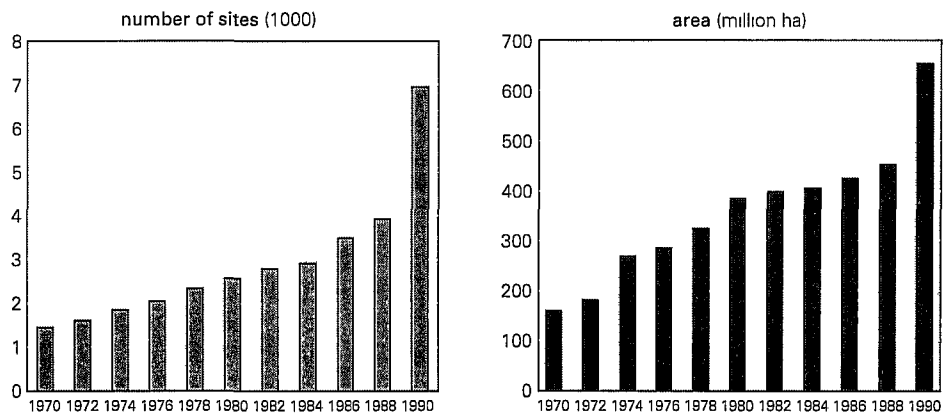
CITES

The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) was adopted in 1973; it entered into force on 1 July 1975. As of 31 December 1990, 109 countries had become Parties to the Convention.

The treaty is designed to conserve endangered species while allowing trade in wildlife which have population that can support it. CITES bans all commercial trade related to endangered species, which it lists in its Appendix I, and limits and monitors trade related to species at risk of becoming endangered, listed in Appendix II. Appendix III allows countries to prohibit trade in nationally protected species.

Enforcement of CITES is the responsibility of the member States, and Governments are required to submit reports and trade records to the CITES Secretariat. A CITES permit is the only legal permit recognized for international transit of a wild animal, plant or product.

Figure 8.2
GROWTH OF NATIONALLY PROTECTED AREAS



Source: Based on data from (10, 14).

8.14 In response to the threat of the loss of genetic diversity, the International Board for Plant Genetic Resources (IBPGR) was established in 1974 under the umbrella of the Consultative Group on International Agricultural Resources (CGIAR). IBPGR has played a catalytic role in developing effective national and international crop genetic resource conservation efforts. Focusing largely on major crops like wheat, rice and corn, IBPGR provided technical assistance and funding to establish national and international seedbanks and to collect a large fraction of the varieties of these crops. More recently, IBPGR has shifted its priorities to crops of regional or national importance and has emphasized training and the need to build up human capacities.

8.15 The World Conservation Strategy, launched by IUCN, UNEP and WWF in 1980, emphasized three global objectives of living resource conservation: (a) to maintain essential ecological processes and life-support systems; (b) to preserve genetic diversity; and (c) to ensure the sustainable utilization of species and ecosystems. The WCS has been used by more than 50 countries as a basis for the preparation of their national conservation strategies. The "Caring for the Earth" strategy recently launched by IUCN, UNEP and WWF in October 1991 reinforces the above-mentioned three global objectives of conservation and emphasizes the importance of social and economic requirements that must be met to achieve sustainable development. "Caring for the Earth" emphasizes that biodiversity must be conserved as a matter of principle, as a matter of survival and as a matter of economic benefit. (13)

8.16 Recognizing the growing severity of threats to biological diversity and the increasingly international nature of the actions required to address the threats, 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, are preparing a global strategy dealing with all aspects of biological diversity. The strategy, which will be launched in 1992, aims to: (a) establish a common perspective, foster international cooperation, and agree to priorities for action at the international level; (b) examine the major obstacles to progress and analyse 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.

8.17 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, which developed and developing countries can infuse a new spirit of cooperation into the conservation into biological diversity as a fundamental element of environmentally sound and sustainable development. UNEP, in cooperation with FAO, Unesco and IUCN, is assisting an Intergovernmental Negotiating Committee – established by UNEP's Governing Council – to elaborate an international convention on the conservation and rational use of biological diversity. This agreement will 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 – including biotechnology – for the conservation and utilization of biological diversity; (g) technical and financial cooperation 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 9

ENVIRONMENTAL HAZARDS

9.1 The human environment is becoming more and more hazardous. Natural disasters are more frequent and catastrophic industrial accidents are on the rise.

9.2 Although disasters are divided into those that are created by geophysical processes (natural disasters) and those caused by human error or failure of technology (accidents), it is now recognized that human activities also increase the occurrence and impacts of geophysical hazards. People can make land flood-prone by removing trees and other vegetation that absorb the water. They can also make land more drought-prone by removing the vegetation and soil systems which absorb and store water in ways that are beneficial to humans. People can also make themselves more exposed and vulnerable to disasters. In many areas in developing countries the poor live in slum or squatter settlements that are unable to withstand strong wind, rain or earth tremors. And again the poor are the ones who are more exposed to the effects of potential industrial accidents. More and more installations are built on the border of cities and people move and live next to such installations because of job opportunities or because it is cheaper to live there.

9.3 In the last three decades, the frequency and magnitude of natural disasters have increased dramatically. Records of major natural disasters (1, 2) indicate that there were 16 such events in the 1960s, 29 in the 1970s, and 68 in the 1980s. Although the number of disasters that hit the developed countries in the three decades 1960-1990 was 63, higher than those that hit the developing countries in the same period, (50) they caused fewer deaths (34,823 were killed in the developed countries as compared to 793,616 in the developing countries). In addition, drought which lasted for long periods of time caused the death of about 500,000 people, nearly all of them in developing countries, between 1974 and 1984. (1) This illustrates the magnitude of the vulnerability of developing countries to the effects of natural hazards, which generally sweep through the poorest areas. The overall economic losses due to natural hazards have also increased world-wide. In the 1960s, the overall losses were estimated at about US$10 billion, in the 1970s, US$30 billion, and in the 1980s, US$93 billion. Adjusted for inflation, the losses were an average of US$3.7 billion per year in the 1960s and US$11.4 billion per year in the 1980s. (2)

9.4 Because natural hazards are primarily the result of geophysical interactions between the atmosphere, hydrosphere and lithosphere, any changes in these interactions may lead to changes in the frequency and magnitude of these hazards. Concern was recently expressed about the possible effects of global warming (Chapter 3) on the magnitude of natural hazards. It is expected that the number and intensity of meteorological hazards will increase, because the atmospheric heat-engine will be running at a higher speed, with an increase in global temperature. Tropical storms will be more frequent and more intensive, and their path will extend

increasingly toward the poles. At the same time, there will be more water vapour in the atmosphere (resulting from increasing evaporation of surface waters), which will generally result in heavier rainfall, more serious floods and greater numbers of thunderstorms, hailstorms and tornadoes. For many coastal regions throughout the world the danger of storm surges will increase, especially in areas in which a rise in sea level and a greater risk of storms coincide.

Natural hazards

9.5 Except for the eruption of the volcano Nevada del Ruiz in Colombia on 13 November 1985, which alone caused the death toll from volcanic eruption is generally limited (28,666 between 1960 and 1990), and few recent volcanic activities have caused substantial death. Not all the death or damage is caused, however, as a result of the eruptive phase itself, but as a result of the secondary effects. Volcanic ash flows, for example, may move as fast as 100 kmh down the sides of a volcano and can be catastrophic if a populated area is in the path of the flow. When the loose ash becomes saturated with water from the rain it produces mud flows which are unstable and suddenly move downslope. Volcanic activity releases ash of various sizes and several gaseous products into the atmosphere. The most important of these are water vapour, hydrogen, hydrogen chloride, hydrogen sulphide, carbon monoxide, carbon dioxide, hydrogen fluoride, methane, ammonia, nitrogen and nitrogen oxides, argon and traces of mercury, arsenic and other metals. It has been estimated that volcanic activity contributes about 20 million tonnes of sulphur (S) into the atmosphere each year in the form of sulphur dioxide, hydrogen sulphide and sulphates. This is equivalent to about 5 to 7 per cent of the total global sulphur emissions into the atmosphere. (3, 4) The injection of large quantities of fine dust into the upper atmosphere from explosive volcanic eruptions could lead to climate change. (5, 5, 7, 8) The National Research Council (8) indicated that model studies predict that if one billion tonnes of ash were emitted into the stratosphere by a volcanic eruption, this would produce a world-wide drop in average temperature of about 10°C for several months. However, most of the ash emitted from the eruptions of El Fuego in Guatemala in 1984 (about 7,000 tonnes), Mount St. Helens, Washington in 1980 (about 100 million tonnes), or El Chichon in Mexico in 1982 (about 200 million tonnes) contained predominantly large ash particles; the submicron mass (which could stay in the atmosphere for longer periods of time) was relatively small. The recent eruption of Mount Pinatubo in the Philippines, however, could lead to a drop in the average global temperature (Box 9.1).

9.6 Earthquakes are the deadliest and most destructive of natural disasters. Between 1960 and 1990, earthquakes killed about 439,394 people world-wide and caused an overall economic loss estimated at US$65 billion. (1, 2) Although it has been estimated that there are about one million earthquakes every year, on average, only a couple of them are of sufficiently high magnitude to cause catastrophic damage. The primary effects of earthquakes are violent ground motion accompanied by fracturing, which may shear or collapse large buildings, bridges, dams, tunnels, and other rigid structures. Secondary effects include short-range events, such as fires, landslides, tsunami and floods, and long-range effects, such as regional subsidence and uplift of landmasses and regional changes in groundwater hydrology. Human activity has augmented the occurrence of earthquakes in three main ways. First, the earth's crust has been loaded with increasing numbers of large water reservoirs and this has caused minor local earthquakes (9, 10). Second, the disposal of

BOX 9.1

MOUNT PINATUBO AND CLIMATE

For 600 years Mount Pinatubo in the Philippines slept. On 2 April 1991 it exploded, shooting plumes of steam and ash as much as 23 km into the sky. In mid-May the volcano was emitting about 500 tonnes of sulphur dioxide daily; by 4 June this had dropped to 280 tonnes per day. Since the explosions on 15 and 16 June 1991, the eruption of Pinatubo has become the largest of the century.

The ash falling on the flanks of the volcano gave rise to "lahars" or mud flows. Being unstable, they swept everything in their way. The death toll was around 300, because people had fled their homes the first day the eruption started, but the damage to property has been very high.

Within 21 days of the first explotion, the earth was girdled by a wide belt of fine dust and sulphuric acid aerosols that now lies between 25N and 20S. The belt covers about 40 per cent of the earth's surface. The particulate matter in this belt is good at reflecting radiation from the sun, but inefficient at holding back reflected heat radiating from the surface of the earth. The net effect is cooling. According to mathematical models, the average global temperature could drop by 0.5°C for between two and four years.

Source: (11).

liquid waste in deep disposal wells has caused an increase in fluid pressures in rocks in certain regions, thereby facilitating movements along fractures. And third, the underground testing of nuclear devices constitutes a potential pressure exerted within the earth which could affect the stability of parts of the earth's crust. Earthquakes affect mostly poor people. Of the ten deadliest earthquakes that occurred between 1960 and 1990 (Box 9.2), 9 occurred in developing countries. Most of the people who were killed or injured lived in rural areas or slums. On the other hand, a number of recent earthquakes such as the 1985 Mexico City earthquake, the 1986 El Salvador earthquake and the 1988 earthquake in Soviet Armenia demonstrated that the collapse of reinforced concrete buildings is a significant problem that hinders rescue operations and may increase the death toll in urban areas.

9.7 Tropical storms (also known as cyclones, typhoons or hurricanes, according to geographical location) are rivalled only by earthquakes as the most devastating of all natural hazards. Between 1960 and 1990 they killed 350,299 people world-wide and caused estimated economic losses of about US$34 billion. (2) Again, most of the devastation was in developing countries. In Bangladesh alone, two major cyclones – one in 1970 and the other in 1985 – killed about 311,000 people, i.e. 89 per cent of those killed by cyclones in the world between 1960 and 1990. A recent cyclone hit Bangladesh on 29 April 1991, killing 132,000 people. The destructive power of a tropical storm can be shown in three principal effects – strong winds, flooding and storm surges. The latter were responsible for most of the deaths in the 1970 and 1991 disasters that hit Bangladesh. Altering the environment can make people and property more vulnerable to the effects of tropical storms. The destruction of coral reefs, mangrove and other sea-front forests, and the levelling of beach dunes clear paths which allow storm surges to reach people

and their property more quickly and forcefully.

9.8 Floods occur in many countries, developed and developing, and are nearly annual events. (12, 13) Although many floods cause no deaths, others normally cause an average death toll of a few hundred. Between 1960 and 1990, severe floods caused the death of about 6,592 people world-wide. (2) The estimated economic losses from floods vary widely from one country to another, but have been estimated at a conservative figure of US$50 billion between 1970 and 1990. In OECD countries the estimated monetary damage from floods in the period 1975-1990 was about US$9 billion. (12) Although hundreds of millions of people have been affected by floods, people continue to inhabit flood plains and are indeed occupying such areas with increasing intensity. They have altered their physical environment to suit their purposes and, in so doing, have frequently established conditions that generate more severe flooding.

9.9 Drought is the most complex and least understood of all natural hazards, affecting more people than any other hazard. The World Commission on Environment and Development (14) estimates that more than 40 million people in Africa alone were affected by drought during the 1980s, as compared to some 24 million affected by drought world-wide during the 1970s. Although droughts in the 1980s in Africa, China, South and southeast Asia, and South America demonstrated the vulnerability of developing countries to the ravages of drought, recent droughts in Australia, Canada and the United States have demonstrated the continuing vulnerability of all nations to this extreme climatic event. It is difficult to estimate the economic, social and environmental costs of droughts, which vary considerably from one country to another and depend, among other things, on the socio-economic conditions of the people affected and on the duration of the drought episodes. To illustrate the high cost incurred by droughts, it has been estimated that the

BOX 9.2

THE DEADLIEST TEN EARTHQUAKES
1960-1990

27 July 1976	China	242,000 killed
31 May 1970	Peru	67,000 "
7 December 1988	USSR	25,000 "
4 February 1976	Guatemala	22,778 "
16 September 1978	Iran	20,000 "
9 February 1960	Morocco	13,100 "
19 September 1985	Mexico	10,000 "
10 April 1972	Iran	5,400 "
23 December 1972	Nicaragua	5,000 "
24 November 1976	Turkey	3,626 "

Source: (1, 2).

1988 drought in the United States caused damage and losses of about US$40 billion. (15)

9.10 Drought results mainly from special fluctuations of atmospheric circulation. Recently, it has been suggested that the El Niño Southern Oscillation (ENSO) has been associated with drought episodes in various parts of the world (EL Niño is the temporary invasion of warm sea surface water into the eastern equatorial Pacific, accompanied by oscillation of mean pressure differences between the western and the eastern equatorial Pacific). The ENSO of 1982-1983 was the most intense in at least a century. It is claimed that it was responsible to a large degree for droughts that occurred in 1982-1983 in Australia, India, Indonesia, the United States and several African countries. (16) The Midwest United States drought in 1988 may have been linked to El Niño of 1987. (17) Human activities may enhance the incidence of drought or increase its duration. It has been speculated that the persistence of drought in western Africa is possibly due to a combination of atmospheric circulation fluctuations plus changes induced by human activities. (18) Overgrazing and deforestation (i.e. removal of vegetative cover) affect the surface albedo (radiation budget), surface roughness and moisture convergence and recycling mechanisms, thereby augmenting drought episodes.

9.11 Drought affects the environment in a number of ways. The most pervasive effect is on soil conditions. Long periods of drought cause severe desiccation and upset the biological reactions in soils, leading to their deterioration and the enhancement of desertification (Chapter 6). Desertification is attributed in part to droughts, overgrazing and firewood cutting. Substantial evidence indicates that drought promotes outbreaks of plant-eating fungi and insects, (19) and this exacerbates the already bad conditions.

9.12 The most dramatic effects of drought are on people. Pastoralists are often the first to feel the impact of a drought. In the Sahel repeated droughts drove hundreds of thousands of nomadic pastoralists southward after they had consumed the last shreds of dried-up vegetation. Many of these "environmental refugees" moved to coastal west African nations, where they took menial jobs and swelled shantytowns and slums. (20) Because of recurrent and long drought episodes, in early 1984 more than 150 million people in 24 western, eastern and southern African nations were on the brink of starvation. Ethiopia and Somalia are the most seriously affected countries in eastern Africa. Governments, trying to cope with the starving populations, established hundreds of transit and refugee camps which had to rely heavily on assistance from the international community. But in their exodus, many environmental refugees - women, children and the elderly - did not survive the journey. Starvation, dehydration and infectious diseases combined to accelerate the death of hundreds of thousands. Conservative estimates indicate that the death toll in Africa directly linked to droughts was about 500,000 between 1974 and 1984. (1)

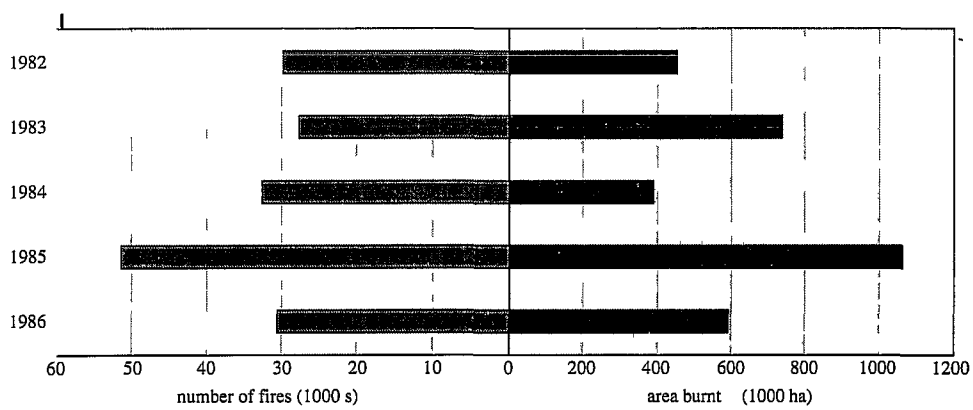
Human induced hazards

9.13 Forest fires – or wildland fires – are due to natural causes (e.g. lightning) or human action (negligence, accidents, and arson). In densely populated regions the latter causes are now very largely preponderant compared with natural causes. Fire is the main cause of forest destruction in the countries of the Mediterranean basin (Fig.9.1). About 50,000 fires sweep through 700,000 to, 1,000,000 hectares of Mediterranean forest each year, causing enormous economic and ecological damage as well as loss of human life. (21) The majority of these fires were set by people, although lightning was the cause of a fire that burnt more than 30,000 ha in Ayora-Enguera,

Spain, in 1979. The economic losses due to forest fires ranged between US$17 million in Portugal to US$111 million in Spain in 1985. Wildfires also burn uncounted millions of hectares of African savannah each year. In Asia, a single fire in Kalimantan, Indonesia, damaged more than 3.6 million ha in 1982. In North America, notwithstanding extensive, highly sophisticated prevention and control efforts, more than 2.3 million ha of forest land still burn each year. During 1988, nearly 75,000 fires burned more than 2 million ha of wildland in the United States. (22) Besides the economic losses incurred and, in some fires, losses of life as well, forest fires have a number of environmental impacts. The first effect is on soil. Such effects vary greatly and depend on the duration, extent and intensity of the fire, as well as soil characteristics. Burning increases nitrogen fixation in the soil. Also, available phosphorus levels are increased on sandy soils and basic cations are released which might have a significant impact on the effects of acid rain by neutralizing the acidic components in precipitation. (21, 23) Forest fires contribute a number of gaseous emissions to the atmosphere. In 1988, forest fires in the United States contributed about 1.7 million tonnes of particulate matter, 13.6 million tonnes of carbon monoxide and 0.7 million tonnes of methane to the atmosphere. (23) Although the direct impacts of such air pollutants may be restricted to local areas, they contribute to the global budget of such emissions.

9.14 Accidental releases of oil (and oil products) occur on land and in the sea. The latter are the ones that normally make headline news, although data show that oil spills on land are equally significant. For example, in 1989 about 239,000 tonnes of oil were accidentally spilled world-wide. Of these, 185,000 tonnes (or 77 per cent) were spilled because of tanker accidents at sea. In 1990, about 111,000 tonnes of oil were spilled, of which 46,000 tonnes (or 41 per cent) were spilled from tanker accidents at sea. (24) Accidental oil spills on land occur mainly from storage tanks and pipelines (Fig.9.2). Recent data show that the oil spilled from tanker accidents decreased from an average of 0.2 million tonnes per year in the early 1970s to about 0.11 million tonnes per year in the late 1980s. (25) This has been partly attributed to decreases in oil transportation by sea and partly to improvements in safety measures of tanker operations. In

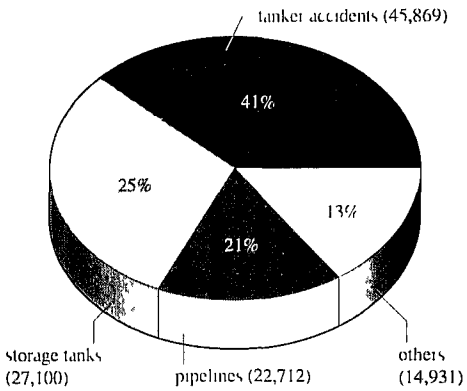
Figure 9 1
FOREST FIRES IN THE MEDITERRANEAN AREA



Source Based on data from (21)

1980, crude oil transported by sea amounted to 1,319.3 million tonnes; in 1989 the figure was 1,097.0 million tonnes, i.e. a decrease of about 20 per cent. (25)

Figure 9 2
OIL SPILLS FROM ACCIDENTS
(tonnes, 1990)

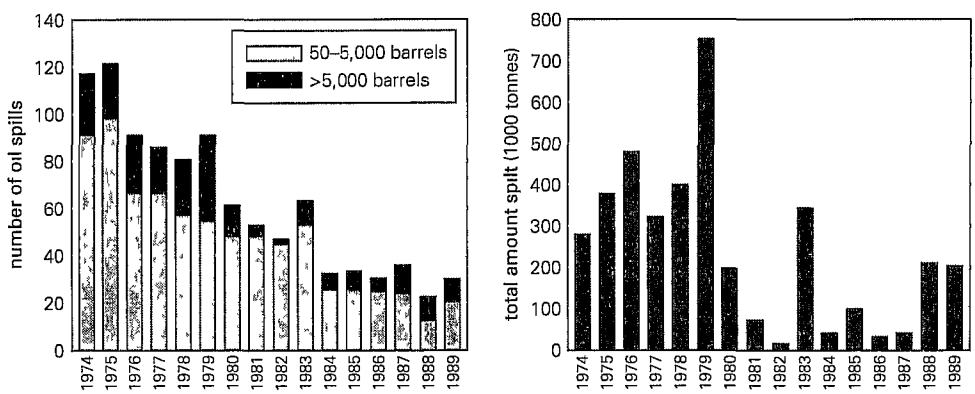


Source Based on data from (24)

9.15 In the period 1970 to 1990, more than 1,000 tanker accidents occurred. About 75 per cent of these accidents spilled between 50 and 5,000 barrels of oil each (i.e. between 6.9 and 694 tonnes); the rest spilled more than 5,000 barrels each (Fig. 9.3). The cumulative amount of oil spilled into the ocean between 1970 and 1990 from tanker accidents (71 accidents, each spilled more than 25,000 tonnes) was about 3 million tonnes. (12, 25) Ten major accidents accounted for about half of this amount (Box 9.3). Another source of oil spills in the sea is from accidents at offshore rigs. The Ekofisk blow-out (North Sea) on 22 April 1977, which caused a spill of about 15,000 to 21,000 tonnes, is one example; another example is the blowout of Ixtoc I in the Gulf of Mexico in 1979, which spilled about 475,000 tonnes of oil over a period of 290 days and is therefore the largest oil spill in the world in the past two decades.

9.16 The extent of the damage caused by oil spills depends on several factors which include, *inter alia*, the location of the spill (near shore or far out in the open ocean), the meteorological conditions prevailing at the spill site, and the composition of the oil. Although there is no evidence that oil spills from tanker accidents have caused damage to the open ocean and its living resources, it has become evident that spilled oil can affect coastal zones, where, under certain conditions, oil may persist for several decades.

Figure 9 3
INCIDENCE OF OIL SPILLS FROM TANKER ACCIDENTS



Source Based on data from (13, 27)

BOX 9.3

THE TEN LARGEST OIL SPILLS FROM TANKER ACCIDENTS 1970-1990

Date	*Tanker*	*Area Affected*	*Oil Spilled*
July 1979	*Atlantic Express*	*Tobago*	*276,000 tonnes*
August 1983	*Castello Belver*	*South Africa*	*256,000 "*
March 1978	*Amoco Cadiz*	*France*	*228,000 "*
December 1972	*Sea Star*	*Gulf of Oman*	*120,000 "*
February 1980	*Irenes Serenada*	*Greece*	*102,000 "*
May 1976	*Urquiola*	*Spain*	*101,000 "*
February 1977	*Hawaiian Patriot*	*Hawaii*	*99,000 "*
November 1979	*Independence*	*Turkey*	*95,000 "*
January 1975	*Jacob Maesk*	*Portugal*	*84,000 "*
December 1985	*Nova*	*Iran*	*71,000 "*

Source: (12, 24).

(26, 27) Marshes and mangroves are especially vulnerable to oiling. Wildlife is often the most conspicuous victim of oil spills. Many biological effects induced by hydrocarbons have been measured and some patterns are apparent: generally, young life stages are more sensitive than adult ones, and crustaceans are more sensitive than fish. Although studies of oil spills have shown that affected environments do recover with time, there is growing concern about the long-term effects of exposure of marine biota to low levels of hydrocarbons. Accidental oil spills can be quite costly. The principal costs involved include containment, clean-up and environmental restoration costs, damages to fisheries and losses suffered in tourism profits and labour earnings (Box 9.4 and Box 9.5).

9.17 Between 1970 and 1990, about 180 severe industrial accidents occurred worldwide, leading to the release of various chemical compounds into the environment (examples, Box 9.6). These accidents, caused mainly by fires, explosions or collision during transport, killed about 8,000 people, injured more than 20,000 and led to hundreds of evacuations involving hundreds of thousands of people (12). Data show a general increase in severe industrial accidents. Between 1974 and 1978, 5 major accidents occurred worldwide (each with at least 100 deaths, or 400 injured, or 35,000 people evacuated). Between 1984 and 1988, the figure was 16 accidents (28). As long as strict safeguards and standards are not implemented and as long as industrial installations are not located far from dense population centres, major accidents are likely to increase, particularly in developing countries. The massive explosion at the liquefied petroleum gas storage facility in the crowded San Juanico neighbourhood of Mexico City in November 1984 killed 452 people, injured 4,248 and displaced 31,000. The blast illustrated the precarious nature of a city where many of the 17 million inhabitants live cheek by jowl with a variety of potentially dangerous

BOX 9.4

AMOCO CADIZ

During the night of 16-17 March 1978, the supertanker Amoco Cadiz ran aground near the shore of Portsall, Brittany, France. Almost the entire cargo (228,000 tonnes) was lost in the sea within 14 days. Approximately 300 km of the shore were polluted to varying degrees. The oil released from Amoco Cadiz was converted to a reddish-brown water-in-oil emulsion (mousse) by tide and wave-induced mixing with water. Evaporation of the more volatile components is thought to have carried from 20 to 40 per cent of the spilled oil from the sea surface into the atmosphere.

The oil spilled caused the death of some 4,500 birds belonging to 33 species, but most were alcids and cormorants. A decrease in phytoplankton productivity was noticed for several weeks. There were minor effects on fisheries: the most affected were young sole, which grew at about 30 per cent of their normal rate.

The total cost of the Amoco Cadiz oil spill has been estimated at about US$380 million (1981 $): clean-up cost, 142 million; loss to commercial fisheries, 46 million; loss to tourism in the area, 192 million.

Source: (26, 29).

BOX 9.5

THE EXXON VALDEZ OIL SPILL

On 24 March 1989, the supertanker Exxon Valdez ran aground on Bligh Reef, Prince William Sound (Alaska). As a result, some 36,000 tonnes of oil were released into the water. Winds of more than 100 kmh on the third day after the grounding rendered containment of the oil on water nearly impossible, and within weeks about 2,000 km of shoreline in south-central Alaska - a pristine environment - had been impacted by oil to varying degrees.

In the spill-impacted area there were more than 10 million sea birds, more than 30,000 sea otters and 5,000 bald eagles. Between March and September 1989 some 36,000 birds, about 1,000 sea otters and 153 eagles were killed by the spilled oil.

Although the spill disrupted the herring and salmon harvests of commercial and subsistence fisheries that had consistently supported people in the area, no marked effects from the spill were detected on herring spawning activity and on pink salmon. Also, no effects were detected on intertidal plans, and the average hydrocarbon concentrations measured in the water column have consistently been below the State of Alaska standards and were 10-100 times lower than levels lethal to plants and animals living in the water column.

Field counts of plants, fish and mammals from throughout the spill area have shown that wildlife species are surviving and reproducing, thus confirming that biological recovery is rapidly taking place.

The clean-up programme of the oil spill cost about US$2 billion.

Source: (30, 31).

installations. Another example is illustrated by the Bhopal accident - most of the victims lived in squatter settlements near the plant where the accident occurred (Box 9.6).

9.18 A number of administrative and technical steps were recently taken to prevent such accidents and mitigate their consequences. One example is the European

BOX 9.6

CHEMICAL ACCIDENTS THAT MADE HEADLINE NEWS (1970-1990)

SEVESO

On 10 July 1976 an explosion at the ICMESA chemical factory in the north Italian town of Seveso released a cloud of chemicals into the atmosphere contaminating the surrounding area.

The chemicals contained 2 kg of dioxin, a potentially toxic compound. The cause of the accident is believed to be a "runaway reaction" in the reactor producing sodium trichlorophenate, a main product.

There were no deaths, but 200 people suffered slight injuries. The main victims were domestic animals. Contamination of the land affected some 37,000 people. Restrictions were imposed for 6 years on an area of 1,800 ha. The worst-affected area covered 110 ha. The estimated direct costs of the accident are about US$250 million.

Source: (28, 32, 33, 34).

BHOPAL

On the night of 2-3 December 1984 a sudden release of about 30 tonnes of methyl isocyanate (MIC) occurred at the Union Carbide pesticide plant at Bhopal, India. The accident was a result of poor safety management practices, poor early warning systems, and the lack of community preparedness.

The accident led to the death of over 2,800 people living in the vicinity and caused respiratory damage and eye-damage to over 20,000 others. At least 200,000 people fled Bhopal during the week after the accident.

Estimates of the damage vary widely between US$350 million to as high as US$3 billion.

Source: (28, 35, 36, 37).

BASEL

On 1 November 1986 a fire broke out at a Sandoz storehouse near Basel, Switzerland. The storehouse contained about 1,300 tonnes of at least 90 different chemicals. The majority of these chemicals were destroyed in the fire, but large quantities were introduced into the atmosphere, into the Rhine River through runoff of fire-fighting water (about 10,000 to 15,000 cubic metres) and into the soil and groundwater at the site. The exact mass of the chemicals that entered the Rhine has been estimated at 13 to 30 tonnes.

Following the accident the biota in the Rhine was heavily damaged for several hundred kilometres. Most strongly affected were the benthic organisms and the eels, which were completely eradicated for a distance of about 400 km (an estimated 220 tonnes of eels were killed). Several compounds were detected in the sediments of the Rhine after the accident.

Within a few months the Rhine River has purged itself of all the chemicals released from the accident (with the possible exception of mercury and endosulfan). One year after the accident, most aquatic life had returned to the situation that existed before the accident. However, the groundwaters in the extensive Rhine alluvial aquifer are still polluted.

The damage caused by the Basel accident has been estimated at US$50 million.

Source: (28, 38).

Economic Community's directive on the major hazards of certain industrial activities (the "Seveso" directive). The directive obliges manufacturers within the Community to identify potential danger areas in the manufacturing process and to take all necessary measures to prevent major accidents as well as to limit their consequences, should they occur, for man and the environment. In 1988, UNEP launched the Awareness and Preparedness for Emergencies at Local Level (APELL) programme to alert communities to industrial hazards and to help them to develop emergency response plans, through the dissemination of information, training, exchange of information and assistance in case of an emergency. ILO recently issued a code of practice to provide guidance in the setting up of an administrative, legal and technical system for the control of major hazard installations. (39) The Basel accident (Box 9.6) has made it clear that industrial accidents can have harmful transboundary impacts. 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.

9.19 As of 31 December 1990, there were 423 nuclear reactors operating in 24 countries world-wide – 112 of these reactors are in the United States. (40) "Routine" accidents – referred to as "unusual events" – frequently occur during the operation of these reactors. These unusual events are classified by the International Atomic Energy Agency (IAEA) into events unrelated to safety (with an average frequency of 0.5 to 1 event/week/reactor), safety-related events (0.5 to 1 event/month/reactor), and events of safety significance (0.5 to 1 event/year/reactor). (41) Although the IAEA established an Incident Reporting System (IAEA-IRS) in the early 1980s, reporting of such events to IRS has been rather uneven and incomplete. The adoption in 1986 of the Convention on Early Notification of a Nuclear Accident should improve the situation (the Convention entered into force on 27 October 1986; and as of 31 December 1990, 49 countries had signed the Convention).

9.20 Several of these unusual events led to a reactor shutdown. In the United States, for example, 16 events led to reactor shutdown in two months – May and June 1976. (42) Forty-four events led to reactor shutdown between August and December 1982, (43, 44) and from May 1984 to September 1984, there were 195 such events in the United States. (45) In general, these and similar shutdowns did not result in release of radioactivity into the environment (although a few did result in contamination of some workers and/or restricted areas around the plants). Human error accounts for the bulk of these unusual events. (46)

9.21 A real catastrophic reactor accident would include a complete loss of cooling, melting of the nuclear core, breaching of the reactor pressure vessel or piping, failure of the primary containment and release of significant quantities of radioactive materials. Several studies have been made to establish the probabilities of reactor accidents of various degrees of severity. The much-publicized Reactor Safety Study (also known as the Rasmussen or WASH-1400 report), published in 1975, (47) estimated that the probability of a meltdown in a pressurized water reactor was 1 in 20,000 per reactor per year, and that most meltdowns would not breach the main containment above the reactor. WASH-1400 estimated that the worst accident might happen once per 10 million years of reactor operation (one reactor operating for one year is one year of operation, if there are 423 reactors world-wide, this would mean 423 years of operation, and so on) and might cause 3,300 early fatalities, about 10 times that number of early illnesses, additional genetic effects and long-term cancers, and perhaps some US$14 billion in property damage. (47) The WASH-1400 estimations have been widely criticized and it has been indicated that there is a large range

BOX 9.7

A FIRE AT BROWNS FERRY

On 22 March 1975, the Browns Ferry power plant (2 units producing 1100 MW of electrical power at that time), Alabama, United States, was subjected to a fire that lasted 7 hours. The fire was initiated by a small lighted candle that was being used to check for air leakage of the reactor containment building. The flame ignited some polyurethane used to seal leakage paths.

The damage inflicted by the fire resulted in the loss of the emergency core-cooling system. But alternatives were available and adequate cooling was provided throughout the event and the reactors were shut down. No one on site was seriously injured. No radioactivity above normal operating amounts was released and there were no adverse effects on public health and safety.

The direct cost of the accident was estimated at US$10 million. As a result of the shutdown of the two units at Browns Ferry, additional costs of about US$10 million were incurred each month for replacement power. In other words, the total cost of the accident was about US$150 million.

Source: (51).

of uncertainty in the numerical results quantifying the risks of an accident with extensive consequences. (48, 49, 50)

9.22 The occurrence, in 1975, of the fire at Browns Ferry nuclear power plant (Box 9.7) as a result of a human error, fuelled the debate on the safety of nuclear installations and validity of studies such as WASH-1400. Four years later, the Three Mile Island accident occurred (Box 9.8), after just 1,500 years of world-wide reactor operation. Although not a light-water reactor, the Chernobyl disaster in 1986 (Box 9.9) followed after another 1,900 reactor years. If this "historical" accident rate were to continue, three additional accidents would occur by the year 2000, at which point - with over 500 reactors in operation world-wide - core damaging accidents would happen every four years. (62) But no one knows how often nuclear disasters will happen, and no one knows the extent of the damage that might occur to people and to the environment.

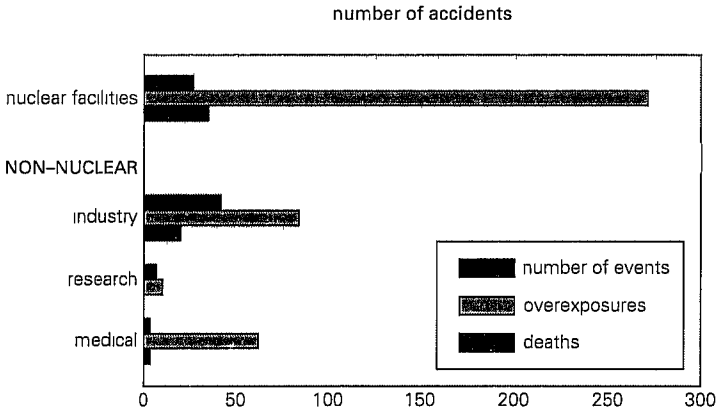
9.23 Although accidents at nuclear facilities have been responsible for the majority of deaths and radiation overexposure (Fig. 9.4), accidents related to the use of radio-isotopes in industry, research and medical facilities account for a significant number of casualties from radiation accidents. The number of such accidents has recently increased. For example, there were 8 fatal accidents between 1970 and 1987 - i.e. in 17 years - as compared to 9 such accidents between 1945 and 1970 - i.e. in 25 years. The radiation accident at Goiania, Brazil, in 1987 (Box 9.10) has demonstrated that public awareness of the potential danger of radiation sources is an important factor in reducing the likelihood of radiological accidents and in reducing the consequences of such accidents if they occur.

Public perception of environmental hazards

9.24 People respond to the hazards they perceive. Their perception is condi-tioned by cultural, traditional, socio-eco-nomic and political factors. A common feature in both devel-oped and developing countries is that public concern becomes highly stimulated when a significant hazardous environmental

incident occurs. For example, public concern about the hazards of chemicals and nuclear power peaked following the accidents at Seveso (1976), Bhopal (1984), Basel (1986), Three Mile Island (1979) and Chernobyl (1986). This is natural, because the public perception of a hazard is heavily weighted by its severity and very little by its frequency.

Figure 9.4
SERIOUS RADIATION ACCIDENTS REPORTED (1945-1987)



Source: Based on data from (67)

9.25 The mass media play a major role in affecting and shaping public perception. Because news is (almost by definition) about the unusual, the media generally emphasize hazards that are relatively serious and/or relatively rare. Catastrophic events are reported much more frequently than less dramatic causes of death and

BOX 9.8

THE THREE MILE ISLAND ACCIDENT

Early on the morning of 28 March 1979, the 880 MWe Three Mile Island Unit 2 (TMI-2) pressurized water reactor (PWR), which was operating at nearly full power, experienced a loss of normal feedwater supply that led to a turbine trip and later to reactor trip. Subsequently, a series of events took place that resulted in bad reactor core damage. Core temperatures locally reached fuel melt. The accident occurred because of a combination of design, training, regulatory and mechanical failures and human error.

From 28 March through 7 April 1979 radioactive fission products were released into the environment. The release consisted mainly of noble gases (Xenon-133, Xenon-135) and traces of Iodine-131. Approximately 8 per cent of the core inventory of Xe-133 was released. Another major release of noble gase radionuclides was during the controlled purge of the reactor building about 15 months after the accident. Approximately 46 per cent of the Krypton-85 inventory was discharged into the atmosphere.

No one was killed as a result of the TMI accident and there were no noticeable public health effects from the radiation released. The accident led to the evacuation of some 220,000 people from around the site for varying periods of time. Some stress and psychological disorders were reported among the population.

The total cost of the TMI accident has been a minimum of US$2 billion.

Source: (50, 52).

BOX 9.9

THE CHERNOBYL DISASTER

The Chernobyl nuclear power station near Pripyat, 130 km north of Kiev, USSR, consisted of four units of water-cooler graphite-moderated reactors, each with 1000 MW generating capacity. On 26 April 1986 at 01.23 hours an explosion occurred at Unit No. 4. The accident resulted in fuel fragmentation, steam and hydrogen explosions; the temperature of the burning reactor rose to several thousand degrees C, resulting in the meltdown of the core and the release of radioactivity from the destroyed fuel elements during a period of 10 days. The accident began while operators were testing a turbine during a scheduled shutdown of the unit. Safety procedures were not, however, followed. Most of the neutron-absorbing control rods had been withdrawn and a chain reaction - as in a nuclear bomb - was narrowly avoided.

The accident led to a great atmospheric release of radionuclides. About 30 radionuclides were released with a total activity of about 2900 PBq (peta-bacquerel). This constituted about 8 per cent of the total inventory of radionuclides at the time of the accident. Among the releases were the biomedically significant nuclides Strontium-90, Iodine-131 and Caesium-137.

The radioactive material emitted from Chernobyl travelled long distances and reached locations thousands of kilometres from its source. It crossed the border into Poland, southern Finland and across Norway and Sweden. The extent of contamination was largely governed by whether rain washed the radioactive material from the clouds. Hot spots appeared in, among other places, southern Germany, Greece, across the Soviet republics, and in Scandinavia and the United Kingdom.

Initial concern focused on Iodine-131, which was taken up by grazing cows and expressed in their milk. Leafy vegetables and fruit grown outside were also contaminated and had to be thrown away. But Iodine-131 has a half-life of only 8 days and attention soon switched to the potential hazard of Caesium-134 and 137. Caesium-137 has a half-life of more than 30 years. Caesium contaminated meat. Special measures were introduced in Scandinavia and the United Kingdom to restrict the movement and slaughter of livestock.

Although the initial death toll of the accident was 31, the Government of the USSR announced that four years after the accident the toll had risen to between 250 and 300. Medical data show that during 1986-1990, in the zone of strict control around Chernobyl, there was a 50-per cent increase in the mean frequency of thyroid disorders, malignancy and neoplasms (leukemia increased by 50 per cent), as well as a serious increase in the number of miscarriages, still born babies, and children born with genetic malformations.

There were several attempts to assess the health effects of the Chernobyl accident outside the USSR. No accute effects have occurred outside the Soviet Union, and projections of excess cancer risk for the northern hemisphere range from zero per cent to 0.02 per cent.

The direct and indirect economic costs of the Chernobyl accident are very high. They have been estimated at a minimum of US$15 billion, 90 per cent of which would be in the USSR.

Source: (53-61).

BOX 9.10

THE RADIOLOGICAL ACCIDENT AT GOIANIA, BRAZIL

On 13 September 1987 a shielded, strongly radioactive source of Caesium-137 for medical use was stolen from its housing in a teletherapy machine at an abandoned clinic in Goiania, State of Goias, Brazil. The two people who took the assembly tried to dismantle it and in their attempt the source capsule was ruptured. The remnants of the assembly were sold for scrap to a junkyard owner. He noticed that the source material glowed blue in the dark. Several persons were fascinated by this and over a period of days friends and relatives came and saw the phenomenon. Fragments of the source the size of rice grains were distributed to several families. A few days later, a number of people showed gastrointestinal symptoms arising from their exposure to radiation from the source.

On 28 September a physician in Goiania recognized the characteristic symptoms of radiation overexposure. Soon an emergency response centre was set up and more than 112,000 people were screened for possible contamination: 249 people were found to be contaminated. Twenty persons were hospitalized; four of them died.

A survey of 67 square kilometres of the area of Goiania showed that 8 locations were contaminated. In total, 85 houses were found to have significant contamination and 200 individuals were evacuated from 41 of them. Decontamination of the affected sites continued until the end of December 1987. As a result, some 3,500 cubic metres of radioactive waste had to be stored in a temporary site 20 km from Goiania.

Source: (67).

damage with similar (or even greater) statistical frequencies. Events like those mentioned above received extensive coverage by the press, radio and television, partly because they have inherent public appeal. For example, the Bhopal accident was ranked as the second biggest news item in 1984 by the Associated Press editors, and the Ethiopian drought ranked third. (63) This natural predisposition towards the dramatic ensures that the information provided by the media about risks is frequently inadequate. An analysis of 952 print and broadcast news stories in the United States media about the Bhopal disaster in the two months immediately following the accident revealed that both print and broadcast reports were event-centred and included little or no discussion of underlying social, cultural and economic forces that had accounted for the chemical plant's construction in India and had been the main reason for the serious negative impacts of the accident. Instead, news reports focused on the disaster itself, the immediate aftermath, and what was being done to clean up the mess. (64) Television news coverage of the Bhopal disaster was the most event-centred. Television did not construe Bhopal in a larger framework of technological hazard, and there was little discussion of the various long-term health, environmental, social or legal issues the tragedy raised. Only after the main immediate news events surrounding the accident subsided did the media pay more attention to such factors. (65) The media coverage of the Three Mile Island and Chernobyl accidents has also been found inadequate. (66) On the

other hand, news coverage of the environmental disaster can trigger regional or international action. The coverage of famine and drought in Africa in 1984 brought the crisis to mass public attention and stimulated public concern and pressure to bring about long-delayed international aid.

9.26 The public perception of environmental hazards is of great importance. If people's perceptions are faulty, efforts for public and environmental protection are likely to be unsuccessful. For example, in many cases a population devastated by a natural disaster refuses to leave the homesite. And, when forcibly relocated, people return as soon as conditions permit. (68) Although this has been described as irrational human behaviour, it illustrates how deep-rooted perceptions are difficult to change. The complexity of public perceptions is best illustrated by the case of Bangladesh. It is easier to agree on an aid package to build embankments that may hold back the flood waters, than to understand and solve the question of why it is that so many millions of Bangladeshis continue to live out on the islands of that country's coastal delta, permanently on the brink of disaster. (69)

9.27 The International Decade for Natural Disaster Reduction (IDNDR), launched by the General Assembly of the United Nations on 1 January 1990, aims at instituting an integrated approach to disasters, by stimulating data acquisition for their application in more widespread forecasting and warning systems, by making improvements in disaster preparedness and by changing the sometimes fatalistic attitudes to disasters. Increased community participation and more and better education and training will be very important components of the Decade. Achievement of these aims will cause a change in the basic approach to disasters, from the present concentration on post-disaster relief to a future emphasis on pre-disaster preparedness.

Chapter 10

TOXIC CHEMICALS AND HAZARDOUS WASTES

10.1 World-wide, about 10 million chemical compounds have been synthesized in laboratories since the beginning of the present century. Approximately one per cent of these – 100,000 organic and inorganic chemicals – are produced commercially (the European Inventory of Existing Commercial Chemical Substances – EINECS – lists 110,000 chemicals) and 1,000 to 2,000 new ones appear each year. Some of these chemicals are used directly (e.g. some pesticides and fertilizers), but most chemicals are "base" or "intermediate" chemicals used for the manufacture of millions of end products for human use. There is virtually no sector of human activity which does not make use of chemical products, and many products have indeed brought beneficial effects to man and his environment.

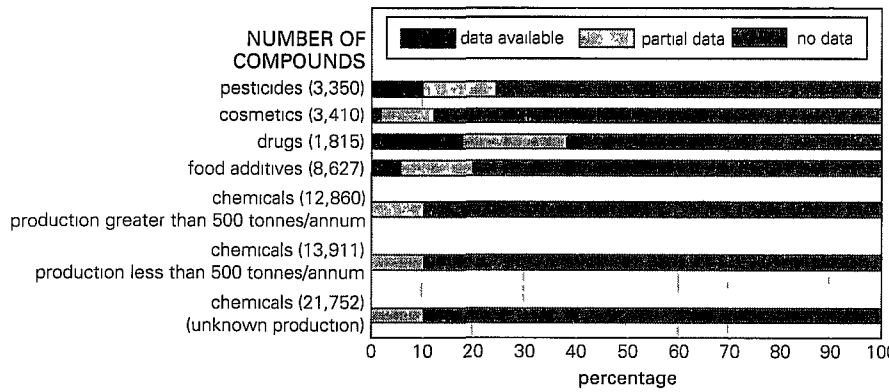
10.2 In recent years, however, there has been growing concern world-wide about the harmful effects of chemicals on human health and the environment. The deleterious effects of pesticides, vinyl chloride and polychlorinated biphenyls (PCBs) have been well-documented since the late 1960s. Over the past two decades many other compounds captured public attention (e.g. dioxin, methyl isocyanate (MIC), lead, mercury and other heavy metals and chlorofluorocarbons, etc).

Toxic chemicals

10.3 All chemicals are toxic to some degree. The health risk from a particular chemical is primarily a function of toxicity and exposure. Only a few parts per billion of a potentially toxic compound like dioxin, for instance, may be sufficient to cause a health hazard following brief exposure. In contrast, only high doses of other compounds like iron oxide or magnesium carbonate pose problems after extended exposure. An important development in the past two decades has been a shift from a focus on just the acute health effects of chemicals to a focus on chronic effects as well. These chronic effects, which include birth defects and genetic and neurological disorders in addition to cancer, are of particular concern to the public, and this makes regulatory decisions both more visible and more difficult (Chapter 18).

10.4 The problem is further compounded by the fact that most chemicals have not been adequately tested to determine their toxicity. A study by the United States National Research Council (1) found that sufficient information exists to allow a complete health hazard assessment of less than 2 per cent of the chemicals produced commercially; for only 14 per cent is there sufficient information to support even a partial hazard assessment (Fig. 10.1). Recently, OECD announced plans to investigate almost 1,500 chemicals (which are each produced in quantities exceeding 1,000 tonnes per year) on whose toxicity there is little or no information. Virtually nothing is known about the impact of these substances on the environment, even though they account for 95 per cent of all chemicals

Figure 10.1
PERCENTAGE OF CHEMICALS WITH TOXICITY DATA



Based on data from (1)

used globally. The first examination will be of 147 compounds about which there is no toxicological information; 70 of these compounds are each produced in quantities exceeding 10,000 tonnes annually. (2) Information has been gathered on the properties of various toxic chemicals and efforts are under way to assess their toxicity and hazardous effects (Boxes 10.1 and 10.2).

10.5 Toxic chemicals are released into the environment directly as a result of human application (e.g. the use of pesticides, fertilizers and different solvents), and indirectly in waste streams of various human activities, such as mining, industrial processes, incineration, fuel combustion and other activities (for accidental releases, see Chapter 9). The chemicals may be released in solid, liquid or gaseous forms and release may be to air, water and land. The distribution and fate of chemicals in the environment is a highly complex process, governed by the physico-chemical properties of the chemicals and of the environment itself. Many chemicals do not remain confined to the vicinity of their

Box 10.1

IRPTC

Adequate information to assess the potential hazards posed by chemicals to human health and to the environment is a prerequisite to their safe use and disposal. In 1976 UNEP established the International Register of Potentially Toxic Chemicals (IRPTC) which collects and disseminates information on hazardous chemicals, including national laws and regulations controlling their use. IRPTC operates through a network of national and international organizations, industries and external contractors, and national correspondents for information exchange which have now been appointed in 112 countries. IRPTC's computerized central data files contain data profiles for over 800 chemicals. In addition, special files are available on waste management and disposal, on chemicals currently being tested for toxic effects and on national regulations covering over 8,000 substances.

Box 10.2

IPCS

In 1980, WHO, UNEP and ILO set up the International Programme on Chemical Safety (IPCS) to assess the risks that specific chemicals pose to human health and the environment.

IPCS publishes its evaluations in four forms: as detailed "Environmental Health Criteria" for scientific experts; as short, non-technical "Health and Safety Guides" for administrators, managers and decision makers; as international "Chemical Safety Cards" for ready reference in the workplace; and as "Poisons Information Monographs" for medical use.

sources of release and are transported locally, regionally or globally to cause widespread contamination of the environment. The use of pesticides in California, for example, led to contamination of fog in the area; 16 pesticides and their alteration products have recently been found in fog in areas far from where the pesticides were used. (3) Polychlorinated biphenyls (PCBs) have been transported by the atmosphere from sources of release in industrial countries to as far as the Arctic. Primarily as a result of consumption of contaminated fish and aquatic mammals, Arctic inhabitants are experiencing near-toxic levels of PCB exposure. (4) Other examples of such transboundary distribution of toxic chemicals include DDT, mercury, lead and other metals and hexachlorocyclohexane. (5) Concern over such growing "global chemical pollution" has recently been demonstrated by the effects of chlorofluorocarbons and other chemicals on the ozone layer (Chapter 2) and of greenhouse gases on climate (Chapter 3).

Responses

10.6 A number of industrialized countries have enacted legislation in attempts to "control" industrial chemicals prior to marketing, in order to protect human health and the environment by ensuring proper handling and use. However, the task has been complex and slow because the tools necessary to evaluate the effects of chemicals, especially long-term toxicity and ecotoxicity, are not sufficiently developed. Assessment of risk to human populations based on data from laboratory animals remains a controversial issue and many uncertainties remain regarding the methods used to determine the potential threat to the environment from chemicals. These difficulties have led to maximum levels of exposure being set for some chemicals, to the banning or restricted use of certain substances as being too dangerous for marketing and consumption, and to the search for substitutes for certain chemicals that would be less harmful to the environment.

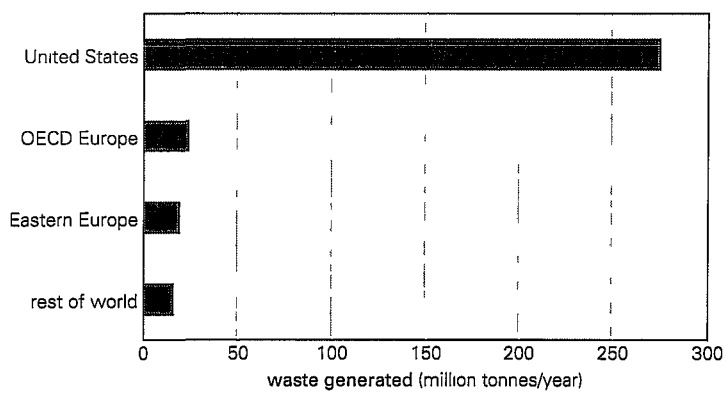
10.7 Unlike developed countries, most developing countries have no toxic chemical control laws, nor the technical or institutional capability for implementing such laws. During recent years, several cases have come to light where products banned or severely restricted in the industrialized countries have been sold to, or "dumped" on, the developing countries. In 1989, UNEP's Governing Council adopted the Amended London

Guidelines for the Exchange of Information on Chemicals in International Trade, which included a procedure for prior informed consent (PIC). By 1990, 75 countries had nominated national authorities to act as channels for PIC. As a start, PIC has been applied to chemicals banned or severely restricted by ten or more countries; next it will be applied to those banned or severely restricted by five or more. IRPTC notifies participating countries of these bans and offers guidance and training on possible action. Countries then decide whether they wish to ban or allow future imports of the chemicals concerned and IRPTC channels this information back to exporting countries. It is then up to participating countries to enforce these decisions. Other international legal instruments on the management of chemicals include the FAO International Code of Conduct on the Distribution and Use of Pesticides (amended, 1989), the ILO Convention Concerning Safety in the Use of Chemicals at Work (1990), the OECD recommendations on information exchange related to export of banned or severely restricted chemicals and guiding principles (1984/1985), and the EEC regulation concerning export from and import into the Community of certain dangerous chemicals (1988).

Hazardous wastes

10.8 Wastes are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law. Certain wastes produced by human activities have been described as "hazardous". Although the term has a different connotation in different countries, wastes having metallic compounds, halogenated organic solvents, organohalogen compounds, acids, asbestos, organo-phosphorus compounds, organic cyanides, phenols, or ethers as constituents are considered hazardous (see annexes to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal for a list of wastes considered hazardous). Most hazardous wastes are produced by industry, but it is now recognized that hundreds of thousands of small-quantity generators of hazardous wastes exist (each generating up to 1,000 kg of waste per month). These include households, medical facilities (wastes referred to as biomedical wastes), garages and auto-repair workshops, petrol stations, and small-scale industries and businesses. In the United States 115,000 such small-scale hazardous waste generators are now being regulated under the Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendments (HSWA). (6)

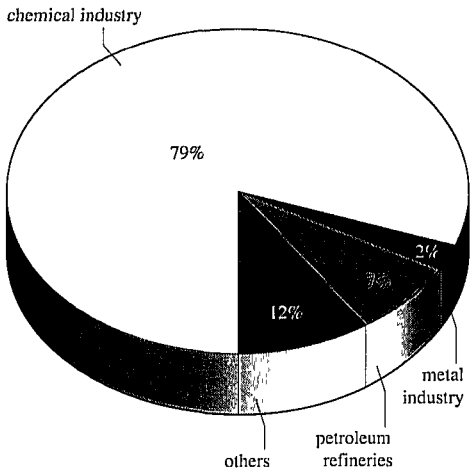
Figure 10.2
HAZARDOUS WASTES GENERATED
million tonnes/year (late 1980s)



Based on data from (7)

10.9 It has been estimated that world-wide about 338 million tonnes

Figure 10.3
HAZARDOUS WASTES GENERATED IN THE UNITED STATES BY TYPE (AS PERCENTAGES)

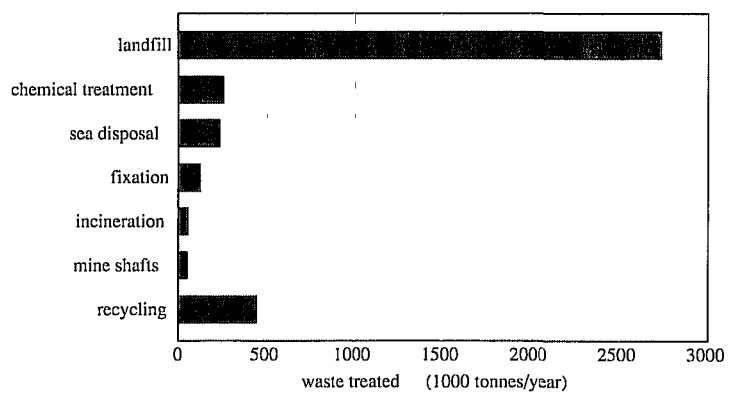


Based on data from (6).

of hazardous wastes are produced annually (Fig. 10.2), of which 275 million tonnes (or 81 per cent) are produced in the United States alone. (7) For comparison, hazardous waste generation in Singapore amounts to 28,000 tonnes per year, in Malaysia 417,000 tonnes per year and in Thailand 22,000 tonnes per year. (8) It should be noted that these figures represent conservative estimates since many countries have no records of the amounts of wastes generated. This is particularly true for the small-scale waste generators. The variation in the composition of the wastes adds to the problem (some constituents considered hazardous in some countries may not be considered so in others). In general, the bulk of the hazardous wastes consists of chemicals (Fig. 10.3). In OECD Europe the main wastes include solvents, waste paint, heavy metals, acids and oily wastes.

10.10 The traditional low-cost methods of hazardous waste disposal are landfill, storage in surface impoundments, and deep-well injection (Fig. 10.4). Thousands of landfill sites and surface impoundments used for dumping hazardous wastes have been found to be entirely unsatisfactory. Corrosive acids, persistent organics and toxic metals accumulated in these sites for decades. For example, the largest site identified in the United States is the Clark Fork Mining Complex in western Montana, where ponds of wastes from copper and silver mining and smelting activities have accumulated for 125 years. It is considered the largest hazardous waste dump in the world. (9) At the time of establishment of such sites little thought was given to their environmental impacts. When leaks happened and threatened public health and contaminated groundwater and soil, policy makers took remedial actions, under

Figure 10.4
MANAGEMENT OF CHEMICAL WASTES IN THE UNITED KINGDOM (1985)



Based on data from (11).

Box 10.3

LOVE CANAL

From 1942 to 1953 a chemical company disposed of some 21,800 tonnes of chemical wastes in a trench - the remnants of an old canal (the Love Canal) - in the city of Niagara Falls, New York.

Shortly after the company closed its landfill in 1953, a school and several buildings were constructed on and near the site. Heavy rains in the winter of 1975 and spring of 1976 caused land subsidence and created ponds of surface water that were heavily contaminated with chemicals from the dump. The contaminated waters infiltrated into the nearby residences and caused public concern and complaints about the possible health hazards.

In August 1978 an emergency programme was undertaken to relocate residents of 238 houses in the area. About $100 million has been spent on site remediation, resident relocation and investigations at Love Canal.

Source: (10, 12).

growing public concern and pressure (Box 10.3). By 1990, the United States Environment Protection Agency had identified 32,000 sites in its inventory of potentially hazardous sites; about 1,200 of these need immediate remedial action. (10) In Europe, 4,000 unsatisfactory sites have been identified in the Netherlands, 3,200 sites in Denmark, and some 50,000 sites in western Germany. (7) Although some industrialized countries have initiated steps to clean up the "problem sites", the cost of remedial action has been found to be very high. Estimates indicate that about $30 billion are needed for remedial operations in western Germany, $6 billion for the Netherlands, and about $100 billion for the United States. (7) This illustrates how the costs of long years of neglect can be so high.

10.11 Other unsatisfactory dumping of hazardous wastes has exposed people directly to hazardous chemicals. Perhaps the most notorious incident of all was the outbreak of Minamata disease in Japan in the 1950s and 1960s. Discharges from a chemical factory into the sea led to the contamination of fish by mercury. When the fish was eaten by local people at the town of Minamata on Kyushu Island, Japan, thousands suffered neurological disorders. As a result of this and a similar incident at Niigata on the east coast of Honshu about four hundred people died. Although dumping of waste at sea is controlled under international and regional conventions, several countries are still using this route for the disposal of hazardous wastes. About 10-15 per cent of hazardous wastes produced in Europe are dumped at sea. (7)

10.12 At the beginning of the 1980s the problem of transfrontier movements of hazardous wastes was brought into focus in Europe and in North America (especially after the well-publicized incident of the mysterious disappearance of a consignment of drums of dioxin-contaminated mud in transit between Italy and France). The reasons for such transfrontier movements of waste are that legal disposal in a foreign country is less expensive than at home and there is no disposal capacity for these wastes in the country of origin. On average, a consignment of hazardous wastes crosses an OECD

European frontier every five minutes, i.e. there are more than 100,000 such movements in OECD European countries each year. All in all, between 2.0 to 2.5 million tonnes of hazardous wastes crossed OECD European frontiers in 1988. (13) The North American figures available indicate about 230,000 tonnes of hazardous wastes exported and about 9,000 crossings in the same year. (7) Legal movements of hazardous wastes have also taken place between OECD and non-OECD countries. About 200,000 to 300,000 tonnes of hazardous wastes have been transported annually from EC countries to East European countries. North America and European countries have also exported wastes to developing countries. Europe sends about 120,000 tonnes of hazardous wastes to the Third World each year. (2)

10.13 In 1985 the OECD adopted a number of principles to control the transfrontier movements of hazardous wastes. These principles have been embodied in EEC law and were endorsed by the OECD in 1988, establishing a core list of hazardous wastes and other wastes that should be controlled in transfrontier movements. With the tightening of the controls over the movements of hazardous wastes and their disposal in industrialized countries, illegal dumping and traffic of wastes increased. A matter of particular concern has been the illegal or "shady deals" which came to light in the late 1980s, involving the dumping of hazardous wastes in the developing countries. Africa, Latin America and the Caribbean have been improperly used as disposal sites for a wide array of wastes from the industrialized world. Illegal traffic and dumping of hazardous wastes have also been reported in Asia and the South Pacific (14) and even in Europe.

Responses

10.14 The growing international concern over the transfrontier movements and dumping of hazardous wastes, especially in the developing countries, led to the adoption of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, in 1989 (Box 10.4). The realization that old, uncontrolled landfills containing hazardous

BOX 10.4

THE BASEL CONVENTION

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal was adopted by 116 governments and the European Community on 22 March 1989. The ultimate aim of the Basel Convention is to reduce generation of hazardous wastes to a minimum. The current targets of the Convention are to control strictly the transboundary movement of hazardous wastes that are permitted to move. It further strictly controls the disposal of such wastes.

The Basel Convention outlined the general obligations of States vis-a-vis the transboundary movements of hazardous wastes, defined illegal traffic in hazardous or other wastes and outlined the responsibilities of the parties involved, and indicated the principles of international cooperation to improve and achieve environmentally sound management of hazardous wastes and other wastes.

As of 31 December 1990, 52 countries and the European Economic Community had signed the Basel Convention, and five countries had ratified it.

Box 10.5

POLLUTION PREVENTION PAYS

Many examples illustrate the economic feasibility and environmental benefits of reducing or preventing waste. The following illustrate that pollution prevention pays:

* *The 3M Company (Minnesota Mining and Manufacturing) executed a 3P programme that entailed more than 2,000 projects. The programme saved the company $420 million over 10 years and prevented the annual discharge of 12,000 tonnes of air pollutants, 14,000 tonnes of water pollutants, and 313,000 tonnes of sludge and solid wastes.*

* *Exxon Chemical Americas installed 16 floating roofs on open tanks of volatile chemicals at its Bayway plant. This resulted in annual savings of 340 tonnes of organic chemicals, worth and about $200,000, in addition to a marked reduction of releases into the environment.*

* *Sunkiss, a French Company developed a low-emission paint-drying technique. The process reduces the emission of evaporated solvents by 99 per cent by destroying them in the heating/drying process, reduces drying time by 99 per cent, and reduces energy use for drying by 80 per cent. Energy savings alone recover the cost of the device in two months.*

Source: (15)

wastes entailed serious environmental risks and the discovery that illicit international trafficking in hazardous wastes was taking place, coupled with the growing reluctance of the public at large to accept landfills or treatment plants in their neighbourhood (the NIMBY syndrome – or "not in my back yard"), have complicated the management of wastes in general and hazardous wastes in particular. Although above-ground storage and "controlled" burial of waste remain the commonest methods of hazardous waste management, some countries (e.g. Denmark, Finland, the Netherlands and the United States) plan to ban landfills without some form of pre-treatment of waste. There is a growing tendency to use specific techniques for certain wastes. For example, in Austria, Germany and Switzerland all hazardous liquid organic wastes would be incinerated or subjected to physics-chemical treatment. Incineration, especially high-temperature incineration using plasma arc furnaces, is a growing technology for the management of hazardous wastes.

10.15 Waste reduction or prevention is certainly the best way to protect human health and the environment. Given the cost and complication associated with handling waste, the principle of "pollution prevention pays" or the complication "3P principle" should be widely promoted (Box 10.5). The benefits are enormous. Occupational and public exposure to hazardous chemicals are reduced. Industrial efficiency and competitiveness are enhanced as waste prevention simultaneously cuts raw material inputs, saves energy and reduces the volume of waste that has to be stored, treated, or disposed of. Less waste means less expense for buying and operating pollution control

equipment. Accidents during rail and highway transportation of waste are reduced. A reduced need for off-site hazardous waste facilities reduces the associated health, environmental and political problems. Companies can reduce liability risks and costs that otherwise arise from inadequate disposal practices. As a matter of fact up to 50 per cent of all environmental pollutants and hazardous wastes could be eliminated with existing technology. (15)

10.16 Recycling and reuse of waste has been practiced in some countries for decades for economic reasons. Perhaps the best-known examples are the reuse of scrap metals, the reuse of glass bottles for soft drinks, etc. Recycling is now receiving increased attention in many countries. In Hungary, for example, about 29 per cent of hazardous wastes are being recycled. (16) Indeed, there is a great potential for recovering several materials, such as solvents and metals, including chromium, mercury and copper. It has been estimated that up to 80 per cent of waste solvents and 50 per cent of the metals in liquid waste streams in the United States can be recovered by existing technologies. (17) In Japan, the United States and Western Europe, waste exchanges - operating on the simple premise that one industry's waste can be another's raw material - have succeeded to varying degrees in promoting the recycling and reuse of industrial waste. Most serve as information clearing-houses, publishing catalogues of waste available and "waste wanted" lists to inform industries of trading opportunities. A successful trade benefits both buyer and seller companies, the buyer reduces its raw material costs, the seller its treatment and disposal costs.

10.17 There are several technological approaches to dealing with the hazardous wastes generated by industries. But more vigorous research and development in waste minimization technologies and recycling, technical and financial support to encourage investments in them and, in some cases, a tax on waste generated could probably cut the production of hazardous wastes in many industrialized countries by a third by the year 2000.

PART II

DEVELOPMENT ACTIVITIES AND ENVIRONMENT

Chapter 11

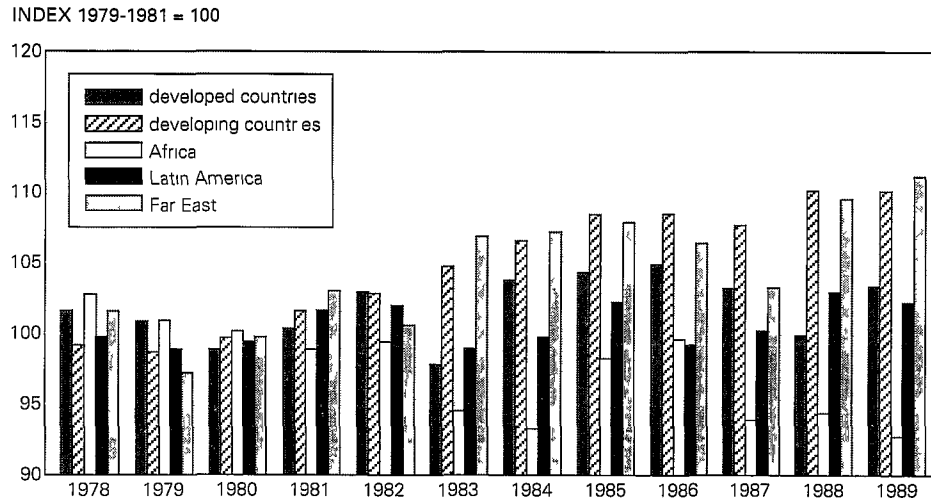
AGRICULTURE AND FOOD PRODUCTION

11.1 At the beginning of the 1990s, a world-wide average of 2,670 calories of food products per capita were consumed – a level considered nutritionally adequate. However, this global average has little significance so long as inadequate food consumption levels prevail in a large number of developing countries. There is a gap of 965 calories per capita between the developed and the developing countries (3,399 and 2,434 calories per capita, respectively), and there are wide gaps between and within the developing countries themselves. (1) In fact, the increase in per capita food availability in the developing countries as a whole slowed in the 1980s compared with the 1970s and 1960s; the situation for some countries, for example sub-Saharan African countries, worsened to the extent that per capita food availability in 1989 was less than it was in 1970. (2)

11.2 This world-wide disparity has been created and aggravated by a combination of social, economic, environmental and political factors, including a decrease in commodity prices, agricultural subsidies in the North, agricultural trade barriers, inequitable access to resources and products and the often primitive conditions of production and processing of agricultural output in many areas. As a result, the number of chronically hungry people in the world increased from about 460 million in 1970 to about 550 million in 1990 and is expected to reach 600-650 million by the year 2000. (2) Close to 60 per cent of the hungry people in the developing world live in Asia, about 25 per cent in sub-Saharan Africa and some 10 per cent in Latin America and the Caribbean. The fact that hunger is closely related to poverty is well established. According to the World Bank (3) 1,116 million people in the developing countries are living in conditions of poverty and 630 million of them can be considered extremely poor. This last group is the most threatened by hunger and chronic malnutrition.

11.3 Agricultural output and food production increased in both developed and developing countries in the period 1970-1990. The annual rate of increase was higher in the developing countries (about 3.0 per cent) than in the developed countries (about 2.0 per cent). In the latter countries there was a near stagnation in per capita food production in the 1980s, with marked drops in 1983 and 1988 due to unfavourable weather conditions, particularly in North America. In the developing countries there were major increases in Asia, a near stagnation in Latin America and a marked drop in Africa (Fig. 11.1). The rate of increase in cereals production (Fig. 11.2) was higher in the developed countries than in the developing countries (about 32 per cent and 15 per cent, respectively, between 1970 and 1990). In the developed countries, the annual rate of cereals production was higher than population growth (about twice as much), but in the developing countries it was much lower (about one-fifth as much). A wide gap, currently 529 kg per capita, continues to exist between annual cereals output of developed and developing

Figure 11 1
FOOD PRODUCTION PER CAPITA

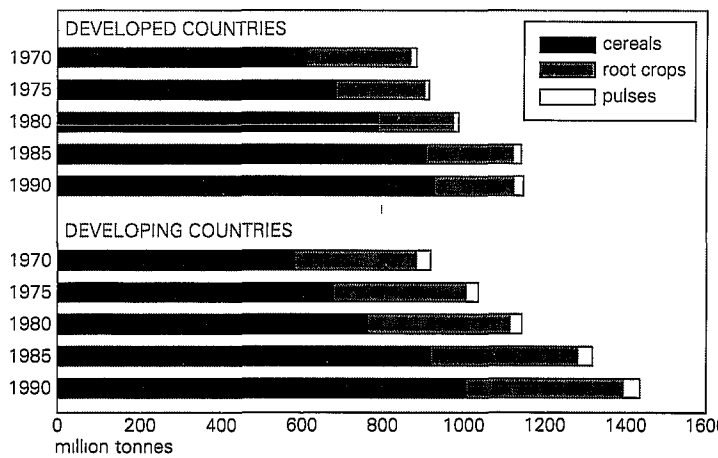


Source Based on data from (12)

countries as a whole (777 kg per capita and 248 kg per capita, respectively, in 1990). (4)

11.4 About 12 per cent of the world's population is entirely dependent on livestock production. On average, one quarter of the gross value of agricultural production is attributed to livestock production, but when the non-monetized contribution of livestock is taken into account (through the provision of draught power and manure), this proportion amounts to 44 per cent. (5) The largest share of the world's livestock population is found in the developing countries – 99.5 per cent of buffaloes, 98.5 per cent of camels, 94.0 per cent of goats, 68.5 per cent of cattle, 57.8 per cent of pigs, and 52.5 per cent of sheep (1989 figures). However, the production of meat in developing countries is much lower than in developed ones (68.7 million tonnes and 103.2 million tonnes, respectively, in 1990). (4) This is attributed mainly to the fact that most livestock in the developing countries is in traditional, small-scale

Figure 11 2
CROP PRODUCTION

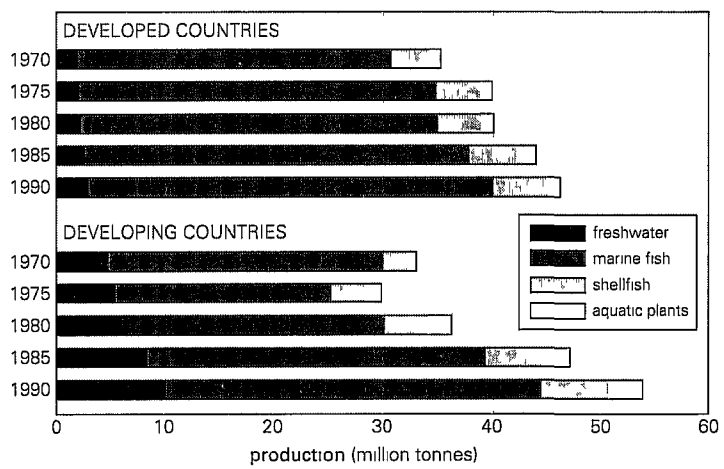


Source Based on data from (1 31)

farming systems, where it is a source of subsistence, and additional income is generated by selling animal products. Also, animals supply the necessary power for agriculture. In Asia, animals provide 28 per cent of the power for agricultural production, and in Africa 10 per cent.

11.5 Fisheries produce 16 per cent of the total animal protein available in the world. This contribution of fish to protein supply is approximately the same as that from beef or pork. (6) Most of the world's fish production comes from marine areas (Fig. 11.3), which accounted for about 86 per cent of the estimated fish production in 1990. Of this amount, some 90 per cent is estimated to be from coastal areas. About 14 per cent of the world catch of aquatic resources comes from inland (fresh) waters. Approximately 7 million tonnes of the total world fish catch, are from freshwater aquaculture as compared to about 5 million tonnes from mariculture. In all, about 11 per cent of global fish production comes from aquaculture. At present growth rates, aquaculture production by the end of the century should be almost doubled. (6) Most of the aquaculture is in Asia. Production from freshwater aquaculture in Asia amounts to about 4 million tonnes per year. (7) Coastal aquaculture (shrimp) in Asia accounted for 82 per cent of world cultured shrimp in 1990 (about 400,000 tonnes from a world-wide production of about 471,000 tonnes). It should be noted that most freshwater aquaculture in Asia is for local consumption in rural areas. Small-scale systems such as rice-fish culture and integration of aquaculture with livestock are common in many Asian countries.

Figure 11.3
AQUACULTURE PRODUCTION



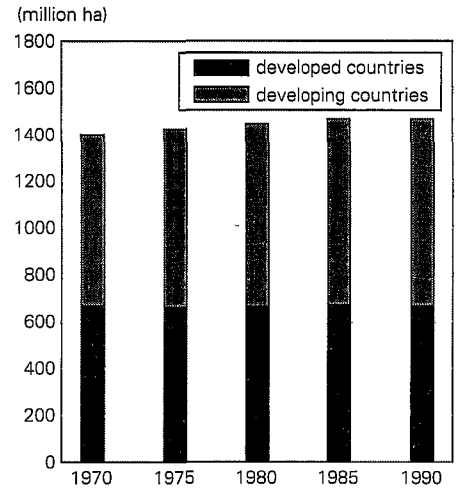
Source Based on data from (1, 6, 31)

Agriculture, resources and environment

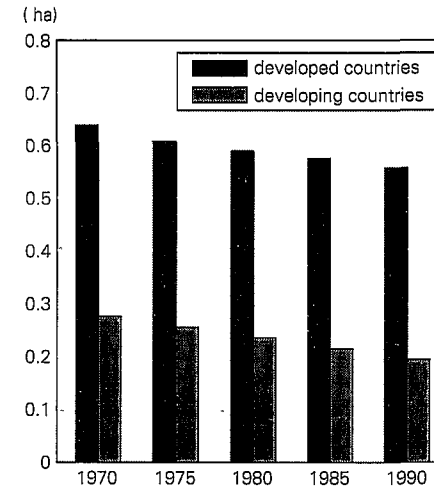
11.6 The total area of potential arable land in the world is about 3,200 million hectares, about 46 per cent of which (1,475 million ha) is already under cultivation. World-wide, the area of arable land increased by only 4.8 per cent over the period 1970-1990; the increase in developed countries was 0.3 per cent and that in the developing countries was 9 per cent (Fig. 11.4). However, per capita arable land decreased from a world-wide average of 0.38 ha in 1970 to 0.28 ha in 1990, mainly due to population growth and loss of land for agriculture (Chapter 6). The decrease was most noticeable in the developing countries, from 0.28 ha per capita to 0.20 ha per capita, i.e. a decrease of nearly 40 per cent. In the developed countries, the decrease was from 0.64 ha per capita to 0.56 ha per capita, i.e. a decrease of 14.3 per cent. It has been estimated that, if the

Figure 11.4

ARABLE AND PERMANENT CROPLAND



ARABLE LAND PER CAPITA



Source: Based on data from (12, 31).

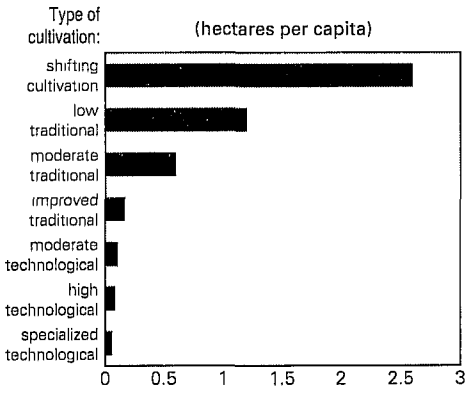
arable land area is maintained at the present level (1,475 million ha world-wide) and assuming that no new land is brought under cultivation and no existing land goes out of production due to degradation, the per capita arable land in the world will progressively decline to 0.23 ha in 2000, 0.15 ha in 2050 and 0.14 ha in the year 2100. (8)

11.7 It has been said that large areas of new land could be brought under cultivation. (9, 10) But unused arable land is not always available to people who need it most, and opening up new areas remains an expensive means of increasing agricultural production. In fact, further expansion of agricultural land is constrained in many parts of the world. In tropical Africa, for example, agricultural and livestock development are severely hindered because of such diseases as river blindness (onchocerciasis) and human and animal trypanosomiasis. The latter renders livestock production virtually impossible over some 10 million square kilometres of high rainfall areas - 45 per cent of all the land in sub-Saharan Africa. In arid regions, shortage of water for irrigation constitutes a major constraint on future expansion of the cropland area.

11.8 It has been estimated that with traditional agriculture the minimum dietary requirement per capita can be met from an average of 0.6 ha of arable land. (11) This means that the present area under cultivation in the world would only meet the minimum dietary requirements of less than half of the world population. Therefore, there has been no alternative but to increase the output of existing arable land through technological innovations. Efforts to do so have been successful; productivity gains have been achieved largely by using the "green revolution" technological packages which require the use of high-yield varieties (HYVs) of seeds and high inputs of water, fertilizers and pesticides. This has led to a drop in the average per capita land requirement to meet basic needs, and the application of more advanced technologies (e.g. advanced biotechnologies) would lead to a further

decrease (Fig. 11.5). However, the intensification of agriculture requires high inputs, and the more impoverished an ecosystem, the more inputs are needed to raise the output. This has implications for the use of different resources and for the state of the environment.

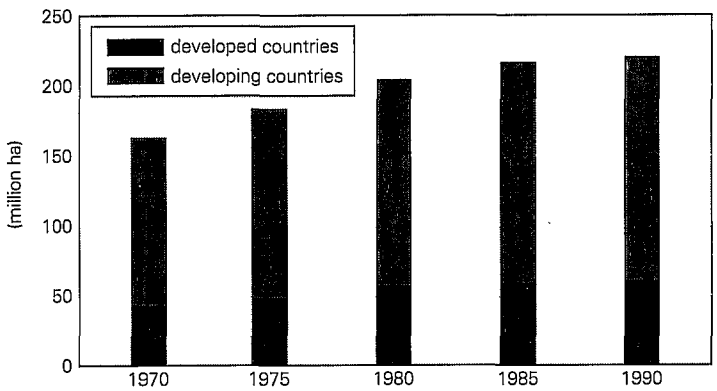
Figure 11.5
AREA NEEDED TO PROVIDE BASIC DIET



Source: Based on data from (11).

11.9 World-wide, about 2,700 cubic kilometres of water were withdrawn for irrigation in 1990, or about 69 per cent of total freshwater used (Chapter 5). The world's irrigated land increased from 168 million ha in 1970 to 228 million ha in 1990, (5, 12) i.e. an increase of about 36 per cent in two decades (Fig. 11.6). Although irrigated land at present accounts for one-sixth of cultivated land, it produces one-third of the world's food (over twice the productivity of average rainfed land). However, the rate of expansion of irrigated land has been slow because the availability of additional irrigable land and of good quality water is severely constrained in many parts of the world. The scarcity of water resources is compounded by the loss of irrigation water in supply systems and on farms. Such losses are generally in the range of 50-60 per cent, but may reach as much as 75 per cent in some countries. (13) In most developing countries irrigation water is supplied free or at a highly subsidized rate. (13, 14) This has led to inefficient use of water for irrigation and has discouraged simple conservation measures, which are more likely to be carried out if farmers pay for irrigation water. Studies have demonstrated that each 10 per cent rise in the price of water generates savings of about 6 per cent in water use. (14)

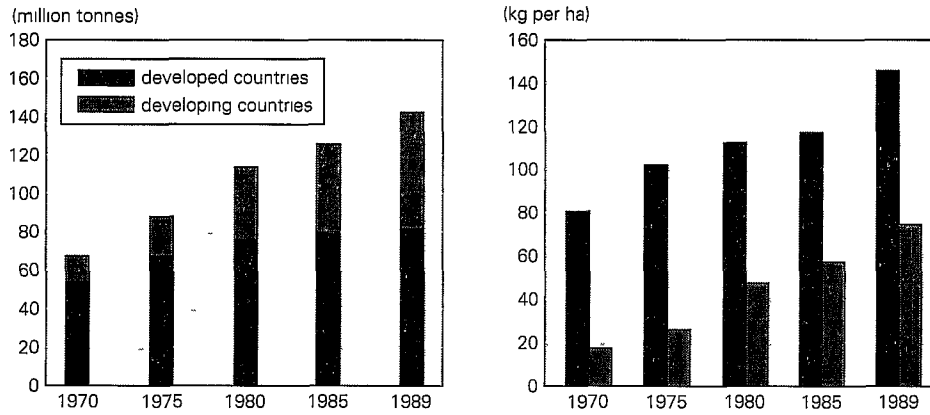
Figure 11.6
IRRIGATED CROPLAND



Source: Based on data from (12, 31).

11.10 The increased application of chemical fertilizers to supply plant nutrients (nitrogen, phosphorus and potassium) is an essential component of modern agriculture. World consumption of chemical fertilizers rose markedly in the past two decades, from about 69 million tonnes in 1970 to about 146 million tonnes in 1990, i.e. more than double (Fig. 11.7). The rate of increase in consumption was much higher in the developing

Figure 11.7
FERTILIZER USE



Source: Based on data from (32)

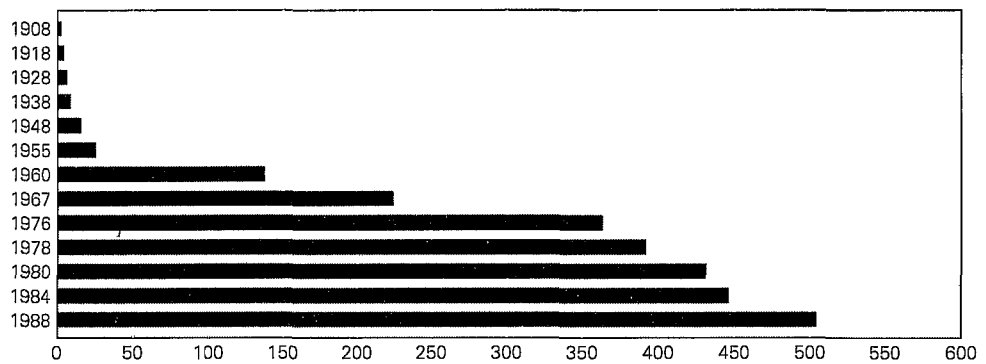
countries (360 per cent) than in the developed countries (61 per cent). Most fertilizers used are nitrogenous fertilizers, followed by phosphates and potash. The use of fertilizers per ha in the developed countries has been much higher than in the developing countries, although the rate of application in the latter countries has been rising fast (327 per cent increase from 1970 to 1989) as a result of the increasing introduction of green revolution packages. About 50 per cent of the fertilizer used benefits the plants; the remainder is lost from the soil system by leaching, runoff and volatilization. (15) Fertilizer subsidies in many developing countries have led to inefficient application, with consequent economic losses and increased environmental damage on and off the farms.

11.11 Crops are affected by different pests and by competition from weeds. In North America, Europe and Japan crop losses caused by pests are estimated to be in the range of 10-30 per cent. In the developing countries such losses are of the order of 40 per cent, but losses of as much as 75 per cent have been reported, for example for maize in Africa. Pests do not only affect the quantitative yields of the crops. Both pre-harvest and post-harvest infestations seriously affect food and feed quality. Pesticides have long been used to control pests. About 90 per cent of pesticides sold are used in agriculture; the remainder is used in public health programmes. (16) The growth of world pesticide use is normally measured in terms of world sales rather than in tonnage, because information on production in terms of weight or volume of active ingredients is scarce. It has been estimated that the total sales of pesticides increased from $US 7,700 million in 1972 to $US 15,900 million in 1985 and reached about $US 25,000 million in 1990 (1985 $); the major groups of pesticides used are herbicides (46 per cent), insecticides (31 per cent), fungicides (18 per cent), and others (5 per cent). About 80 per cent of the pesticides used in the world are used in the developed countries. However, the rate of use in the developing countries (7-8 per cent per year) is faster than that in the developed countries (2-4 per cent per year). Not all the amounts of pesticides used control pests. It has been estimated that more than 90 per cent of pesticides do not reach the target pests (17) and contaminate land, water and air. Repeated applications of pesticides (often highly

subsidized in developing countries) have led to the build-up of resistance among target pests (Fig. 11.8). In several cases this has prompted the use of other, more toxic pesticides, with more occupational and environmental risks.

11.12 Relative to other economic sectors, agriculture is a modest user of commercial energy, accounting for an estimated 5 per cent of commercial energy use in the world, or about 375 million tonnes of oil equivalent per year. This estimate takes into account energy used in irrigation, pesticide and fertilizer production and machinery operation, but not energy used in food processing, storage and transportation. The developed countries – where use of fertilizers and pesticides and farm mechanization are high – account for about 77 per cent of commercial energy use in agriculture.

Figure 11.8
NUMBER OF SPECIES OF PESTS RESISTANT TO PESTICIDES



Source: Based on data from (33)

Impact of agriculture on atmosphere

11.13 Agricultural practices contribute to both local and global atmospheric pollution. Shifting, or swidden, cultivation and the burning of savannah lands and the clearing of forest and savannah for livestock and arable farming produce a number of emissions into the air. The amount of biomass burned between 1970 and 1990 has been estimated at from 4.9 to 8.9 billion tonnes annually, about 60-65 per cent of which is directly related to agriculture, the rest to wildland fires, burning of industrial timber and fuelwood and other deforestation. (18) The burning of biomass produces carbon dioxide, carbon monoxide, methane, nitrogen oxides, ammonia, sulphur oxides and particulate matter. Paddy fields and the guts of livestock produce considerable amounts of methane. Ammonia is released from livestock waste – the greatest emissions occur in Argentina, Brazil, China, India, and the United States, each producing more than one million tonnes of ammonia-nitrogen annually. (18)

11.14 Even with no application of nitrogen fertilizers, cultivated soils may emit large amounts of nitrous oxide (especially in the tropics), in aggregate perhaps as much as is released from fertilized fields. (19) Application of fertilizers increases nitrous

oxide emissions. Air can easily become contaminated with pesticides during spraying operations. Traces of pesticides have been found in fog in California (20) and in rain. It has been shown that even relatively non-volatile pesticides such as DDT evaporate into the atmosphere quite rapidly, particularly in hot climates, and can be transported over long distances, contributing to what has been known as the global chemical pollution. Box 11.1 summarizes the estimates of major emissions into the atmosphere due to present agricultural practices.

Impact of Agriculture on Water

11.15 Excessive irrigation wastes large quantities of water, leaches out soil nutrients and micronutrient trace elements and creates problems of secondary salinization and alkalinization, which have damaged millions of hectares of productive lands (Chapter 7). Over-exploitation of groundwater for irrigation has led to the depletion of groundwater resources in some arid areas, e.g. in the Middle East, and in coastal zones it has resulted in excessive intrusion of salt water from the sea into groundwater aquifers. In several countries, inadequately designed and operated irrigation systems have created favourable ecological environments for water-borne diseases such as schistosomiasis, liver fluke infections, filariasis and malaria (Chapter 18). These diseases are not new, but their incidence has markedly increased with the introduction of various irrigation schemes.

11.16 Because water of good quality is not always available, in some countries there is a growing tendency to use water of marginal quality for irrigation. For example, brackish water is used in some States in the Middle East. Drainage water mixed with fresh water is used to irrigate some crops in Egypt. (13) Unless the use of such water is carefully managed and monitored, it could lead to a considerable increase in the salinization of land and deterioration of the quality of

Box 11.1

ESTIMATES OF MAJOR EMISSIONS INTO THE ATMOSPHERE DUE TO AGRICULTURE

	million t/y	*% of global anthropogenic emissions*
Carbon dioxide	*1,200*	*17*
Methane	*230*	*66*
Nitrous oxide	*2*	*71*
Ammonia	*28*	*80*
Sulphur oxides	*2*	*2*
Nitric oxide	*5*	*7*
Particulate matter	*20*	*35*

Emissions include contributions of burning of biomass directly related to agriculture, paddy rice, livestock rearing and use of fertilizers.

Source: (26).

groundwater in the aquifers near irrigated lands. Although the use of municipal wastewater for irrigation has been practiced for centuries, a conservative approach in fully utilizing this source of water has been taken. Pathogenic bacteria, parasites, and viruses are all found in sewage and may survive treatment processes. Once in the environment, many are able to exist for prolonged periods of time and outbreaks of cholera, typhoid, etc. associated with wastewater irrigation have been documented. (21)

11.17 Despite their general low solubility, pesticides can be leached into drainage water causing pollution of surface and coastal waters into which drainage water is discharged. Pesticides have been detected in coastal waters and in freshwater bodies in many regions (Chapters 4, 5). Groundwater contamination is also common in areas where pesticides are heavily used. In California, in 1980-1984, dibromochloropropane was detected in some 2,000 wells over an area of 18,000 square kilometres. The herbicides atrazine, alachlor and simazine are also important contaminants. Aldicarb, a nematocide, has become a common contaminant of aquifers below potato fields and citrus orchards in several countries. (18) The pollution of surface and groundwater with pesticides can affect aquatic life and human health. Pesticides, especially persistent ones, can build up through the food chain, with consequent risks to humans (Chapter 18).

11.18 Fertilizers can be easily leached into drainage water and, when such water is discharged into rivers or the sea, the leached nutrients (nitrogen and phosphorus) create widespread eutrophication. Nitrate and phosphate have been responsible for generating dense algal growth which has harmed fish and other aquatic life (Chapters 4, 5). In Sweden, in 1989, it was estimated that 26 per cent of the total nitrogen load on surrounding sea areas came from agriculture, 23 per cent from forests and forestry, 8 per cent from wetlands, 19 per cent from municipal and rural sewage, 4 per cent from industry, 10 per cent from atmospheric deposition, and 10 per cent from other land uses. (22) Fertilizers are not the only source of nutrients. Nitrate-nitrogen is a common pollutant on large feedlots. Wastes from feedlots are becoming a major source of water pollution in several industrialized countries. For example, in England and Wales 20 per cent of the annual number of pollution incidents recorded by the water authorities in 1988 were from feedlot wastes. (18) Nitrates from fertilizers and feedlot wastes have caused the contamination of groundwater in many countries, and the issue has been of major concern in Europe and North America. According to WHO, (23) water becomes unpotable when nitrate concentration exceeds 45 ppm. The EC issued a directive which would require any area where the nitrate concentration in surface or groundwater exceeded 50 ppm to be declared "vulnerable zone", in which compulsory restrictions on farming would be automatic.

Impact of Agriculture on Land

11.19 The pressures to expand the area under cultivation have resulted in more and more utilization of marginal land. Cultivation on steep hillsides and increasing rates of deforestation, especially in the tropics, have led to soil degradation, declines in productivity and to desertification (Chapters 6, 7). The draining of wetlands for conversion to agricultural uses has detrimental effects on fish, wildlife and wetland habitats. Increased use of estuarine areas, the nurseries for most of the coastal fish stock, may affect bay, river-mouth and shallow coastal habitats (Chapters 4, 8). In several countries, aquaculture accounts for the conversion of large areas of coastal lowlands into ponds. For example, in 1980 in the Philippines, the coastal area under extensive pond culture amounted to 176,000 ha; in Indonesia,

192,000 ha; in Thailand, 2,500 ha; and in India, 12,000 ha. (24) In these and other countries, such as Ecuador and Malaysia, large areas of coastal mangroves or marshlands are being converted to ponds. Mangrove swamps act as protective areas between land and sea and are the habitat of a wide variety of terrestrial and aquatic organisms. The conversion of mangroves into ponds for aquaculture will not only affect this habitat, but will lead to other environmental impacts, e.g. removing a natural barrier against the storm surges that accompany cyclones (Chapter 9).

11.20 Rangeland has been degraded in many parts of the world as a result of mismanagement and overgrazing (Chapter 6). The situation is especially precarious in arid and semi-arid lands. The grass and shrub vegetation in extensive rangeland areas in the Middle East and North Africa has undergone extensive changes, particularly because of overgrazing. (13) Rangeland in the region is particularly prone to xerification, or drying out, that can be caused or accelerated by drought and/or overgrazing.

Impacts of Use of High-yield Varieties of Seeds

11.21 The extensive use of HYV seeds has led to a marked decrease in genetic diversity. For example, the spread of HYVs of wheat and rice since the mid-1960s has inadvertently caused a loss of the gene pools in centres of crop diversity such as Afghanistan, Iran, Iraq, Pakistan and Turkey. (13) In 1980 there were as many as 30,000 varieties of rice in India. It is estimated that, by the turn of the century, as few as 12 varieties will dominate 75 per cent of that country. In addition, the uniform genetic background of HYVs opens up the possibility of lower resistance to new diseases or pests.

11.22 Some of the limitations of HYVs that have received increasing attention in recent years stem from their dependence on the presence of a whole package of complementary inputs (water, fertilizer, pesticides, etc.) which are not always readily available in developing countries. In areas with conditions that are favourable to the adoption of the new varieties, especially as far as water availability is concerned, the use of the new seeds spreads rapidly. In areas with less favourable conditions, the new varieties offer little or no advantage over traditional farming methods. (25) The use of HYVs has created several socio-economic problems. Small farmers are generally unable to acquire the HYV packages and the yield of their farms remains low. Therefore, many have been forced to abandon agriculture. On the other hand, increasing numbers of farmers have switched to cultivation of "urban consumer" or "export" crops, which are more profitable. This has not only contributed to the disturbance of the patterns and structures of agricultural systems in some countries, but has also negated the main rationale behind the introduction of packages of HYVs, that is, to increase the yields of the main, staple food crops. (13)

Agricultural Residues and Livestock Waste

11.23 World-wide, farm crops leave substantial residues, the extent and scale of which are rarely realized. The amount of such residues was estimated at about 930 million tonnes in 1970 and about 1,500 million tonnes in 1990, (26) about 75 per cent of which was cereal straw and residues from maize and barley crops. These residues must be removed from the fields to control pests and diseases and to prevent fouling of the soil for the next crop. In several countries, especially industrialized countries, most of the residues are burned in the field. In developing countries, however, substantial quantities of these residues are directly used as fuel, mainly for domestic purposes (Chapter 13), and as additives to animal dung to make dung-cakes for fuel, or to mud to

make mud-bricks for building purposes. (25) A substantial amount of cereal straw and other residues is also used as animal feed.

11.24 Livestock in the world produced about 1,500 million tonnes of dung in 1970 and about 2,200 million tonnes of dung (air-dry) in 1990. (26) This waste constitutes a major source of pollution, especially in developed countries, in the neighbourhood of animal farms. The contribution of such waste to air and water pollution has been referred to above. In developing countries, dung is extensively used as fuel in many rural areas in the form of dung-cakes, or to produce biogas for fuel, especially in China, India and other Asian countries (Chapter 13). The residues from biogas plants, which are rich in nutrients, have been used as fertilizer and/or as feed for algae and fish ponds. (27)

Responses

11.25 Agricultural impacts on the environment can be viewed in the context of a three-component, interrelated system: agricultural resources, agricultural technology and environment. The quantity, quality and availability of resources determine the technologies to be used. In turn, the technologies employed have environmental and/or socio-economic impacts, generating demands for other technologies and/or policies to reduce or eliminate the negative impacts. Agricultural practices that lead to environmental degradation will trigger or exacerbate the neglect of land and of rural development (a symbiosis exists between agricultural and rural development, but it is not fully appreciated in several developing countries), prompting an increase in rural-urban migration. This will not only aggravate urban problems, but will also undermine efforts to increase indigenous food production, thereby increasing national dependence on imported food. Therefore, it is in the interest of national stability and security that countries should pursue the development and implementation of environmentally sound agricultural development plans.

11.26 A great deal of research activity is under way in many research centres around the world to study ways and means of increasing agricultural productivity in an environmentally sound manner. A number of international and regional organizations are also supporting various research and development activities to achieve the same goal. Many activities of FAO, IFAD, UNEP and bodies such as the International Board for Plant Genetic Resources (IBPGR), the Consultative Group on International Agricultural Research (CGIAR), the International Rice Research Institute (IRRI), the International Centre for Maize and Wheat Improvement, the International Centre for Insect Physiology and Ecology (ICIPE) and several others are geared to that goal.

11.27 Many simple ways and technologies have been developed to increase the efficient use of the different inputs in agricultural systems. Adjusting the timing of fertilizer application and the amounts used has led to a considerable saving of fertilizer, with both economic and environmental benefits. (18) The use of sulphur-coated urea (SCU) on rice has led to control of nitrogen release and hence a lowering of the concentration of nitrogen in both the soil and water at any given time. Although costs are more than for ordinary urea, the economic returns are potentially of the order of $US 6-7 for every dollar spent, not counting the environmental benefits. (28) Recourse to biological processes for fertilization (nitrogen-fixing plants, crop rotations, use of trees as a "nutrient pump", recycling of wastes) is growing in several countries, especially in industrialized countries, where it is sometimes referred to as "ecological" agriculture. There is also a growing tendency to apply the concept of integrated plant nutrition systems (IPNS) which involves the use of carefully derived combinations of mineral and organic fertilizers which are

applied in combination with complementary crop practices, such as tillage, rotation and moisture conservation. As a result, soil quality is conserved and pollution is reduced to a minimum.

11.28 In the past two decades, increased attention has focused on the use of integrated pest management (IPM) to keep pests and diseases at an acceptable level. IPM strategies may include the selective use of pesticides and rely on the use of biological methods, genetic resistance and appropriate management practices. Although the application of IPM has been slow, especially in relation to food crops, many success stories have demonstrated its viability (Box 11.2). In the United States, IPM is now used on about 15 per cent of the total area of cultivated land, (18) and its use is growing, for example

BOX 11.2

MORE ENVIRONMENTALLY SOUND PEST CONTROL

* *In the 1970s, the development of high-yield strains of rice and the increasing use of fertilizers and pesticides allowed farmers in Indonesia to grow two rice crops each year instead of one. Unfortunately, this led to an enormous growth in the population of brown planthopppers. Farmers were spraying up to eight times in the rice-growing season to try to reduce the damage done by this pest, and the Government was providing huge subsidies to help the farmers pay for the expensive pesticides.*

Then scientists showed that spraying had caused the problem in the first place. The sprays had wiped out all the natural predators of the brown planthoppers, particularly spiders, and yet had only a limited effect on the pest itself.

In response, the Indonesian Government introduced an integrated pest management (IPM) system. First, it reduced the subsidies on chemical sprays, and banned farmers from using 57 insecticides on rice. It then set up a nationwide training programme to show farmers how to conserve natural predators such as spiders. Spraying was to be considered only as a last resort.

Within three years, farmers were using 90 per cent less pesticide, with large savings in cost both for them and the Government. And yields of rice were increasing. And less harm was done to the environment.

Similar IPM programmes for rice are being introduced in Bangladesh and India.

* *A lethal pest - the new world screw worm fly - has recently killed more than 12,000 animals in the Libyan Arab Jamahiriya. Unchecked, the larvae of the fly could have eaten their way through 70 million head of livestock in five north African countries. The outbreak began in the Libyan Arab Jamahiriya in 1988 and the flies had infected about 40,000 square kilometres there. Female screw worm flies lay their eggs in open animal wounds. The maggots that develop eat living tissue and can eventually kill the host animal. FAO and IFAD started an eradication programme that relied on swamping the female screw worm flies with male flies that had been irradiated to make them sterile. The males mate with females whose eggs then fail to hatch, and the population eventually dies out. More than a billion sterilized Mexican flies were flown into the area and used in the control operation. No infected animals have been found since April 1991.*

Sources: (29, 30).

in Central America and some Asian countries. If IPM strategies are implemented in combination with the application of the International Code of Conduct on the Distribution and Use of Pesticides and the training of farmers, a great deal will be achieved in reducing the environmental impacts of pesticides (see also Chapter 10).

11.29 Several biotechnologies have recently been developed to solve specific agricultural problems. For example, the herbicide atrazine is used to kill weeds in maize fields. Maize can tolerate atrazine. However, where maize is planted in rotation with soybeans, the latter are susceptible to residues of atrazine and their yield is affected. An atrazine-resistant soybean has been developed for growing in rotation with maize. Marked progress has been made in transferring the genes for nitrogen fixation present in certain bacteria to some crops, which would lead to dramatic improvements in biological nitrogen fixation and decrease the dependence on chemical fertilizers. (25) However, advanced biotechnology is extensively dominated by private sector R & D, and the transfer of such technologies to developing countries will be complicated and costly.

Chapter 12

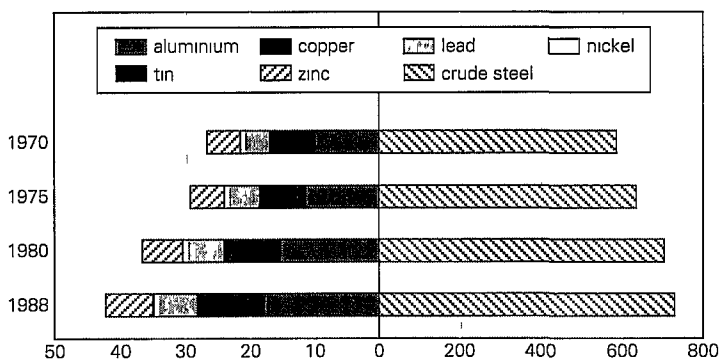
INDUSTRY

12.1 One of the most visible results of development is the enormous growth of industry. Today, the world manufactures seven times as many goods and produces three times the amount of minerals that it did in the 1970s. (1) Although industrial production grew rapidly between 1950 and the early 1970s, with 7 per cent annual growth, it has since slowed down to about 3 per cent per year. Industry's contribution to the gross domestic product (GDP) of low-income countries increased from 28 per cent in 1965 to 37 per cent in 1989. In middle-income countries, it grew from 34 per cent in 1965 to 36 per cent in 1989. In industrial market economies, on the other hand, the contribution of industry to GDP decreased from 42 per cent in 1965 to 35 per cent in 1989. (2, 3, 4) This can be attributed to the general downturn and stagnation in industrial output in these countries since the early 1980s.

12.2 The developing countries' share of world manufacturing output remained virtually stagnant at around 12.7 per cent during the period 1980-1985, but increased slightly to about 14 per cent in 1990. (5, 6) Developing countries are beset by various problems that greatly impede industrial growth. These include, *inter alia*, the rising burden of debt servicing, net capital outflows, protectionist barriers against entry into the markets of developed countries and the urgent demand to meet the increasing needs of their people.

12.3 The industrial sector is dynamic and rapidly evolving. The emergence of new technologies is one of the most important recent trends in industrial development. Robotics, automation, micro-electronics, information technology, new materials and biotechnology have provided the basis for and the driving force behind both the development of new high technology industries and the modernization of existing production processes in traditional industries such as textiles and pulp and paper. Other important trends have been the growing substitution of one material by another and an increase in recycling.

Figure 12.1
WORLD CONSUMPTION OF METALS
(million tonnes)

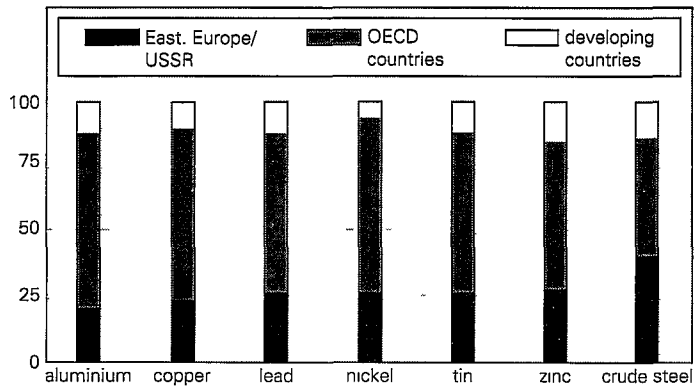


Source. (36).

Industry, Resources and Environment

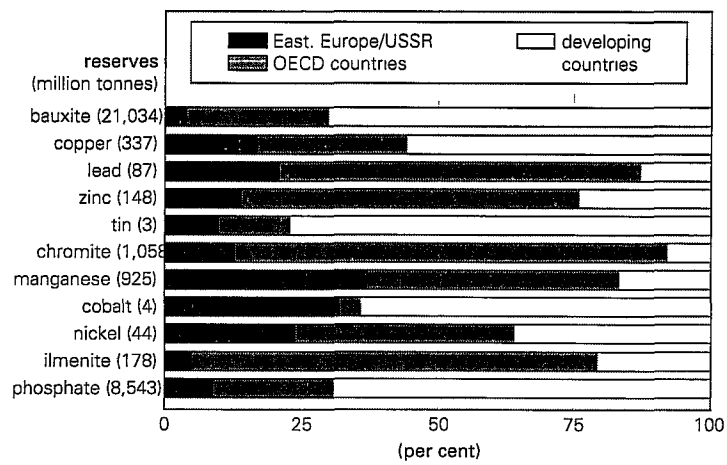
12.4 The industrial sector is an important user of natural resources and is the major contributor to the pollution

Figure 12.2
WORLD CONSUMPTION OF METALS (BY PERCENTAGE)



Source: (36).

Figure 12.3
PROVEN WORLD RESERVES OF METALS AND ORES



Source: (36).

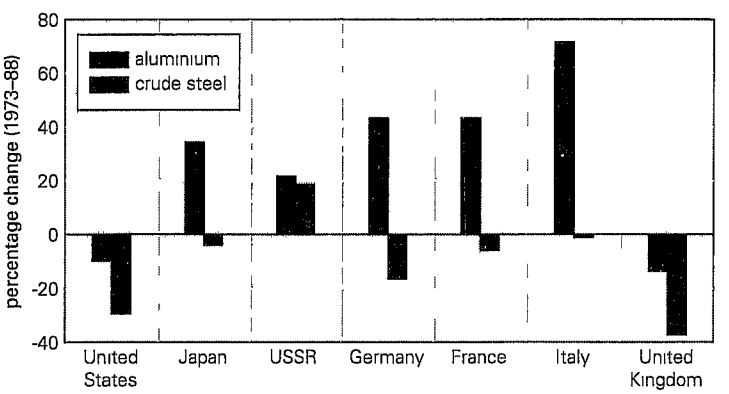
loads in the world. World-wide, the use of metals has increased over the last two decades (Fig. 12.1), although marked differences exist between different groups of countries (Fig. 12.2) and from one country to another. Although the developing countries account for most of the world's proven reserves of important minerals such as bauxite; copper, tin and cobalt ores; and phosphates (Fig. 12.3), their consumption is only about 12 per cent, and most of their production is exported to developed countries. The extraction of minerals (and their concentration and initial processing) has several negative impacts on land, water and atmosphere. These impacts are especially magnified in developing countries, where mining operations are generally less sophisticated than those in developed countries and mostly lack environmental protection measures. For example, bauxite processing in Jamaica produces massive quantities of "red mud", which has contaminated groundwater resources. (7) The mining of tin, copper, phosphates and iron ores has also created water and air pollution problems in some African and Asian countries. Long years of mineral extraction in some countries, for example in the United States, without due consideration for environmental impacts have created large areas of wasteland and massive amounts of accumulated hazardous wastes (Chapter 10).

12.5 One important feature of the last two decades has been the growing substitution of one mineral resource by another or by non-mineral material, basically to reduce costs and to save weight and, consequently,

energy. The automobile industry, for example, achieved a weight saving of about 25 per cent over the last decade through the use of plastics, ceramics, aluminium and ultra-strong sheet metal. The aircraft industry uses carbon fibres and ultra-lightweight alloys of aluminium and lithium to achieve the same goal. (8) Another reason for material substitution is the superior technical properties offered by some new material. In communications, for example, glass fibre is superior to conventional copper cable for nearly every application. A communications satellite weighing 250 kilogrammes gives higher performance than a transoceanic telephone cable weighing 150,000 tonnes. The substitution of one mineral by another or by a non-mineral material has lead to a decrease in the consumption of, for example, crude steel and an increase in the use of, for example, aluminium (Fig. 12.4). This material substitution has its environmental impacts. On the one hand, it reduces the environmental impacts associated with the extraction and processing of one mineral, but on the other hand it increases the environmental impacts of the extraction and processing of the new material used. In some cases, the latter impacts are more severe. For example, the processing of semiconductors, optical fibres, and new classes of ceramics and composites requires the use of large quantities of toxic chemical compounds, which creates significantly greater health and safety problems for workers and the public, especially in the case of accidents. Another important issue is that most such new materials cannot easily be decomposed and the disposal of their waste products will create problems never previously encountered. (9)

12.6 World-wide, industry consumed about 540 cubic kilometres of water in 1970 (about 21 per cent of total global fresh water withdrawal), and about 973 cubic kilometres in 1990 (24 per cent of total withdrawal), i.e. an increase of about 80 per cent in two decades (Chapter 5). This amount is expected to reach 1,280 cubic km in 2000, constituting about 25 per cent of total fresh water withdrawal world-wide. The modest amounts of water used in the industrial sector, compared to water withdrawn for agriculture, are due to the fact that many industries re-use water several times before it is finally discharged as industrial wastewater. For example, in the United States, each cubic metre of water is used on average about 9 times before being finally discharged as wastewater. This rate of water re-use is expected to reach 17 times in 2000. (10) Such water re-use varies from one industry to another and also from one country to another, and depends on the cost of water and its availability and on the cost of recycling. In some

Figure 12 4
CHANGE IN ALUMINIUM AND CRUDE STEEL CONSUMPTION (1973-1988) AMONG MAJOR CONSUMERS

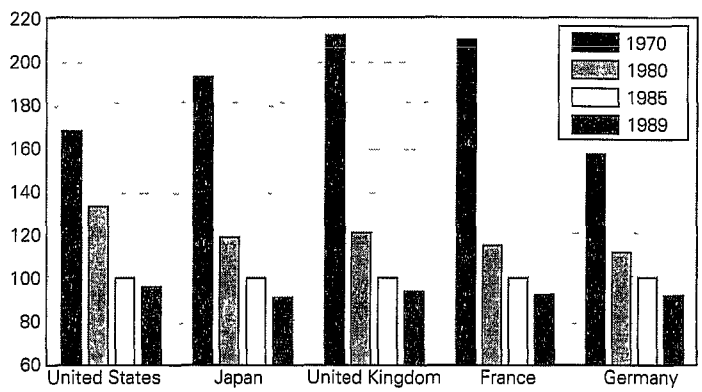


Source: (36).

countries, for example in Germany, India, Japan, and several others, treated domestic wastewater (sewage) is used in some industries for cooling or as process water.

12.7 Industry is the most energy consuming end-use sector, accounting for an average of 37 per cent of total commercial energy consumption in the world in 1990. However, differences exist between countries. In the OECD region, the average percentage is 33; in Eastern Europe it amounts to 60 per cent. (11, 12) In the developing countries, energy use in the industrial sector varies from a low of 11 per cent in Uganda to a high of 69 per cent in China. (13) An important development in the last two decades has been the marked decline of industrial energy intensity (the ratio of industrial energy use to value added) in most OECD countries. (14, 15, 16) Improvements in energy efficiency appear to have been the major cause of decreased industrial energy intensity, although structural changes within the industrial sector also played a very important role (Fig. 12.5). In contrast, industrial energy intensity in Eastern Europe has remained either constant or declined only slightly.

Figure 12.5
ENERGY INTENSITY OF INDUSTRY
(1985 = 100)



Source: Based on data from (37).

Measures to increase industrial energy efficiency in developing countries have had very limited success where industry often consumes two to five times as much fuel for a given process, due to decades-old industrial equipment. (13, 17) In some countries, industrial energy subsidies and the requirements to produce fixed quotas of goods at fixed prices have deterred efforts to improve energy efficiency. However, a study in Thailand (18) has shown that housekeeping alone could lead to a 12 per cent improvement in energy efficiency, and process improvement would lead to an additional 16 per cent. Another study in Egypt (19) showed that housekeeping could lead to a 20 per cent conservation of industrial energy.

Impacts of Industry on the Atmosphere

12.8 Many air contaminants are emitted by industry. The quantities and types of compounds emitted depend on many factors, in particular the type of industry, the characteristics and quantities of raw material used, the type and quantity of fuel, the technology applied, and the environmental protection measures in place. Factors such as the size of the industrial installation, the age of the machinery, and the standard of maintenance and management are also important. In addition to the common emissions into the air, such as sulphur and nitrogen oxides, carbon dioxide, carbon monoxide, hydrocarbons and particulate matter, industry emits hundreds of trace contaminants, some of which are potentially toxic (Chapter 10). Estimates of quantities of industrial emissions into the atmosphere vary from

one country to another. On average, in 1989 industry in OECD countries was responsible for 25 per cent of NOx emissions, 40-45 per cent of SOx and 50 per cent of total greenhouse gases. (20) More detailed statistics from the United Kingdom (21) show that in 1988 industry was responsible for 91 per cent of sulphur dioxide emissions, 47 per cent of nitrogen oxides, 60 per cent of carbon dioxide and 3 per cent of carbon monoxide (utilities such as power stations including steam generation are normally included in the industry sector). In Hungary, industry is responsible for 94 per cent of sulphur dioxide emissions and for all emissions of chlorine and fluorine. (22) Box 12.1 gives the calculated estimates of the contributions of industry to global, anthropogenic air emissions. The impacts of these emissions on the environment have been discussed in Part I of the present report.

Impacts of Industry on Water

12.9 The use of water in industrial processes produces billions of cubic metres of industrial wastewater daily. These wastewaters vary markedly in composition according to the industry, ranging from those with a composition similar to municipal sewage (but often more concentrated) to those which are more toxic and contain a great variety of heavy metals and synthetic organic compounds. In 1989 industrial wastewater in the OECD region contributed about 60 per cent of the biological oxygen demand load of surface waters receiving discharges, and about 90 per cent of the toxic substances load. (20) Industrial wastewater discharged into surface waters without adequate treatment has created a number of serious environmental problems that have affected aquatic life, in particular when accidental releases have occurred (see

BOX 12.1

ESTIMATES OF MAJOR EMISSIONS INTO THE ATMOSPHERE FROM INDUSTRY

	million t/y	*% of global anthropogenic emissions*
Carbon dioxide	*3,500*	*50*
Methane	*84*	*24*
Nitrous oxide	*0.2*	*13*
Ammonia	*7*	*20*
Sulphur oxides	*89*	*90*
Nitric oxide	*30*	*44*
Particulate matter	*23*	*40*
Hydrocarbons	*26*	*50*
Chlorofluorocarbons/halons	*1.2*	*100*

Includes utilities (power stations including steam generating stations). Chlorofluorocarbons and halons represent 1986 level (Chapter 2).

Source: (38).

Chapters 4, 5 and 10). In several countries, wastewater from some industries has been discharged into public sewers under the pretext that such wastewater contains mainly biodegradable material that can be treated together with sewage in treatment plants. However, the uncontrolled discharge of industrial wastewater, especially that containing toxic compounds, into municipal sewers could stress and completely destroy the microbial-based systems used to treat domestic wastes. Then neither the industrial nor the municipal wastewater is effectively treated. In addition, the sludge produced from treatment plants would contain high concentrations of toxic contaminants that would create problems in the management of such sludge.

Solid Wastes

12.10 World-wide, industry generated about 2,100 million tonnes of solid wastes and 338 million tonnes of hazardous wastes in 1989. Of these, 68 per cent of the former and 90 per cent of the latter were generated in OECD countries. (20) Most solid wastes are generated by the metallurgical, building and chemical industries, especially at the raw-material extraction and processing phases. Although some industrial solid wastes are considered "inert" and can be treated and disposed of like urban solid wastes, others (especially hazardous wastes) require special management techniques. In Italy, for example, of about 35 million tonnes of industrial solid wastes generated every year, 40 per cent is recycled, 46 per cent is treated as inert waste in ways similar to urban refuse, and the remaining 14 per cent requires special handling and treatment. (23) In Spain, industry generates about 10 million tonnes of solid wastes every year, of which about 9 million are considered inert and the remaining one million are considered hazardous. The management of industrial solid wastes, especially the hazardous wastes, remains a problem in many countries, although there are several opportunities to use many of the wastes in beneficial ways. For example, fly and bottom ash collected from power plants has been used for the manufacture of bricks and for road building in some East European countries (see also Chapter 10, especially on the transboundary movement of hazardous waste).

Emerging Issues

12.11 In the light of several serious accidents that occurred in the last two decades (Chapter 9), the location of industrial installations has become an issue of concern. Although some countries have encouraged a dispersion of industrial installations, others have encouraged the concentration of industries in "industrial estates". Interest in controlling pollution has been a contributing factor - but rarely the decisive one - in the choice of approach. (24) Industrial dispersion policies are most often viewed as means of distributing resources, markets and employment and of diverting population growth from overcrowded urban centres. On the other hand, the establishment of industrial estates, for example, in Brazil, Colombia, Mexico, Republic of Korea and Thailand, was mainly based on economies of scale in the construction of infrastructure. However, the economic benefits have been partially offset by environmental and health hazards created by the estate or industrial district itself. For example, in the industrial district of Cubatao, Brazil, where 23 major industrial plants and numerous small operations are concentrated, serious health problems, including an elevated neonatal mortality rate, birth deformities and a high prevalence of respiratory disorders, have been associated with high levels of water and air pollution. (25, 26) Recent environmental management measures undertaken in the district have contributed to a considerable decrease in different industrial emissions. In many

developing countries, industries that were constructed five or ten years ago beyond city limits have now become part of and have contributed to urban sprawl. Given scarce resources and limited transport facilities, new migrants and the low-wage labour force attracted to urban areas have no alternative but to settle in dangerous proximity to the plants. The high death toll from accidents such as those at San Juanico in Mexico and Bhopal in India has been mainly attributed to high population densities in squatter settlements around the plants in question (Chapter 9).

12.12 Many analysts predicted that in the 1970s and 1980s there would be a proliferation of industries relocating to developing countries as a result of the application of strict environmental regulations in the industrialized countries. (27, 28) There is little evidence that this has taken place on the scale predicted, although some developing countries have promoted investment by loosening environmental controls. (24, 29, 30) In general the decision to relocate an industry has been based on economic factors, but in some cases these economic factors may have been based on environmental factors. Industries that prove unprofitable in industrialized countries may find relocation to developing nations attractive, because they are able to avoid costly health and safety measures in their new locations. The relaxing of safety standards has been responsible for serious accidents. Numerous countries in South-East Asia, Latin America and the Caribbean have developed export processing zones, "free zones", to attract foreign-owned firms in such fields as chemical and raw material processing and the assembly and manufacture of several types of goods, with the final products being exported to foreign markets. Because environmental protection measures are not very stringent in such areas, industrial activity could have serious impacts on the health of workers, the surrounding population, and the environment. (31)

12.13 Hitherto, the focus has been on the environmental impacts of large industries. In many developing countries, small-scale industries have substantially grown in type and number, and in some countries they account for employment of more than 60 per cent of the labour force, many of whom are women and children. Textiles, garment and footwear manufacture, auto repair, gem-polishing, foundry work, scrap-processing and rubber-curing are among the hundreds of expanding small industries in urban and rural areas. In China, for example, about 18 per cent of the national industrial output in the 1980s came from small-scale industries, involving nearly 7 million workers. Planners estimate that during the next 20 years, 150 million people will be employed in small-scale industries in China. (32) Although small-scale industries have contributed both to national economies and to improving the living conditions of many people, they have also carried with them increased health and environmental risks. Studies in Brazil and Thailand, for example, have shown that the prevalence of occupational diseases is higher in small-scale industries than in medium-scale or large industries. (33, 34) Women and children are particularly vulnerable. (31) Nearly all small-scale industries dispose of their liquid wastes, without any treatment, into public sewers or in nearby surface waters. Solid wastes are often dumped with domestic refuse. The cumulative effects of these wastes could in some cases surpass those from large industries.

12.14 Since the late 1970s, the world has experienced a technological revolution, propelled by extraordinary scientific progress and rapidly advancing technology across a wide spectrum. Computers, telecommunications, biotechnology, lasers and new materials have brought the global economy to the

threshold of a new industrial age. However, our knowledge of the environmental impacts of these new technologies is still in its infancy. For example, although industrial applications of genetic engineering will be introduced, subject to strict safety measures to ensure that genetically engineered organisms are contained, we do not know what may happen if such organisms are accidentally released into the environment. The deliberate release into the environment of organisms for agricultural or environmental purposes may cause health hazards and/or damage to particular ecosystems - damage that cannot be controlled. If "prevention is better than cure", then information on new technologies should be widely disseminated to enable the various risks to society and the environment to be assessed and hence to help identify gaps in knowledge which call for further research by the scientific community. Once the risks have been assessed, suitable measures could be formulated to deal with them and to prevent or minimize any possible hazards before they occur.

Responses

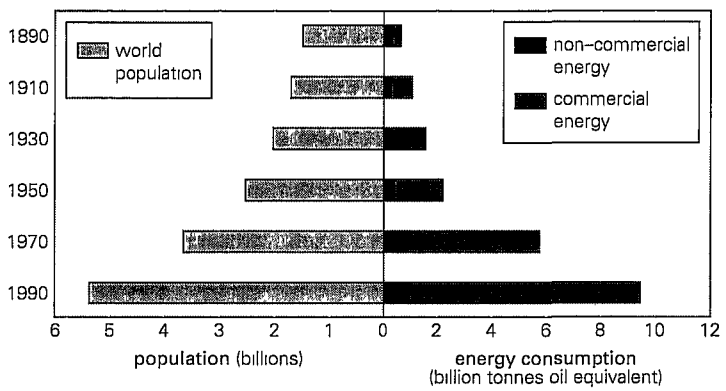
12.15 The traditional model of industrial activity – in which individual manufacturing processing takes in raw materials and generates products to be sold, plus waste to be disposed of – is now being gradually transformed into a more integrated model, "an industrial ecosystem". In such a system the consumption of energy and materials is optimized, waste generation is minimized and the effluents of one process serve as the raw material for another process. (35) This "greening" of industry is demonstrated by achievements in several OECD countries in the increased efficiency of energy and water use, increased recycling of waste, and more development of cleaner technologies (Chapter 10). The cooperation of the chemical industry has been an important driving force behind the steps taken to phase out chlorofluorocarbons and other compounds that deplete the ozone layer (Chapter 2). By this and by increasing the efficiency of energy use, industry is contributing to reducing the emissions of greenhouse gases. There have also been several achievements in reducing sulphur oxides emissions (Chapter 1) and in treatment of industrial wastewater, with consequent improvements in the quality of some rivers, such as the Rhine and the Thames. The growing international concern over the transfrontier movements and dumping of hazardous wastes, especially in the developing countries, led to the adoption of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal in 1989 (Chapter 10).

Chapter 13

ENERGY PRODUCTION AND USE

13.1 World-wide, the demand for energy increased dramatically over the last century (Fig. 13.1). Prior to the 1950s, energy consumption grew at an annual rate of about 2.2 per cent, but between 1950 and 1970 it grew at a much higher rate of 5.2 per cent per annum. Between 1970 and 1990, however, the increase in demand for energy slowed down to an annual rate of 2.3 per cent. This was a result of, *inter alia*, increases in oil prices in the early and late 1970s and the institution of measures to increase the efficiency of energy use and curb the rising demand for energy in the developed countries.

Figure 13.1
WORLD ENERGY CONSUMPTION

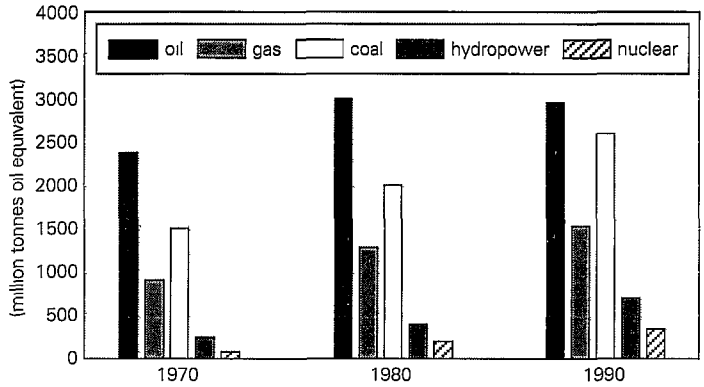


Source: Based on data from (29).

13.2 Throughout history, the increase in energy consumption has been accompanied by major changes in the energy mix used. A century ago, non-commercial sources of energy (fuelwood, agricultural residues, dung, etc.) constituted about 52 per cent of total energy used. That share dropped significantly as fossil fuels became the predominant source of energy. In 1930, the share of non-commercial fuels was 25 per cent of total energy used; in 1950, 21 per cent; in 1970, 12 per cent; and since then it has remained almost the same, although more than 2 billion people in the developing countries today depend on non-commercial fuels, especially fuelwood, for a substantial part of their energy needs (Chapter 7). Another important change was the decline of the share of coal. In the 1920s coal accounted for about 80 per cent of the world's total commercial energy consumption. By 1970, coal accounted for only 29 per cent of the total energy consumption, although its share increased slightly to 32 per cent in 1990 (Fig. 13.2). In later decades coal has been displaced mainly by oil which has been the main source of energy, although its share has declined from 46 per cent in 1970 to 36 per cent in 1990.

13.3 The consumption of commercial sources of energy is heavily concentrated in

Figure 13 2
WORLD COMMERCIAL ENERGY CONSUMPTION BY SOURCE

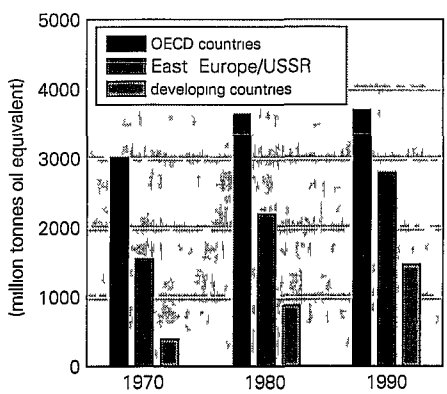


Source (30)

OECD countries and in Eastern Europe and the USSR (Fig. 13.3). In 1990 these countries, with about 22 per cent of the world population, consumed about 82 per cent of the world's commercial sources of energy, whereas the developing countries, with 78 per cent of the world population, consumed only about 18 per cent. On average, a person living in a high-income country consumes 15 times more energy than one living in a low-income country (Fig. 13.4), and about 4 times more than one living in a middle-income country. (1) However, wide disparities exist among different groups of people in the same country.

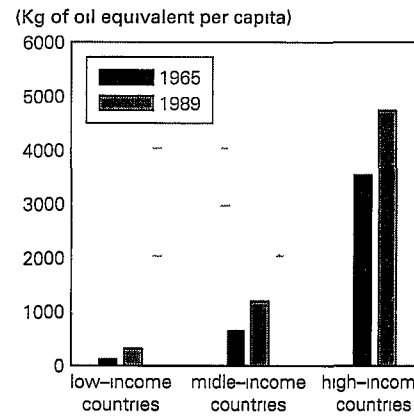
13.4 Events in the last two decades brought home a general realization that the era of cheap energy was over and that all economies would have to adapt to high energy prices. Furthermore, the fact that fossil fuels are finite in nature became more evident than ever. This has brought into focus the importance of establishing energy mixes to meet demand – with more reliance on indigenous resources – and the importance of increasing the efficiency of energy utilization. By the end of the 1980s, it had become clear that continuation of the current trends of energy consumption – especially of fossil fuels – could lead to increased degradation of the global environment

Figure 13 3
COMMERCIAL ENERGY CONSUMPTION



Source (30)

Figure 13 4
PER CAPITA ENERGY CONSUMPTION



Source Based on data from (1)

(through, for example, increased acidic deposition, urban air pollu-tion, and climate change), undermining future devel-opment and well-being across the planet.

13.5 Many projections have been made for future world energy demand (2, 3, 4), but the many uncertainties that are inherent in the assumptions on which these projections were based make them only roughly indicative. However, it seems that there is general agreement that world energy demand will continue to rise. The growth rate will be highest in the developing countries (about 4.5 per cent per year), followed by Eastern Europe and the USSR (3 per cent), and least in the OECD countries (about 1.3 per cent per year). Although OECD's share of total world energy consumption is likely to fall from 46 per cent at present to about 43 per cent by 2000, it will continue to be the region with the highest consumption of energy, especially of fossil fuels. (5)

13.6 At the end of 1989 the proven recoverable reserves of oil in the world were estimated at 139 billion tonnes (77 per cent in OPEC countries, 12 per cent in other developing nations, 6 per cent in Eastern Europe and USSR, and 5 per cent in developed market economies). (6) Coal resources are about 534 billion tonnes of oil equivalent, and natural gas, 104 billion tonnes of oil equivalent. At the world's 1990 level of consumption, oil reserves would last for about 46 years, coal for about 205 years, and natural gas for about 67 years. The uneven distribution of the world's fossil fuels has created a huge world-wide trade in energy commodities: some 44 per cent of oil, 14 per cent of gas and 11 per cent of coal are traded internationally. (7) Extensive distribution systems exist to serve this trade and ensure that resources reach the consumer. Natural gas is transported over land through some one million kilometres of pipelines, and oil through 400,000 kilometres of pipes, excluding local distribution systems. About 2,600 tankers ply the world's oceans carrying crude oil; another 65 vessels deliver liquid natural gas around the world.

13.7 World-wide a substantial amount of fossil fuels is used to generate electricity. Of about 11,000 TWh (1 terawatt hour = 1 billion kWh) generated in 1989, about 62 per cent came from thermal power stations (fossil fuel-fired), 20 per cent from hydropower, 17 per cent from nuclear power stations, and less than one per cent from geothermal resources. The share of nuclear power grew from 1.6 per cent in 1970 to 16.8 per cent in 1989. (8) As of 31 December 1990, there were 423 nuclear power plants in the world, with a total of 325,873 megawatts-electric (MWe) of installed nuclear power generating capacity. (9) Projections made in the mid-1970s that nuclear power would contribute 2,600 gigawatts-electric (GWe) by the year 2000 were revised and scaled-down to 1,075 GWe in the early 1980s and then to 444 GWe, according to a 1987 IAEA projection. (10) In the OECD region, nuclear power accounted for an average of 22 per cent of electricity generation in 1987, fossil fuels for 60 per cent and hydropower and geothermal energy for the remaining 18 per cent. It is projected that these proportions will remain unchanged until the year 2005. (11) However, the mix of fossil fuels used for electricity generation will change; the share of oil will decrease and will be displaced by coal.

13.8 Energy production, transformation, transport and use have important impacts on the environment. These impacts vary widely depending on the source of energy, technologies for its production, and its use in different sectors: agriculture, industry, transport, and domestic and commercial. The environmental impacts of different energy systems are normally assessed for the entire fuel cycle, i.e. from extraction of raw material, through transportation, processing,

storage and use of the fuel, to the management of wastes generated in all steps of the cycle. Such environmental impacts have been the subject of extensive studies by UNEP and other organizations since the mid-1970s (see, for example, (12 to 21) for details on the environmental impacts of different sources of energy).

Impacts of Energy Production and Use on Atmosphere

13.9 The combustion of fossil fuels and biomass generates a number of emissions into the air which vary in type and quantity according to the composition of the fuel used. On average, fossil fuel combustion in the different sectors accounts for the release of 90 per cent of global anthropogenic sulphur oxides, 85 per cent of nitrogen oxides, 30-50 per cent of carbon monoxide, 40 per cent of particulate matter, 55 per cent of volatile organic compounds, 15-40 per cent of methane, and 55-80 per cent of carbon dioxide. (21) The shares of emissions in the different sectors vary widely from one country to another and depend on the amount and composition of fuel used and on the emission abatement technologies in place. Coal combustion emits more sulphur oxides, nitrogen oxides and carbon dioxide per unit of energy than oil, natural gas or biomass. On the other hand, biomass burning emits more carbon monoxide than coal, oil or natural gas. The trends and impacts of emissions of sulphur oxides, nitrogen oxides, carbon monoxide and particulate matter from stationary and mobile sources have been discussed in Chapter 1. Of particular concern are the impacts of different emissions on urban air quality and their role in the formation of acidic deposition and climate change. The amount of carbon dioxide emitted from energy use in 1988 was about 6.3 billion tonnes of C (oil combustion contributed about 2.4 billion tonnes of C; natural gas, 1.1; coal, 2.4; and non-commercial fuels about 0.5), and if current trends in energy use and efficiency prevail, carbon dioxide emissions would reach about 9.1 billion tonnes of C in 2005 (5) and may double by 2010. (7) However, if greater efficiency in energy use prevails, the amount of carbon dioxide emitted in 2010 may be only 50 per cent higher than that in 1988. If radical improvements in energy use are made, the increase will be only 15 per cent.

Impacts of Energy Production and Use on Water

13.10 Water pollution can result from several energy-related activities. Acid mine drainage has polluted surface water streams in the United States and several other countries, and has reduced or eliminated aquatic life in many of them. Marine pollution has occurred from normal discharges of ships and offshore oil platforms and from accidental oil spills (Chapter 9). Oil refineries discharge liquid effluents containing oil, grease, phenols, ammonia and other toxic compounds. Power plants use water for cooling and the discharged waters are usually about 7 degrees Centigrade warmer than the receiving water bodies. It has been claimed that such thermal pollution affects aquatic life, but in some countries such thermal waters have been used for aquaculture, irrigation or other purposes. (12)

Impacts of Energy Production and Use on Land

13.11 Coal mining, especially strip mining, disturbs large areas of land. Although reclamation of strip-mined areas has been successfully carried out in some countries, for example in Germany, there is concern that a future increase in coal utilization could disturb more land and affect human settlements near mining areas. (12, 22) All other energy-related activities require land which may not be readily available, or which may preferentially be used for other purposes. The building of a dam may inundate forest

areas, with detrimental effects on wildlife; the construction of windmill parks or of solar power stations requires extensive areas and may compete with other land uses; and energy plantations may compete with land use for food production. Land is also required for the management of the massive amounts of solid wastes generated in some fuel cycles (especially coal and nuclear). Mining and processing of coal and uranium leave considerable amounts of solid wastes that must be disposed of properly. A major and growing source of solid wastes has developed along with air pollution control measures at fossil fuel-fired power plants. Sludge from flue gas desulphurization and ash collected by electrostatic precipitators, in addition to bottom ash, add to the problem of solid waste management, which requires increasing land areas.

Nuclear Power and the Environment

13.12 Concern about nuclear power development has focused on a number of issues, the most important of which are: the effects of radiation on humans, the safety of nuclear installations, the environmental impacts associated with radioactive waste management (including the decommissioning of nuclear installations), and the possibilities of diversion of nuclear material for non-peaceful uses. (12, 15) At each stage of the nuclear fuel cycle – from the mining and milling of uranium ores to fuel fabrication, power plant operation, eventual reprocessing of irradiated fuel, and the disposal of nuclear wastes – radioactive materials are released into the environment. The radionuclides released decay at different rates: most are of only local importance, because they decay rapidly; some live long enough to spread right around the world; and some remain in the environment virtually for ever. Different radionuclides also behave differently in the environment; some spread quickly, others move very little. In all, the operation of the nuclear fuel cycle contributes about 0.04 per cent of all radiation to which humans are exposed; natural sources, in comparison, account for 83 per cent and anthropogenic medical sources for about 17 per cent. (23) People living near nuclear installations do, of course, receive much higher doses than the average. Even so, typical doses around nuclear reactors at present constitute a fraction of one per cent of doses from natural sources. All these figures assume that the nuclear plants operate normally, for very much larger quantities of nuclear material may be released in accidents (Chapter 9). Although a vast amount of information has accumulated about the acute effects of radiation, many uncertainties still prevail on the effects of low-level radiation. (12, 15, 23, 24) The difficulty in proving cause and effect is also a problem in studying links between human genetic effects and irradiation. However, a recent study, (25) revealed that the incidence of leukaemia was higher in children born near Sellafield nuclear plant in the United Kingdom and in children whose fathers were employed at the plant, particularly those with high radiation dose recordings before their children's conception.

13.13 Radioactive wastes are generated at all steps of the nuclear fuel cycle. The bulk of the wastes occurs at the front end of the cycle, which includes mining and milling, while the more radioactive wastes occur at the back end of the cycle, which includes reactor operation and fuel reprocessing (in case of recycling). The latter wastes are generally divided into low-level wastes (LLW), intermediate-level wastes (ILW), and high level wastes (HLW) - which include wastes from reprocessing plants and/or spent fuel from nuclear reactors. World-wide, the volume of LLW generated in 1990 was about 370,000 cubic metres, that of ILW about 27,000 cubic metres and that of HLW and spent fuel about 21,000 cubic metres. (26) By the year 2000, the cumulative amount of LLW from nuclear power reactors could reach some 7 million cubic metres, and that

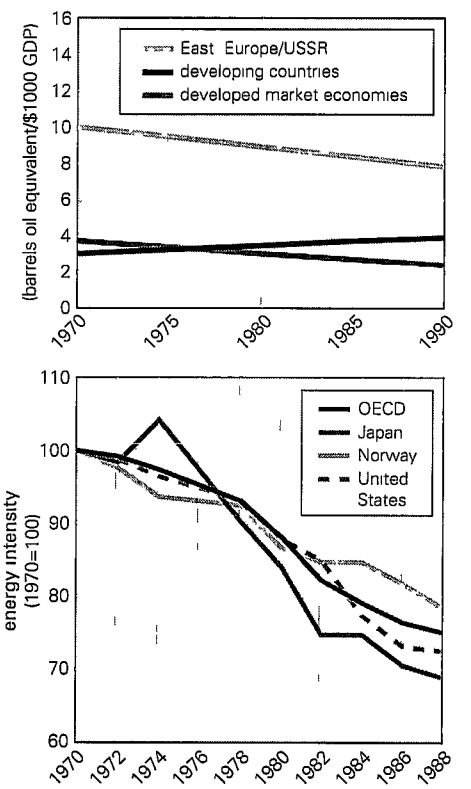
of HLW about one million cubic metres. (12) Low-level wastes are normally disposed of in surface, shallow or underground installations, which should be controlled for about 300 years. (27) Intermediate-level wastes are generally conditioned in cement, bitumen or resin and buried underground in shallow repositories. No disposal of high-level wastes has yet taken place. National authorities are storing them and some have been researching ways of solidifying them and disposing of them in stable geological formations on land, or on or under the seabed. (23, 27)

13.14 Decommissioning of nuclear installations--the process of dismantling and disposing of old nuclear plants--is technically feasible. However, the issues involved in decommissioning are complex. The various aspects of the problem--technical, economic, radiological, environmental and organizational – are in many ways, conflicting and will not be resolved until waste disposal routes are defined. In 1990, IAEA reported that 143 nuclear facilities (116 research reactors, 16 power plants and the rest other facilities) in 17 countries were at some stage of decommissioning (no large nuclear power plant has yet been decommissioned). Moreover, 64 nuclear reactors and 256 research reactors could be in need of decommissioning by the year 2000. (28) The costs of decommissioning are high, estimated at about $US 480 million for a 1000 MWe nuclear plant, but they could be higher.

Responses

13.15 In many countries, especially OECD countries, the environmental impacts of production and use of energy have been reduced over the last two decades as a result of more efficient use of energy, changes in the energy mix used, and control of emissions. The least progress has been in the developing countries, where energy conservation has been weak in all sectors and financial problems have constrained investment in emission control. Overall, from 1970 to 1990, energy intensity (energy use per unit of gross domestic product, GDP) in the developed market economies declined by 29 per cent, and in Eastern Europe and the USSR, by 20 per cent, although energy intensity there is about 3 times as high as in developed market economies. In contrast, energy intensity in developing countries increased by 30 per cent from 1970 to 1990 (Fig. 13.5). This increase has mainly been attributed to the very limited success of efforts to increase the efficiency of energy use and to the fact that non-commercial fuels have rapidly been replaced by commercial sources such as oil products and electricity. It is expected that

Figure 13.5
TRENDS IN ENERGY INTENSITY



Source Based on data from (6, 27, 31)

energy intensity will continue to decline in OECD countries by about 1.3 per cent per year until 2000, (5) but will not change in East Europe and the USSR, and may continue to rise in developing countries. (5, 6)

13.16 The change of the energy mix, especially in OECD countries, and the introduction of emission control measures have led to a marked decrease in emissions of sulphur oxides and carbon monoxide in the last two decades (Chapter 1). Although in OECD countries there is a trend towards strict regulation of large new combustion facilities, regulation of existing power plants is less consistent, because in some cases the retrofitting of existing plants is not cost-effective. Advanced generating technologies, which offer a number of advantages over conventional technologies (lower emissions of NO_x and SO_x and higher thermal efficiencies), are being developed in countries planning to depend on increased utilization of coal for electricity generation (such as Germany, the United Kingdom and the United States). The development of combined heat and power (CHP), the promotion of industrial autogeneration, the use of industrial waste heat and the development of CHP/district heating systems have also contributed to more efficient use of energy and, consequently, to the reduction of emissions.

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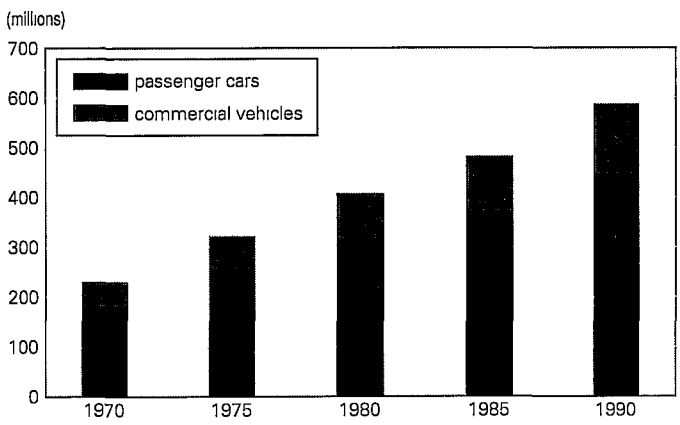
Chapter 14

TRANSPORT

14.1 Transport is an essential component of social and economic development. Today, more people travel over greater distances and more fuels, raw materials and products are transported around the world than ever before. Transport systems and modes vary geographically and are continuously changing over time. In many developing countries, draught animals remain the principal means of conveying goods over short distances, while personal travel is predominantly on foot, particularly in rural areas. In semi-urban and urban areas, tri-shaws, cycle-rickshaws, pedal carts, and other similar traditional forms of transport account for a large share of road transport use in developing countries. In some countries, bicycles represent an important mode of transport. In 1989 China and India together had an estimated 600 million bicycles. (1) In Denmark, the Netherlands and some other European countries cycling has been and remains popular.

14.2 In the developed nations road transport is the most popular mode of transport for both passengers and freight and it is becoming increasingly important in developing countries. The number of motor vehicles in the world has more than doubled in the last 20 years (Fig. 14.1) and is expected to double again in the next 20 or 30 years. Automobile production and ownership are still overwhelmingly concentrated in developed countries. The OECD countries account for 88 per cent of car production and 81 per cent of the global fleet. (2, 3) Car ownership in the developing countries has risen sharply, averaging an annual growth rate of 10 per cent per annum between 1970 and 1990, and is expected to grow further as vehicle ownership in developed countries stabilizes. However, the average level of motorization will continue, to be much higher in the developed countries than in the developing countries. At present, the number of cars per 1,000 inhabitants in the United States is about 550; in Western Europe, 200-400; in Africa, 9; in India, 2; and in China, 0.4. Other modes of transport have also shown an increase since 1970. Civil aviation flew about 7 billion km in 1970, with the number of passenger-km at 382 billion. These figures rose to

Figure 14.1
MOTOR VEHICLES IN USE



Source: Based on data from (4, 5, 23).

12 billion km and 1,368 billion passenger-km in 1987. (4, 5) Railway freight increased, from 5,019 billion net tonne km in 1970 to 7,285 billion in 1987. Sea shipping rose from 2,605 million tonnes in 1970 to 3,675 million tonnes in 1980, but dropped to 3,361 million tonnes in 1987 as a result of the decrease in oil transport, which accounts for about 55 per cent of all goods transported by sea.

Transport, Resources and Environment

14.3 The transport sector consumes vast amounts of resources. It consumes land for roads, railways, harbours, airports and associated facilities. It also uses minerals and metals for vehicle and infrastructure construction, and substantial amounts of energy. Motorways in the OECD countries increased from 73,000 km in 1970 to 132,000 km in 1988, i.e. an increase of 81 per cent. (6) In the developing countries the construction of new motorways (and roads in general) has been constrained by economic difficulties, and over the past two decades the conditions of existing roads have deteriorated in many developing countries due to lack of or inadequate maintenance. In some countries, land used for the transport sector (whether for construction of motorways, railways, harbours, or airports) has conflicted with other land uses, e.g. for food production.

14.4 World-wide, the transport sector accounts for about 30 per cent of total commercial energy consumption, of which road transport alone consumes 82 per cent, almost all of which comes from oil-derived products. (7, 8) However, wide differences exist between regions and countries. For example, in Eastern Europe and the USSR the transport sector accounts for about 13 per cent of total energy consumption; (9) in Kenya, it accounts for about 45 per cent. (10) Since the early 1970s, several alternatives to oil have been studied as automotive fuel. Attention currently centres on alcohol fuels (ethanol and methanol), natural gas and, to a lesser degree, electricity. Alcohol fuels can be derived from biomass; methanol can also be produced from natural gas and coal. Brazil's ethanol programme (derived from sugar cane), launched in 1975, provided roughly half the country's automotive fuel in 1986. Almost one-third of Brazil's cars are now capable of running on pure ethanol; others run on an 80/20 gasoline-ethanol blend. (2, 11) The use of natural gas directly as an automotive fuel, either in compressed from (CNG) or in liquefied form (LPG), is becoming popular in some countries. Today, there are more than 300,000 CNG vehicles on the road in Italy. Italy and Japan meet almost 4 per cent of their national transportation fuel demand by using LPG. Other countries, such as Argentina, Australia, Indonesia, New Zealand, Pakistan and Thailand, are beginning to use natural gas as a transportation fuel.

Impact of Transport on Atmosphere

14.5 Cars, trucks, and buses play a prominent role in generating virtually all the major air pollutants, especially in cities. Petrol-burning vehicles emit carbon dioxide, carbon monoxide, hydrocarbons, oxides of nitrogen, particulates and trace compounds. In confined places and congested streets carbon monoxide concentrations can rise to levels that are hazardous to health, especially for people with a heart or lung weakness. Oxides of nitrogen and hydrocarbons interact in the presence of sunlight to produce an oxidant smog which irritates the eyes and lungs and damages sensitive plants. In countries where leaded gasoline is used, almost all the lead in air emissions in cities is from automobile exhausts. Studies carried out near highways have shown elevated concentrations of trace metals such as cadmium, lead, copper, zinc, nickel and chromium in vegetation and soil. (11, 12) Although diesel-powered vehicles emit

comparable or lower amounts of carbon monoxide and hydrocarbons than gasoline-powered cars, they emit 30-50 times more particulate matter. (13, 14) Some 80-90 per cent of such particulates are less than one micrometre in diameter and hence are easily transported by the airstream and readily settle in the lower respiratory tract when inhaled. These particulates contain hundreds of organic compounds, several of which are carcinogenic. Aircraft and railway locomotives together emit a far smaller volume of air pollutants than road vehicles do. However, it has been estimated that the world's fleet of civilian aircraft generates about 2.8 million tonnes of nitrogen oxides per annum, which could increase the formation of tropospheric ozone. (15)

14.6 All in all, world-wide, the transport sector generates about 60 per cent of anthropogenic carbon monoxide emissions, 42 per cent of nitrogen oxides, 40 per cent of hydrocarbons, 13 per cent of particulates, and 3 per cent of sulphur oxides (Box 14.1). The transport sector is also a major contributor to greenhouse gases; it generates about 18 per cent of all carbon dioxide released from fossil fuels (8, 16, 17, 18) or about 15 per cent of total global anthropogenic carbon dioxide emissions. The chlorofluorocarbons contained in air-conditioning systems and foams for automobiles are now being phased out. (18)

14.7 Of all present day sources of noise, the noise from transport - above all that from road vehicles - is the most diffused. In many countries it is the source that creates the greatest problems. Everywhere it is growing in intensity, spreading to areas until now unaffected, reaching ever further into the night hours and creating as much concern as any other type of pollution. Recent data show that about 16 per cent of the population in OECD countries - approximately 110 million people - are exposed to road traffic noise in excess of 65 dBA, the level above which noise causes disturbance and harm. (19, 20) For aircraft noise, about 0.5 per cent of the population in the European countries and Japan are exposed to noise levels above 65 dBA, whereas the proportion of the population affected in the United States is 2

BOX 14.1

ESTIMATES OF MAJOR EMISSIONS INTO THE ATMOSPHERE FROM TRANSPORT

	million t/y	*% of total anthropogenic emissions*
Sulphur oxide	*3.0*	*3*
Particulates	*7.4*	*13*
Nitrogen oxide	*28.6*	*42*
Carbon monoxide	*106.2*	*60*
Hydrocarbons	*21.2*	*40*
Carbon dioxide	*1,050.0*	*15*

Source: (23).

per cent. In many countries the percentage of the population living in grey areas, that is, those exposed to noise levels between 55 and 65 dBA, is increasing and therefore noise has become a more significant problem than it was thought to be a decade ago. The problem is growing, in particular in many urban centres in developing countries. Noise is a major problem in Manila, Bangkok, Cairo and many other cities.

Impact of Transport on Water

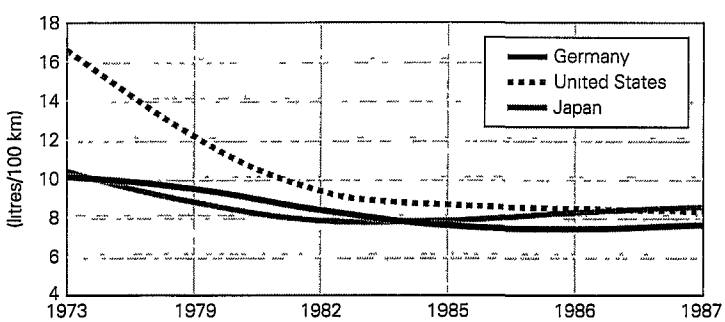
14.8 Oil pollution of inland waterways and of the marine environment results from normal discharges of barges and ships, and from accidental releases (Chapter 4, 9). In several developing countries, used motor oils are dumped on land or in surface water bodies, resulting in a number of environmental impacts (e.g. pollution of groundwater resources, effects on aquatic life in surface waters, unpleasant fouling odours, etc.). In some cases, used motor oils are discharged into sewers (especially at gasoline stations and garages). This could create problems at sewage treatment plants by destroying or reducing the efficiency of micro-organisms that digest organic matter. Leakage from underground gasoline storage tanks, especially at gasoline stations, has caused pollution of groundwater, for example, in the United States. (21)

Response

14.9 Over the last two decades, significant progress has been made in increasing the energy efficiency of new cars. New passenger cars in the United States today are almost twice as efficient as those of the early 1970s. On average, fuel consumption decreased from 16.6 litres/100 km in 1973 to 8.3 litres/100 km in 1987 (Fig. 14.2). In OECD countries, in general, fuel consumption per car has decreased by about 25 per cent since 1970. (2, 7) This higher efficiency has been achieved mainly by weight reduction in cars by substituting steel by aluminium, plastic and ceramics in car manufacture, and by improvements in the engine and transmission.

14.10 Progress has also been made in controlling automobile emissions, especially in developed countries. Among the air pollutants, lead has been most successfully fought by phasing out leaded gasoline. Between 1976 and 1987, lead in auto emissions dropped by 87 per cent in the United States. (8) Similar results have been achieved in other OECD countries. However, in most developing countries leaded gasoline is still the main fuel used. Abatement of other automobile emissions has been less successful and has been complicated by the fact that controlling one or more pollutants may, in some cases, be achieved only at the expense of in-creases in others. For example, lean-burn engines (with an air to fuel ratio of 20 to 1 or

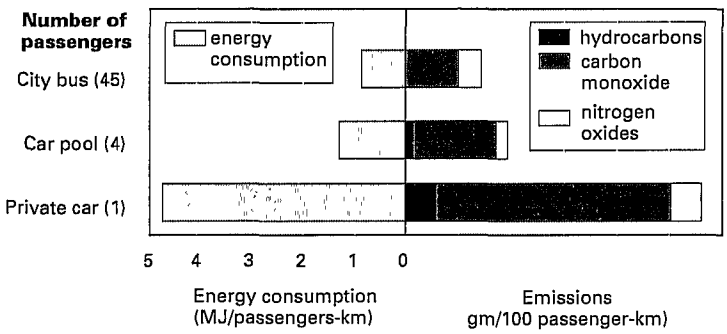
Figure 14.2
FUEL EFFICIENCY OF MODERN AUTOMOBILES



Source: Based on data from (7).

more instead of the conventional 15 to 1) allow more efficient fuel combustion and reduce the emission of nitrogen oxides and carbon monoxide, but tend to increase emissions of hydrocarbons. And while a catalytic converter reduces carbon monoxide, it slightly increases carbon dioxide and sulphur oxides emissions. (8) Although significant declines in carbon monoxide and hydrocarbons have been achieved in Canada, Japan, the United States and several other OECD countries, auto emissions are on the rise because of the increase in the number of vehicles. (6) This is particularly true in developing countries, where control measures are rarely implemented because of technical and economic problems (old age of vehicles, especially public vehicles and buses, inadequate maintenance and repair due to lack of or high prices of spare parts, traffic congestion, etc.).

Figure 14.3
ENERGY CONSUMPTION AND EMISSIONS OF URBAN TRANSPORT MODES



Source: Based on data from (24).

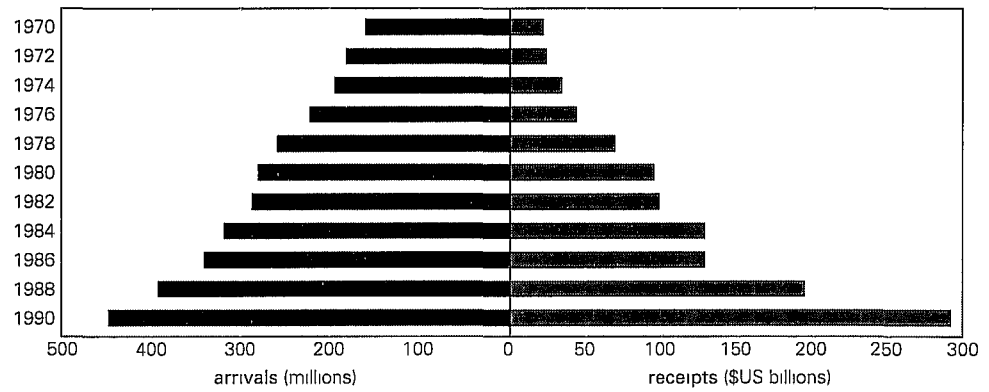
14.11 The regulatory measures introduced in the last two decades, (such as control of emissions, noise control, safety improvements in road, sea and air transport, traffic improvements, reduction of noise around airports, etc.), especially in developed countries, have contributed to varying degrees to a general reduction of the environmental impacts of the transport sector. The fact that public passenger transport systems are more energy efficient and less polluting on a passenger-km basis (Fig. 14.3) has been brought into focus. It has been demonstrated in some countries that the switch to buses and fixed rail transport systems in intra-city travel has led to marked energy savings and a reduction in pollution. (22) Reduced highway speed limits have also led to an increase in fuel efficiency and automobile tyre life, and have reduced the number of highway accidents in several countries.

Chapter 15

TOURISM

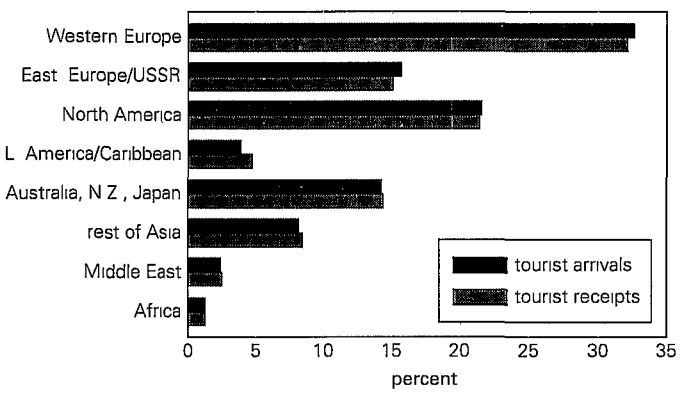
15.1 Tourism is big business. It has become a major industry world-wide and is expected to show continued strong growth. In the past two decades, international tourist arrivals grew nearly three-fold, and international tourist receipts rose from approximately $US 22 billion in 1970 to about $US 300 billion in 1990 (Fig. 15.1). If domestic tourism and travel are included, these figures will be much higher. According to a study carried out for American Express Travel, (1) travel and tourism accounted for sales of about $US 1,916 billion in 1987, making it the largest source of employment in the world. Over the past two decades, the bulk of tourism centred on Western Europe, North America, Eastern Europe and the USSR and East Asia and Pacific (Fig. 15.2). The Mediter-ranean region has accounted for an average of 36 per cent of international tourism. (2)

Figure 15 1
WORLD TOURISM



Source Based on data from WTO reports

Figure 15 2
TOURIST DESTINATIONS AND RECEIPTS (1989)



Source Based on data from (12)

15.2 Tourism expenditures as a contribution to gross domestic product (GDP) vary widely from one country to another, depending on the size of the economy and level of expenditure. In many Caribbean States, tourism's share in the GDP amounts to between 15 and 30 per cent. Although it has been considered that international tourism is an easy means of contributing to the economic growth of developing countries, studies carried out in the past two decades have demonstrated that the costs of the necessary infrastructure and supplies for international tourism have been very high in terms of foreign exchange, and that global balance sheets often show that many years must elapse before the receipt of the first real foreign exchange earnings from tourism-related activities. In fact, the balance of foreign exchange accruing to developing countries is relatively small. (3)

15.3 In many developing countries a significant part of the foreign exchange pays for the cost of importing goods and services used by tourists, some of the costs of capital investment in tourist amenities, such as hotels and vehicles, payments to foreign travel agents, royalties, etc. and promotion and publicity expenditure abroad. Therefore, the international tourist receipts are not an indicator of the real income from tourism. The net income will vary from one country to another, depending on the sums spent for tourist services and investment in the sector. It is now becoming increasingly clear that it is not tourism that leads to development, but a country's general development that makes tourism profitable.

Impact of Tourism on Environment

15.4 Like other sectors of development, tourism can have both positive and negative impacts on the human environment. Tourism has benefitted the environment by stimulating measures to protect physical features of the environment, historic sites and monuments, and wildlife. Recreation and tourism are normally the primary objectives of establishing and developing national parks and many other types of protected areas. These natural areas are becoming major attractions and constitute the basis for what is now known as "nature tourism" or "ecotourism". Two main types of ecotourism exist: marine-based, and big-game/safari tourism. Case studies (e.g., the Khao Yai National Park, Thailand; the Virgin Islands National Park; Kangaroo Island, South Australia; and the wildlife parks in East Africa) have demonstrated that ecotourism yields direct financial benefits that outstrip the cost of maintenance and development of the parks. In addition, it stimulates employment and rural development in surrounding areas. (4) The public in such areas is becoming increasingly aware that environmental protection increases the people's economic gains by increasing the number of visitors. In Rwanda and the United Republic of Tanzania, surveys have indicated that national parks can be protected and promoted to bring more tourists (5) and the concomitant economic benefits.

15.5 The historic and cultural heritage that determines the attractiveness of a country to tourists encourages the authorities to protect it. There are many examples of cultural salvage operations stimulated by tourism and many efforts have been made to provide for systematic protection of old towns, villages and groups of buildings of historic and artistic interest. Unesco has supported many of these activities.

15.6 Tourism has been a driving force for the establishment and/or improvement of summer and winter tourist settlements and health resorts. At Ixtapa, on the Pacific coast of Mexico, a new tourist resort has benefitted the neighbouring environment by providing infrastructure facilities (water supply, sewage

systems, roads, electricity, telecommunications, etc.). In many developing countries projects have been undertaken which have contributed both environmentally and economically to improving the quality of life of local populations. "Farm" or "rural" tourism has grown in some countries, for example in France and the United Kingdom, contributing to the enhancement of farming and development in the countryside and thereby discouraging excessive rural-urban migration. (6, 7)

15.7 The environment, natural and man-made, constitutes the basic assets of the tourist industry. If the carrying capacity of these assets is exceeded, they suffer from deterioration and even irreversible damage. Many examples of such deterioration have resulted from mass tourism (especially the so-called "sand-and-sun tourism") in the Caribbean, Mediterranean, and other seaside areas. In Barbados the growing numbers of tourists have exerted increasing pressure on land use and infrastructure on the island. The increased discharges of sewage into the sea have led to the physical reduction of nearshore marine habitats. Water and electricity shortages have become common in Antigua, Barbados and Grenada, because the carrying capacity of such services has been exceeded. (8) In Tunisia the groundwater level in the Hammamet region has been lowered due to excessive withdrawal to meet the increasing needs of tourism. (2) In Egypt increased tourism has put excessive pressures on electricity consumption. In a study, (9) it was demonstrated that one of the several multinational hotels built in Cairo to meet the increasing numbers of tourists consumes sufficient electricity to meet the needs of 3,600 middle-income households.

15.8 Tourism and recreation have affected coastal areas in a number of ways. The damage to coral reefs in Kenya, Madagascar, Malaysia, Mauritius, Seychelles, Thailand, United Republic of Tanzania and other countries has been well-documented. (10) The pressures of tourism on coastal areas are best illustrated by the situation in the Mediterranean region, which attracts about 36 per cent of international tourism (and much more in terms of resident recreation). Pollution of coastal waters as a result of increased discharge of sewage into the sea in the high seasons has become a chronic phenomenon. Many countries (e.g. France, Greece and Italy) have had to close some beaches temporarily because the quality of their waters was not acceptable for bathing. In the early 1980s, a survey of 1,200 beaches in France showed that 30 per cent were not suitable for bathing. (11) Similar numbers have been recorded in other countries.

15.9 Excessive tourism has created excessive seasonal atmospheric pollution in some areas. The high tourist inflows by road into Spain, France and Italy has largely contributed to this problem. In Yugoslavia, where the proportion of international arrivals by road reaches 86 per cent, seasonal atmospheric pollution due to tourism is the highest in the Mediterranean region. (2) Morocco, Syrian Arab Republic and Turkey are also increasingly affected by such a seasonal increase in atmospheric pollution.

15.10 The increasing number of visitors to archaeological and historical sites has been a matter of concern. This could have negative and even destructive impacts, notably through trampling, visitor's breath or artificial lighting in confined or underground areas. Such pressure is becoming acute in places like Luxor in Egypt and Venice in Italy. It is also becoming acute in some museums and art galleries. (2, 8)

15.11 While tourism plays a major role in mountain area economies, in some instances ecosystem damage has reached a critical level, thus impairing the future of tourism

itself. About 150 million visitor nights are spent in the European Alps each year, and in the high season the local and tourist population density may reach a high of 1,800 persons per square kilometre, higher than that of many industrialized districts. Such excessive pressure affects the mountain ecosystem: the soil, the vegetation, wildlife and water balance. The Mount Everest region in Nepal, once very isolated and rarely visited, has become a victim of success. Now there is a major trekking and climbing industry in the area. Major management problems include garbage and waste disposal and excessive firewood collection. (4)

Responses

15.12 The relationship between tourism and environment is one of a delicate balance between development and safeguarding the environment. The Manila Declaration (1980) emphasized that the needs of tourism must not be satisfied in a fashion prejudicial to the social and economic interests of the population in tourist areas, to the environment or, above all, to natural resources and historical and cultural sites, which are the fundamental attraction for tourism. It stressed that these resources are part of the heritage of mankind, and national communities and the entire international community must take the necessary steps to ensure their preservation. If tourism is to become a sustainable development activity, long-term and environmentally sound planning is a prerequisite for maintaining a balance between tourism and the environment.

15.13 However, burdened by foreign debt and desperate for hard currency, many developing countries have shrugged off their worries that tourism could degrade the natural environment – the very beautiful resource that makes them attractive. These short-sighted policies have in fact led to marked degradation of the environment in some countries, which has kept away numbers of tourists. It would take years and massive financial resources to redress this degradation and re-accelerate tourism. On the other hand, in many countries several efforts have been made to establish and/or promote protected areas and protect wildlife (Chapter 8). Efforts to improve the environment in coastal zones are also under way in several countries (Chapter 4).

PART III

HUMAN CONDITIONS AND WELL-BEING

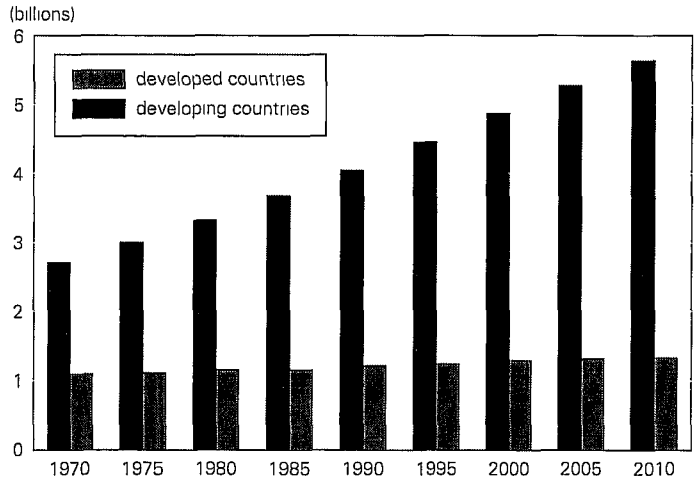
Chapter 16

POPULATION GROWTH AND HUMAN DEVELOPMENT

16.1 Between 1970 and 1990, the world population grew by 1.6 billion; 90 per cent of that growth was in the developing countries (Fig. 16.1). In the next two decades, it is projected, another 1.7 billion people will be added, and the world population will reach about 7 billion in the year 2010. Although the rate of population growth has been steadily falling since 1970, in both developed and developing regions (Fig. 16.2), the net annual addition to the number of people has been rising since the 1970s. The 1990s will witness the largest average annual increment to world population in history (Fig. 16.3), after which population growth will slow down and world population may reach a stationary level of 10.5 billion by 2110. (1, 2)

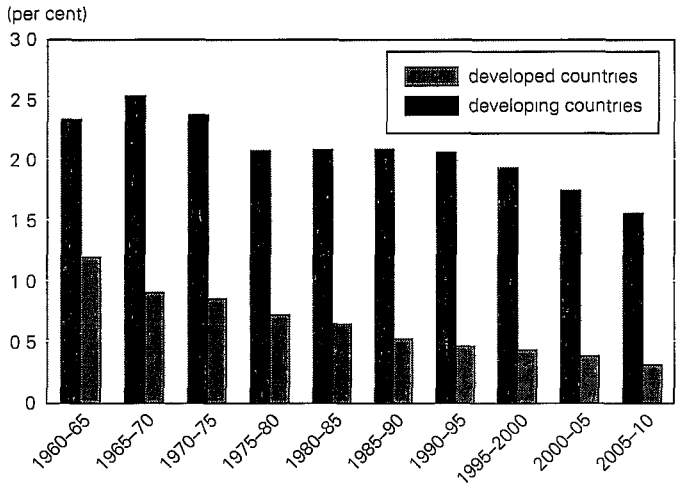
16.2 The average annual rate of population growth in the developed countries decreased from 0.86 per cent per year in the period 1970-1975 to 0.53 per cent per year in the period 1985-1990. In contrast, the annual rate of population growth in the developing countries as a whole decreased from 2.38 per cent per year in the period 1970-1975 to 2.10 per cent per year in the period 1975-1980, and has since remained constant. However, regional differences exist. 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 subregion to another. China, with nearly a fifth 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

Figure 16.1
WORLD POPULATION



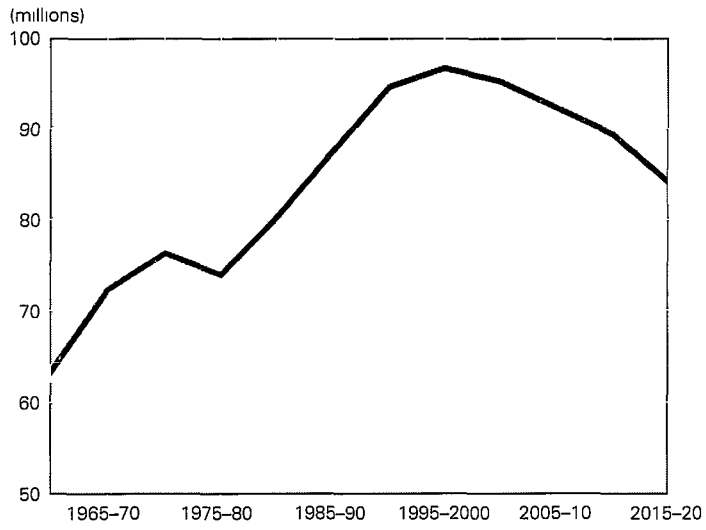
Source: Based on data from (2).

Figure 16.2
AVERAGE ANNUAL POPULATION GROWTH RATE



Source Based on data from (2)

Figure 16.3
AVERAGE ANNUAL WORLD POPULATION INCREASE

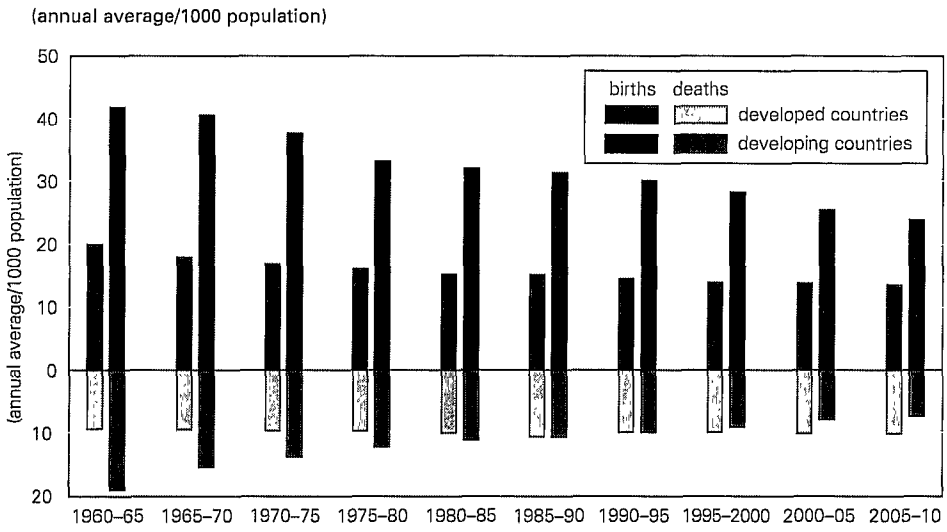


Source: Based on data from (2).

to 1.39 per cent per year in 1985-1990. (2) The five most populous countries: China, India, Indonesia, USSR and the United States 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.

16.3 While birth and death rates have fallen world-wide (Fig. 16.4), life expectancy at birth has risen from an average of 56.7 years in 1970-1975 to an average of 61.5 years in 1985-1990, and is projected to increase further in future. (2) The infant mortality rate has fallen from 94 per 1,000 births per year in 1970-1975 to 71 per 1,000 births per year in 1985-1990. 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 1,000 live births). In contrast, infant mortality in 34 developing countries (2 countries in Latin America and the Caribbean, 2 in the Middle East and North

Figure 16.4
BIRTH AND DEATH RATES



Source: Based on data from (2).

Africa, 23 in Africa south of the Sahara, and 7 countries in Asia) is still more than 100 per 1,000 live births. (3)

16.4 Although the elements of family planning are well understood, questions remain about how to promote and implement it. Early marriage and child-bearing in the developing countries are inextricably tied to the economic and social rewards that societies attach to children. The industrialized world has found that development is the best means of population control. In fact, population growth, development and a productive environment form the three points of a triangle. Progress cannot be made in any one area unless progress is made in the other two. The World Fertility Survey has found that women would have an average of 1.41 fewer children if they were able to choose their family's size. The difference amounts to approximately 1.3 billion more people in as little as 35 years' time. (3) Therefore, without the provision of adequate women's education and without radical improvements in the status of women, family planning cannot fully succeed. And this cannot be achieved without development. The most telling and tragic indicator of poverty is high infant mortality rates. In poor societies, experience has repeatedly demonstrated that attempts to lower birth rates - and population growth - cannot be separated from efforts to keep children alive and healthy. The survival of children is one of the major motivating forces in parents' desire for smaller families. (4) Successful programmes to improve birth spacing revolve around a range of health and literacy initiatives. If these are implemented world-wide, the world may achieve "replacement level" fertility rates – i.e. slightly over two children per couple - by 2010, and the world population may stabilize at 7.7 billion by 2060. If, however, this replacement level fertility rate is not reached till 2065, global population would be 14.2 billion in 2100. (5) Such an explosion would obviously mean fewer resources per

capita than are available today – a startling example of intergenerational irresponsibility and inequity.

People, Resources, Environment and Development

16.5 An underlying theme of the last two decades has been the recognition that development is a multidimensional concept that encompasses not only the economic and social aspects of national activity, but also those related to population, the use of natural resources and management of the environment. (6) The growing attention to interrelationships among people, resources, environment and development stemmed from three basic considerations. First, it became increasingly evident that development efforts at national and regional levels affect the productive process in a variety of ways - not all of them beneficial. Second, while such effects involve strong interactions among economic, social, demographic and physical factors, it is difficult to trace out the casual links among them. Third, accordingly, there continued to be great uncertainty about the likely long-term impact of development efforts as they affected quality of life and environment; appraisal has tended to focus on the risks of negative impacts rather than on positive impacts.

16.6 The relationship between people, resources, environment and development is in fact very complex. Population, environment and development factors interact in different ways in different places. Not only the pace of development, but its content, location and the distribution of its benefits determine, in good measure, the state of the environment. These factors also influence the growth and distribution of population. Environmental resources provide the basis for development, just as environmental factors constitute part of the improvement in the quality of life that development is meant to bring about. Similarly, the size of population, its rate of growth and the pattern of its distribution influence the state of the environment, just as they condition the pace and composition of development.

16.7 Many global and regional models (for example, Worlds 2 and 3 by the Club of Rome, the Mesarovic-Pestel World Model, MOIRA-Model of International Relations in Agriculture, the Latin American World Model, the United Nations World Model, Global-2000, the energy models of the International Institute for Applied Systems Analysis, and several others) have been used in the last two decades in attempts to determine future consumption of resources and their availability. Because of inherent uncertainties in assumptions and the limited factors involved, the results of these models have been only roughly indicative. The models have, however, been useful in identifying gaps in knowledge. The construction of a single aggregate global or regional model that incorporates all the variables in the equation of population-resources-environment-development remains a challenge to the scientific community. Today, the question "Is there any way to meet the needs and aspirations of the five billion people now living on the earth without compromising the ability of tomorrow's eight to 10 billion to meet theirs?" is still as valid – and without answer – as it was at the time of the Stockholm Conference in 1972. Population growth need not necessarily reduce standards of living, impair the quality of life or cause environmental degradation. Global and historical assessments of the earth's capacity and human ingenuity to produce goods and services have prompted some experts to project an optimistic outlook. (7, 8) Growth of world population has in the past been accompanied by a steady increase in the world's capacity to provide for the necessities and amenities of human life. The problem, therefore, is not simply only one of numbers.

The problem has been the widening disparity in consumption and lifestyles between the rich and the poor. A child born in a rich industrialized country or in a rich family in a developing country, where per capita consumption of energy and materials is high, places a much greater burden on the planet than a child born in a poor country. (9) Two groups in particular are responsible for a disproportionate share of consumption of resources and environmental degradation: the world's top billion richest and bottom billion poorest. (10) Those at the top consume the largest slice of the earth's resources and generate enormous quantities of waste. Those at the bottom have the highest fertility rates and in their quest for survival are responsible for a disproportionate amount of environmental destruction.

Human Development

16.8 In the last two decades, several indices have been proposed to measure the quality of life, for example, the physical quality of life index, (11) the human suffering index (12) and, more recently, the human development index introduced by UNDP. (13, 14) These indices have brought into focus the widening gap between the North and South. The developing countries, with 77 per cent of the world's population, earn only 15 per cent of the world's income. The average GNP per capita in the North ($US 12,510) is now 18 times the average in the South ($US 710). According to the human development index, about 2 billion people have a low degree of human development, (14) most of them are the poorest in the world.

16.9 Poverty has been defined in a number of ways. Perhaps the most eloquent definition is that of Robert McNamara, 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". (15) This means that poverty is, indeed, far more than just an economic condition. The World Bank has recently used two poverty lines to estimate the number of poor people in developing countries. (16) Those whose annual consumption is less than $US 370 per person per year are considered poor, and those whose annual consumption is less than $US 275 per person per year are considered extremely poor. The use of the upper poverty line of $US 370 gives an estimate of 1,116 million people in the developing countries living in poverty. Of these, 630 million people were classified as extremely poor. UNDP estimates (14) that the number of poor people in the developing countries will rise to 1.3 billion by 2000 and probably 1.5 billion by 2025.

16.10 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, but there is a steady concentration of poverty in Africa. It is estimated that Africa's share of the world's poor will rise from 30 per cent today to 40 per cent by 2000, overtaking Asia. (14)

16.11 Economic performance in the last two decades has been erratic and has varied widely among countries and continents. In general, there has been economic deterioration in much of the developing world. The two decades have seen escalating external debt, falling prices for raw commodities, and adjustment policies that have exacted a severe toll from the poor. 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. (13)

16.12 As countries have foundered in the inhospitable world economy of the last two decades, many developing countries have 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 foodstuffs, and deep cuts in government spending. But soon it became clear that economic recovery and structural change were slow in coming. Not only that: the impacts of declines in incomes and cutbacks in social services began to be evident. Studies by the United Nations Children's Fund (UNICEF) (3) showed that in 37 poor nations, spending per capita 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. The basic problem with structural adjustment is that little attention has been paid to its effects on the poor. Accumulating evidence suggests that many structural adjustment measures have hurt the poor disproportionately, and by the end of the 1980s the issue of adjustment had come under scrutiny by many agencies. (3)

16.13 The problems of the developing countries have been compounded by the dramatic increase in their foreign debts, which are now more than $US 1.3 trillion, requiring nearly $US 200 billion a year in debt servicing alone. (13, 14) Also of vital importance is the way resources are now moving across the North-South boundary. Before 1984, the net flow was progressive: industrial countries gave more to developing countries in loans and grants each year than they took back in interest and principal payments. By 1990, the South was transferring at least $20 billion a year to the North. Reduced prices paid by industrialized nations for the developing world's raw materials have resulted in losses to developing countries of as much as another $US 40 billion each year. (17)

16.14 This dismal economic situation of the developing countries causes and/or aggravates environmental despoliation which, in turn, makes economic and structural reform difficult to achieve. It has long been recognized – and particularly since the Stockholm Conference – that poverty is one of the greatest threats to the environment. In the developing countries, many choices that degrade the environment are made because of the imperative of immediate survival, not because of a lack of concern for the future. Economic deprivation and environmental degradation have thus come to reinforce one another in a vicious cycle that perpetuates destitution in many developing countries. Top priority for the world community will have to be agreement on ways and means – many of them are well-known – to stop this cycle.

Chapter 17

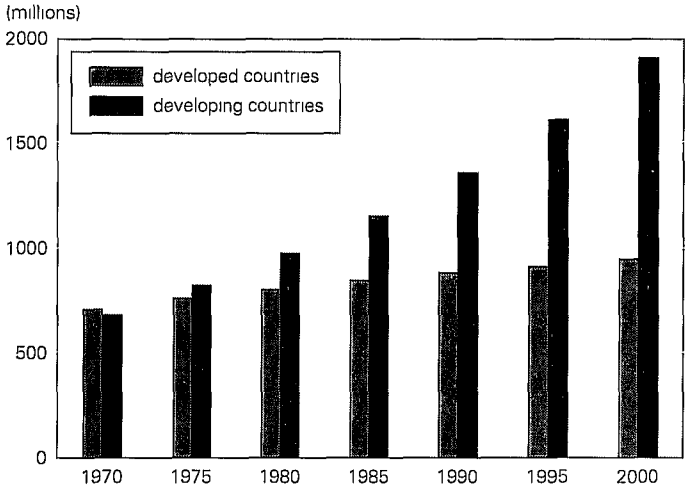
HUMAN SETTLEMENTS

17.1 A human settlement is a community - a group of people living in one place. (1) The development of such a community for productive purposes involves a transformation of the natural environment into a man-made environment that includes a variety of structures and institutions designed to meet the community's needs for work, recreation and other aspects of human life. It thus has a natural setting, a physical infrastructure of housing, transport, water, waste disposal and energy sources; and a social infrastructure of political, educational and cultural services.

17.2 Throughout the world, the single most frequent form of human settlement is the village. Cities and towns are far fewer than villages, isolated farmsteads or herding camps. In 1970, 62.9 per cent of the world population lived in rural areas; in 1990 this proportion declined to 57.4 per cent and is expected to decline further to about 40 per cent by the year 2025, (2) mainly as a result of rural-urban migration.

17.3 Urbanization has been growing in developing countries at a much faster rate than in developed nations (Fig. 17.1). In the developing countries, the level of urbanization increased from 25.4 per cent in 1970 to 33.6 per cent in 1990 and is expected to reach 39.3 per cent by the end of the century, and 57 per cent by the year 2025. (2) By the year 2000, 77 per cent of Latin America's population, 41 per cent of Africa's and 35 per cent of Asia's will be urbanized. The urban population in the developing countries is growing by 3.6 per cent a year, compared to industrialized regions, where the urban population is growing by only 0.8 per cent a year. (3) This runaway expansion of towns and cities in the developing countries has overwhelmed transport, communications water supply, sanitation and energy systems and created a vast array of environmental, social and economic problems.

Figure 17.1
URBAN POPULATION



Source: Based on data from (2).

Urbanization and Environment

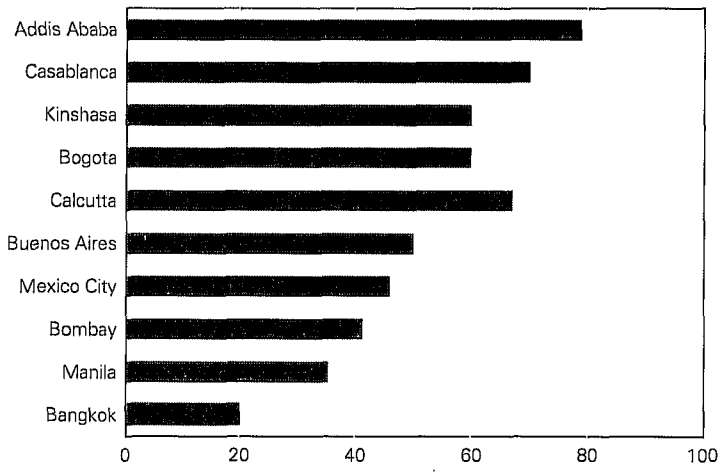
17.4 Despite technological achievements that enable people in developed and in some developing

countries to live and work in high-rise buildings, the most common pattern of urban growth is still urban sprawl. Such urban sprawl chews up land; in some countries valuable agricultural land. Between 1980 and the end of the century, urban areas in developing countries will more than double in size, from about 8 million hectares to more than 17 million hectares. (3) This means loss of land, additional to that lost by over-use and mismanagement (Chapter 6). This loss of land leads to more deterioration of rural areas and it creates more food supply problems for the urban areas, which normally depend on nearby farms for supplies of various agricultural products. Even in countries like Australia and the United States, where food and raw material supplied for cities are drawn from long distances, there were local examples of urban expansion having harmful effects on specialized rural production, e.g. wine growing around Adelaide in Australia, and fruit and vegetable production in California. (1)

17.5 Another important impact of urban growth on neighbouring areas is illustrated by the increased demand for natural resources and the increase in the inflow and outflow of various materials, products, energy, water, people and wastes. A study of fuelwood use in Kenya has shown that one of the major contributors to deforestation was the wholesale conversion of wood to charcoal for sale to people living in towns and cities. (3) In several countries, for example in Egypt, there has been a growing tendency among farmers living near cities to grow the more profitable agricultural products needed by the urban consumers (e.g. vegetables, fruits, etc.) at the expense of staple crops. (4) Increased inflow and outflow of people, materials and products from urban areas created the need for more transport systems and their infrastructure, which meant the use of more land areas. Chronic traffic congestion in and around cities is a by-product of urban growth. For example, Bangkok traffic jams are now so severe that the amount of passengers' time lost on city streets plus the amount of extra petrol consumed are reckoned to cost at least $US 1 billion a year. A further $1 billion is lost through medical bills and worker absenteeism due to air pollution-related ailments. (3) Similar chronic congestion is manifest in most cities of the developing countries.

17.6 As cities increase in size, slums and squatter settlements proliferate. It has been estimated that about one-third of the urban population in developing countries - about 200 million in 1970 and 450 million in 1990 - live in urban slums and shanty towns. The percentage of people living in such areas varies markedly from one city to another, and from country to country (Fig. 17.2), but most of them share the same precarious and dismal environment: overcrowded sub-standard shelters with inadequate clean water supply, and a lack of sanitation, of pared roads and of garbage collection services. Many of them are unemployed, uneducated, undernourished and chronically sick. They are sometimes referred to as those living on the "margins", or the "urban poor". (5) The socio-economic and environmental conditions of the slums are best illustrated by the intra-urban differentials in health. In Manila, for example, the infant mortality rate for the whole city was 76 per 1,000 against 210 per 1,000 in Tondo, a squatter area. Neonatal mortality in Manila was 40 per 1,000, while it was 105 per 1,000 in Tondo. (5) In Buenos Aires mortality due to tuberculosis was 3 times higher in the peripheral areas than the average for the city as a whole. Similar studies exist which point to intra-urban differentials in morbidity. The greater prevalence of diarrhoea and various helminthic infections is associated with poorer housing, water and sanitation facilities. In addition, those living in slums and squatter

Figure 17.2
PERCENTAGE LIVING IN SLUMS AND SQUATTER SETTLEMENTS IN SOME URBAN CENTRES (percentage)



Source: Based on data from (6).

settlements are more prone to natural hazards and/or the impacts of industrial accidents (Chapter 9).

17.7 The unplanned growth of urbanization has resulted in an acute shortage of housing in many countries. In the developing countries, the percentage of households unable to afford the normal-standard dwellings in selected cities (e.g. in Cairo, Manila, Bangkok and others) has increased over the last two decades from 35 to 75 per cent. The result has been increased overcrowding and more proliferation of sub-standard housing and squatter settlements. The average rate of occupancy in the developing countries is now about 2.4 persons per habitable room, as compared to 0.8 in the developed countries. (7)

17.8 Although the water supply to urban areas in the developing countries improved over the last two decades, in 1990 there were about 244 million people – or 18 per cent of the urban population – without a clean water supply (Chapter 5), as compared to 33 per cent in 1970. The proportion with sanitary facilities did not improve over the last two decades. In 1990, 377 million people in urban areas – 28 per cent of the population - did not have sanitary facilities; in 1970 the percentage was 29. In fact, most urban centres in Africa and Asia have no sewerage system at all – including many cities with a million or more inhabitants. (8) Rivers, streams, canals, gullies and ditches are where most human excrement and household wastes end up, untreated. As for those cities with a sewage system, rarely does it serve more than a small proportion of the population – typically the richer, residential, government and commercial areas.

17.9 The daily per capita domestic refuse generation in cities of the developed countries has been estimated at between 0.7 and 1.8 kilograms, whereas the figure is somewhere between 0.4 and 0.9 kilograms in the developing countries. (9) On average, the amount of municipal solid wastes generated in the developed countries increased from 318 million tonnes in 1970 to 400 million tonnes in 1990; an increase of about 25 per cent. In the developing countries, the amount of refuse was about 160 million tonnes in 1970 and increased to 322 million tonnes in 1990, i.e. doubled. Garbage collection services are inadequate or non-existent in most residential areas in Third World cities; an estimated 30-50 per cent of

the solid wastes generated within urban centres is left uncollected. It accumulates on streets, open spaces between houses and wasteland. Such uncleaned refuse, particularly in hot climates, constitutes a breeding ground for all sorts of vectors and pathogenic organisms. Where municipal solid wastes are managed, hand picking of refuse is the most viable economic option. Crude dumping is almost universal in developing countries and often supports a large army of scavengers, who extract various materials from the waste and sell them. It is paradoxical that the poorest countries are achieving a high level of recycling in this way, despite the small proportion of saleable matter in the waste. The grim realities of child labour and public health hazards must not be overlooked. As the whole family is usually employed in scavenging, even the young and the elderly are exposed to a wide variety of pollution effects, obnoxious odours and, most especially, disease vectors which may seriously endanger the health of all workers who come into direct contact with the waste. (10) Although several technologies for municipal solid waste management are available, the problem is more than a technical one. Today, social and political considerations, such as the recognition of the role of scavengers and public participation, particularly in the process of decision-making, are influencing solid waste management and may play a greater role than technical innovations in bringing about future changes. (11)

Rural Settlements

17.10 Conditions for people living in rural areas are, in general, no better today than they were in 1970. Houses are still much below standard, made of mud bricks, bamboo, wood, or other locally-available material. Although the percentage of the rural population with clean drinking water increased from 14 per cent in 1970 to 63 per cent in 1990, there were still 988 million people without access to clean water supplies (Chapter 5). The percentage of the rural population with some sort of sanitary facilities increased from 11 per cent in 1970 to 49 per cent in 1990, but there were still about 1,364 million people without any such facilities. In rural areas, obtaining water and making it more readily available for domestic use has traditionally been women's work. In many developing countries, women (and children) have still to walk long distances to bring water home. Such water is mainly used for cooking and drinking and canal or pond water is still generally used for washing and bathing (especially of children) in many rural areas. Wood, agricultural residues and cow dung are still the main source of fuel in rural areas. Again, women and children are responsible for collecting branches, bushes, crop residues and cow dung. Electricity is still a rare commodity in most rural homes, in spite of some efforts to increase rural electrification.

Human Settlements and Health

17.11 The environment in and around human dwellings offers an important habitat for a wide range of insects and rodents. Sub-standard houses, whether in rural areas or in urban slums, overcrowding and inadequate water supplies and sanitation offer fertile grounds for fleas, cockroaches, bugs, mosquitoes, flies, rats and other insects and rodents. These insects transmit a variety of diseases. (12) Amongst the best known is Chagas disease, transmitted by bugs that live in cracks and crevices of poor-quality houses in Latin America. According to WHO estimates, about 500,000 people become infected every year, 300,000 of them children. Between 10 and 15 per cent of infected

people die during the fever that is typical of the acute phase of Chagas disease. (13) The rest become chronically infected, and ultimately suffer different heart and other chronic disorders. WHO estimates that between 16 and 18 million people in South America are infected; another 90 million are at risk. A programme was recently launched to eradicate Chagas disease from parts of Argentina, Brazil, Bolivia, Chile, Paraguay, Uruguay and southern Peru. (13) Other diseases characteristic of poor human settlements conditions include filariasis, malaria, typhoid, dengue, and yellow fever (Chapter 18).

17.12 The use of wood, agricultural residues, coal, and dung for domestic purposes in rural areas creates massive indoor air pollution, to which women and children are particularly exposed. Studies carried out in the 1980s (14, 15, 16) provided evidence of the increased incidence of respiratory diseases and naso-pharyngal cancer among persons exposed to emissions of such fuels in rural homes.

17.13 Because many coastal cities discharge their sewage into the sea without treatment, coastal bathing water may become hazardous to health. Studies carried out in Canada, Egypt, France, Hong Kong, Israel, Spain and the United States have shown the incidence of eye infections, skin complaints, gastro-intestinal symptoms, and ear, nose and throat infections due to exposure to polluted bathing water. (17) It has been estimated that 40 per cent of tourists on vacation at Mediterranean coastal resorts become ill at the same time during or immediately after their visit (Chapter 15). The discharge of industrial waste into the sea creates additional hazards that impair not only health, but also the environment of coastal cities (Chapters 4, 10).

Responses

17.14 The problems and opportunities provided by human settlements differ in magnitude and kind between developed and developing countries. How far developing and developed countries have advanced in their human settlements policies is difficult to judge. But the conditions outlined in the previous paragraphs and the widening intra-urban differentials and rural-urban differences point to the inadequate responses in most countries to tackle existing and emerging problems. In developing countries, in particular, Governments have not coped with the demands for infrastructure and services that accompanied the massive increase in urbanization. And the economic burdens of developing countries have hampered investment in proper rural and urban development.

17.15 During the last two decades it has become evident that the conventional financing mechanisms for the housing of low-income families did not and could not resolve their difficulties and that rent controls were a weak tool. It has also become evident that clearing squatter areas will not solve the problem. (18) Grassroots initiatives have often been thwarted by institutional arrangements and government policies. Innovative efforts to improve the situation have been made in such countries as Chile, Dominican Republic, El Salvador and the Philippines, but the need for much broader assistance, targeted to reach lower-income groups has been recognized.

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Chapter 18

HUMAN HEALTH

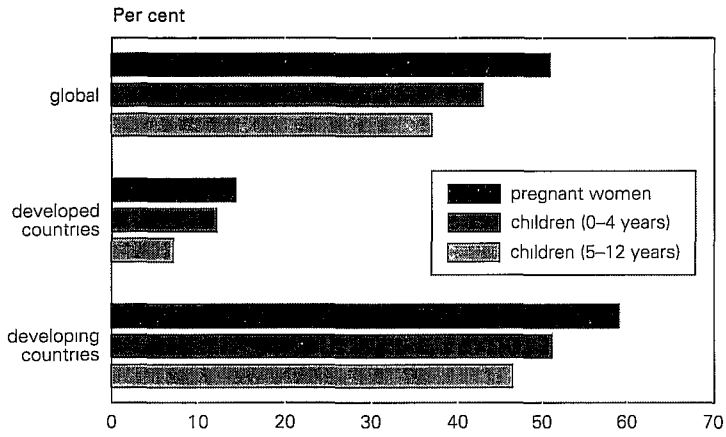
18.1 All constituents of the environment of our planet ultimately exert an influence on human health and well-being. However, the environment that exerts the greatest and most immediate influence on the lives of people, their health and well-being is the immediate environment of their homes, workplace and neighbourhood. However, both environmental and genetic factors are involved in the production of disease. While genetic factors usually give rise to congenital diseases and environmental factors to acquired ones, there is often an interplay between the two.

18.2 Although freedom from organic disease is usually considered synonymous with a reasonable state of health, freedom from non-organic disease is usually important. Health demands a sound mind in a sound body. The socio-economic implications of impaired mental health in any population group cannot be ignored. Impaired mental health, like its organic counterpart, can be caused by genetic or environmental factors, or by an interplay of both. During the past two decades, evidence of the role of biochemical changes in the aetiology (causation) of mental ill health has increased. Some of these biochemical abnormalities could be inherited or induced environmentally. Certain organic causes of mental ill health are certainly due to environmental factors, as with the group of psychoses resulting from infectious agents such as trypanosomiasis. Exposure to heavy metals such as mercury or lead and to certain synthetic compounds may also create a predisposition to brain tumors or abnormal behaviour. For example, a study on the long-term effects of exposure to low doses of lead in childhood indicated that this exposure is associated with deficiencies in the functioning of the central nervous system that persist into young adulthood. (1)

Malnutrition

18.3 Malnutrition is the most pervasive cause of ill health (see Chapter 11) and a major contributor to the high death rate among infants and young children in developing countries. An infant's birth weight is the single most important determinant of its early chances of survival and healthy growth and development. Because birth weight is conditioned by the health and nutritional status of the mother, the proportion of infants with a low birth weight (less than 2,500 grammes) accurately reflects the health and social status of women and of the communities into which children are born. In communities where malnutrition is a chronic problem, or during periods of food shortages or physical stress such as recurrent droughts, pregnant women rarely get enough to eat and foetal growth suffers. Approximately 51 per cent of pregnant women in the world suffer from nutritional anaemia (low haemoglobin levels due to poor diet); the percentage in developing countries is 59, much higher than the 14 per cent encountered in industrialized countries (Fig. 18.1). Some 22 million (or about 16 per cent) of the 140 million infants born each year in the world have a low birth weight. At least 20 million of these infants are born in developing countries, the majority (more than 13 million) in South Asia and the rest in Africa, Latin America and East Asia. (3, 4)

Figure 18.1
PREVALENCE OF ANAEMIA
(Early 1980s)



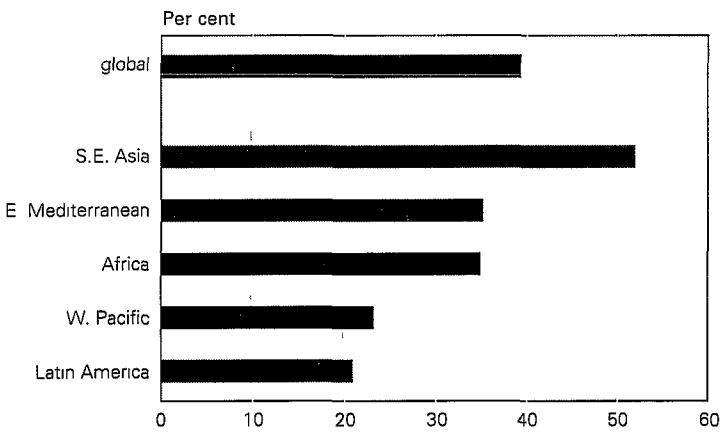
Source: Based on data (2).

The Global Strategy of Health for All, launched by the World Health Assembly, aims at reaching a target birth weight of at least 2,500 grammes for 90 per cent of newborn infants, and adequate growth of children, as measured by weight-for-age goals, by the year 2000. (4)

18.4 In terms of numbers, malnutrition is the most serious condition affecting the health of children, particularly in developing countries. Surveys in different regions of the world indicate that at any moment an estimated 10 million children are suffering severe malnutrition, and a further 200 million are inadequately nourished (Fig. 18.2). Malnutrition makes a child (or an adult) more prone to infection, and infection may exacerbate malnutrition. The best protection for infants against both malnutrition and infection is breast feeding. The last two decades have seen a heightened awareness of the importance of breast feeding.

18.5 However, nearly all the chemical compounds ingested by the mother will be found in her milk in one form or another. DDT, its derivatives, other pesticides, cadmium, lead and mercury have been found in human milk in several countries. Several studies (5, 6, 7, 8) have revealed that the concentration of DDT and DDE in human milk in some countries is higher than the acceptable daily intake criteria and maximum residue limits established by WHO/FAO. However, no evidence has been found to suggest that the levels of DDT and DDE generally found in

Figure 18.2
MALNOURISHED CHILDREN AGED BETWEEN 6-60 MONTHS
(Early 1980s)



Source: Based on data from (11).

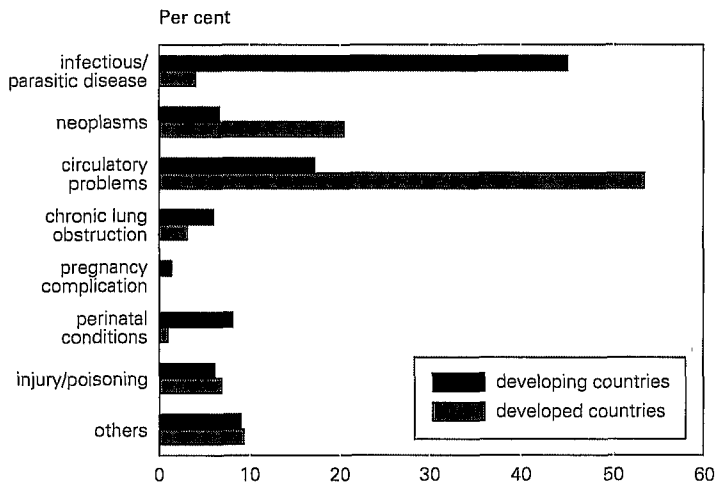
human milk have harmed infants. In fact, breast milk tends to be much less contaminated than substitutes. The common high death and disease rates among artificially fed infants in many developing countries can be attributed to improper preparation, as well as to contamination of infant formulae and other foods. The acceptance of the WHO International Code for Marketing of Breast Milk Substitutes has stimulated Governments to design programmes for more energetic promotion of breast feeding. Yet despite the increasing popularity of breast feeding in the industrialized countries, no similar increase has occurred in developing countries. (9)

Communicable Diseases

18.6 Different environmental conditions determine not only the regional differences in the incidence of diseases, but the seasonal differences as well. Fig. 18.3 illustrates the main causes of death in the world around the mid-1980s. (10) Infectious and parasitic diseases and perinatal and pregnancy complications predominate in developing countries. Some communicable diseases are transmitted much more easily during the rainy season. Temperature, humidity, soil, rainfall and atmospheric conditions are all important factors in the ecology of certain infective and infectious diseases, especially because they control the distribution and abundance of their vectors.

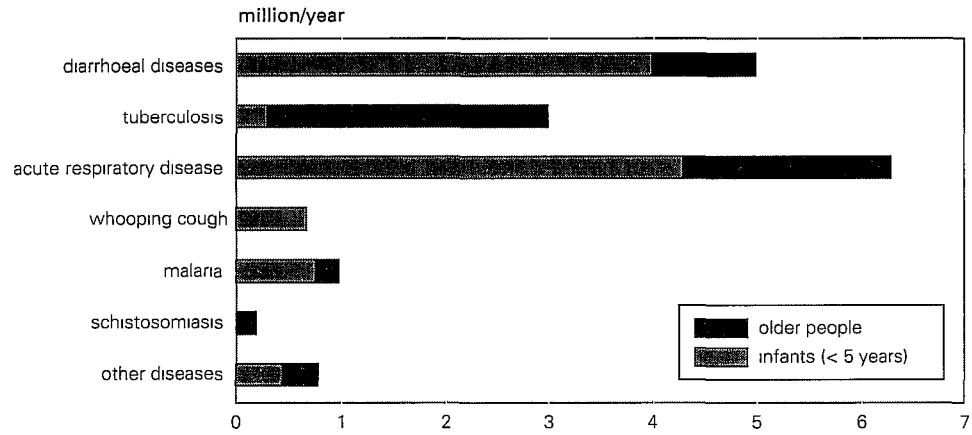
18.7 Communicable diseases account for a large proportion of illness and death in developing countries, where billions of people still lack the basic needs for living, adequate shelter, access to safe water supplies and sanitation and refuse disposal facilities. The deteriorating environmental conditions in which they live propagate the spread of infective agents and the breeding of disease pests and vectors. Overcrowding accelerates the spread of tuberculosis and other respiratory infections. The absence of sanitation and lack of safe water supply provides fertile ground for water-borne and food-borne outbreaks of enteric diseases and, the larger the number of people exposed to a contaminated source, the greater the risk and subsequent prevalence of infection. In the mid-1980s, it was estimated that 17 million people (of which 10.5 million were infants under the age of 5) in the developing countries died every year of infectious and parasitic diseases (Fig. 18.4), as compared to about half a million in developed countries. (10)

Figure 18.3
CAUSES OF DEATH
(Mid-1980s)



Source: Based on data from (10).

Figure 18.4
DEATHS DUE TO INFECTIONS AND PARASITIC DISEASES IN DEVELOPING COUNTRIES (Mid-1980s)

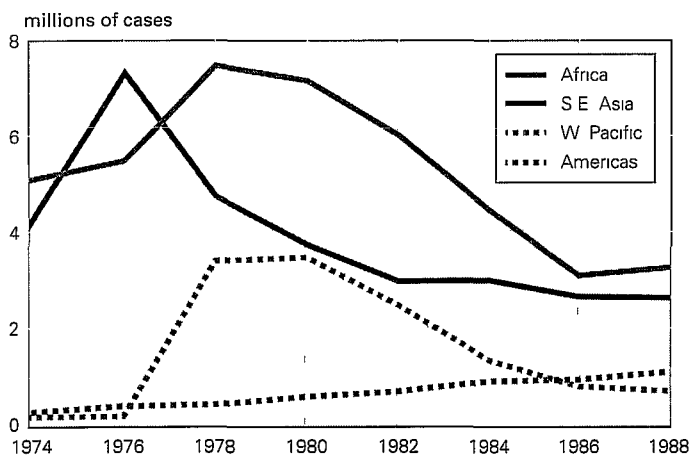


Source Based on data from (10)

18.8 Although cholera subsided in Asia, it has made its way into the Americas, with a resulting dramatic increase in the number of cases reported to WHO (about 250,000 cases in 1991). In Africa the total number of cholera cases has been almost stable in the last two decades. But occasional local outbreaks of cholera have occurred in different countries, mainly because of contamination of drinking water and food.

18.9 Malaria continues to be one of the most serious public health and environmental problems in a large part of the developing world. This disease is endemic in 102 countries, placing over half the world population at risk. Since 1980 there has been a general decrease in the number of malaria cases in Africa, South-East Asia and the Western Pacific, but there has been a gradual increase in the Americas (Fig. 18.5). In 1988, there were 8 million cases of malaria in the world reported to WHO, but it is believed that the overall number of cases is in the order of

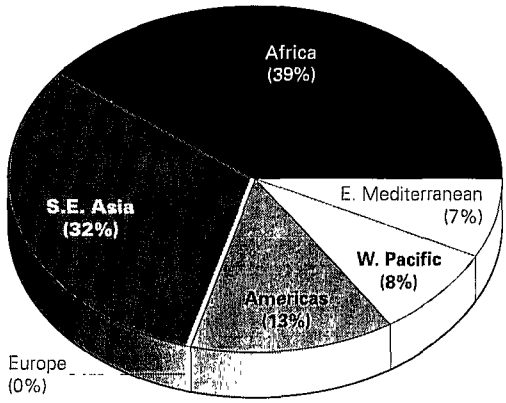
Figure 18.5
TRENDS IN NUMBER OF MALARIA CASES IN MOST-AFFECTED REGIONS



Source Based on data from (13, 14)

100 million. (12) Of the total number of cases reported in 1988, 39 per cent were in Africa and 32 per cent were in South-East Asia (Fig. 18.6). It is believed that 43 per cent of the world population lives in malarious areas. Some 445 million people inhabit malarious areas where no specific measures are undertaken to control transmission and where the prevalence of malaria remains virtually unchanged. (12)

Figure 18.6
DISTRIBUTION OF MALARIA CASES BY REGION (1988)



Source: Based on data from (14).

18.10 Schistosomiasis remains a major health threat in some 76 developing countries. Brazil, Central Africa, China, Democratic Kampuchea, Egypt and the Philippines are the countries and areas with large numbers of cases. All in all, it has been estimated that some 200 million people are infected and another 600 million are at risk from the disease. The creation of man-made lakes, fish ponds and irrigation schemes has contributed to an increase in the incidence of the disease. For example, following the construction of the Diama dam on the Senegal River in 1986, it has been found that intestinal schistosomiasis has largely increased since early 1988; by 1989, 71.5 per cent of the examined samples were positive. (15, 16)

18.11 The last decade has seen the first reported cases of HIV infection and AIDS (acquired immunodeficiency syndrome). AIDS kills people of all ages, but is a growing threat to newborn children and infants. At least 1.5 million women world-wide – of whom about one million are in Africa – are infected with HIV. Babies born to such women have a 25-40 per cent chance of being infected before or during birth. These children are almost certain to die by the age of five. (17) It is estimated that world-wide some 5-10 million people are infected with the AIDS virus; about 400,000 are sick with AIDS. (14) It is estimated that, by the end of 1991, over a million cases of AIDS will have occurred world-wide, whereas by the year 2000 the cumulative number could exceed five million. (14)

Chemical Pollution and Health

18.12 Humans are exposed to various chemicals in occupational and community settings. A vast amount of scientific information is available on the short-term effects of exposure to high levels of hazardous chemicals. But little is known about what happens to individuals exposed to very low concentrations of such chemicals over 20 or 30 years. However, the consequences can be measured among the population at large in terms of disease and death and in terms of physiological changes. Genetic mutations (the production of new, mostly detrimental hereditary traits) may also have chemical causes, and such mutations are permanent. Cancer and birth defects are among the other hazards to health that may result from long-term exposure to toxic substances. Birth defects occur in 2-3 per cent of all births. Of these, 25 per cent have underlying genetic causes, while 5-10 per cent result from the

influence of four classes of known causes: radiation, viruses, drugs, and chemicals. The remaining 65-70 per cent arise from unknown causes, but may follow from an interplay of several environmental agents and genetic factors. (18, 19, 20)

18.13 The effects of being exposed to a chemical pollutant depend on the period and severity of exposure and the type of chemical to which the individual is exposed. A distinction should be made between two main types of exposure. The first is exposure to abnormally high levels of pollutants such as, for example, in the case of accidental releases of chemicals (Chapter 9), occupational exposures, or in the case of abnormal environmental episodes, such as air pollution episodes. The second type of exposure is to general ambient pollutants. In the first types of exposure, the effects are evident and are represented by direct death, premature death and/or an increase in morbidity. For example, the accidental release of methyl isocyanate in the Bhopal accident (Chapter 9) led to direct death and a high rate of morbidity. Exposure of workers to high concentrations of chemicals has led to various occupational diseases. Lead poisoning, pneumoconiosis (a lung disease caused by dust inhalation), pesticide poisoning and various cancers are examples of the consequences of such exposures. WHO has estimated that the number of unintentional acute poisonings due to exposure to pesticides was half a million in 1972 and increased to one million in 1985 due to an increase in pesticide use. About 60-70 per cent of these cases are due to occupational exposure. Some 20,000 deaths per year occur as a result of pesticide poisoning. (21) Although many of the traditional occupational diseases are declining in the developed countries (as a result of strict enforcement of protection measures), they are on the rise in several developing countries, because of the lack of or non-enforcement of regulatory measures to protect workers (and also the lack of awareness and cooperation of workers). There is also increasing concern about the increase in occupational diseases in small-scale industries (including repair workshops), especially among children, who constitute a large proportion of the workforce (Chapter 12). The effects of air pollution episodes (such as the London smog of 1952) are well-documented; children and the elderly (in particular those with respiratory and circulatory problems) were most affected.

18.14 The assessment of the health impacts of exposure to chemical pollutants in the general environment is a difficult task, because the individual is generally exposed to several pollutants at the same time. A person's total exposure includes inhalation, ingestion, or skin absorption of the pollutants from air, water, food, or soil. In many cases the effect of an individual pollutant is either increased or decreased through interactions with other pollutants. For example, the effects of sulphur dioxide on health are known to increase in the presence of particulate matter. Tobacco smoking increases the incidence of cancer due to exposure to indoor radon (Chapter 1). In the last two decades various attempts have been made to estimate the health impacts of total human exposure by using models to calculate the environmental distribution, transformation and fate of chemical pollutants, human exposure via different routes, and the toxicological and pharmacokinetics of chemical substances in humans. (22, 23) In 1984, WHO/UNEP set up the Human Exposure Assessment Locations programme (HEALs) as part of the Global Environmental Monitoring System (GEMS), in order to monitor total human exposure to pollutants. The results should enable countries to assess the combined risk from air, food and water pollutants, and take appropriate action to safeguard human health.

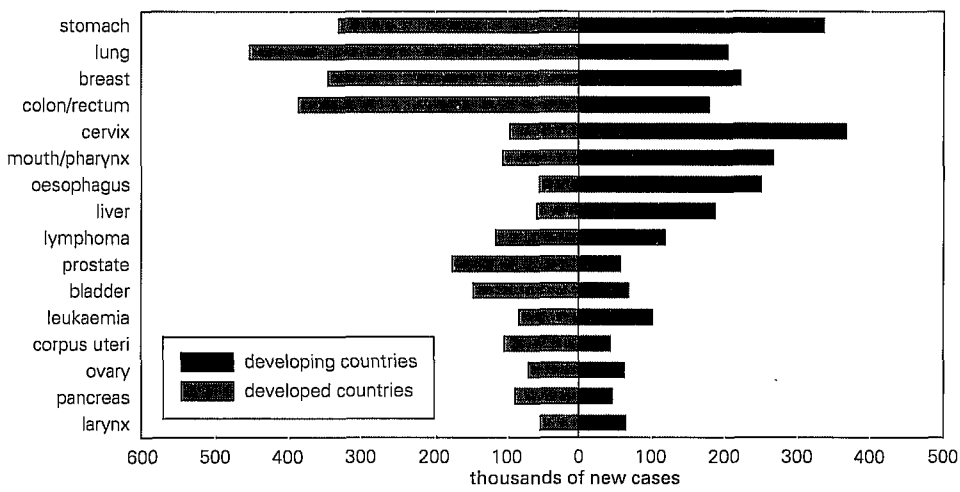
18.15 Cause and effect have been established for several pollutants. For example, the health effects of carbon monoxide, tropospheric ozone, sulphur oxides combined with particulates, and lead in ambient air are well documented (Chapter 1). Epidemiological research in the last two decades has established that indoor air pollution could cause an increase in cancer incidence due to exposure to radon and tobacco smoke, and in rural areas of the developing countries could increase respiratory diseases and cancer due to exposure to emissions from biomass fuel. The increase in nitrates in groundwater has become a cause of concern in several countries. Nitrates constitute a health risk, especially for infants. WHO, UNEP and ILO have been working together since the early 1970s to establish health criteria for various pollutants (see also Chapter 10).

18.16 There is now widespread agreement that roughly 85 per cent of all cancers are caused by broad environmental factors such as ionizing radiation, carcinogenic chemicals in air, food or water, smoking, alcohol and drugs (chemotherapeutic agents). The rest, presumably, have a hereditary basis or else arise from spontaneous metabolic events. Although the percentage of deaths from cancer is higher in developed than in developing countries (Fig. 18.3), the incidence of cancer in both groups of countries is generally similar. However, variations in the incidence of different types of cancer are encountered (Fig. 18.7). Tobacco smoking (including passive smoking) is the most important cause of lung cancer. In spite of this well-established fact, the global use of tobacco has grown by nearly 75 per cent over the past two decades; the prevalence of smoking has markedly increased among young people.

Responses

18.17 The different responses outlined in the previous chapters contribute directly and indirectly to the improving of human health and to reducing the health risks associated with exposure to different

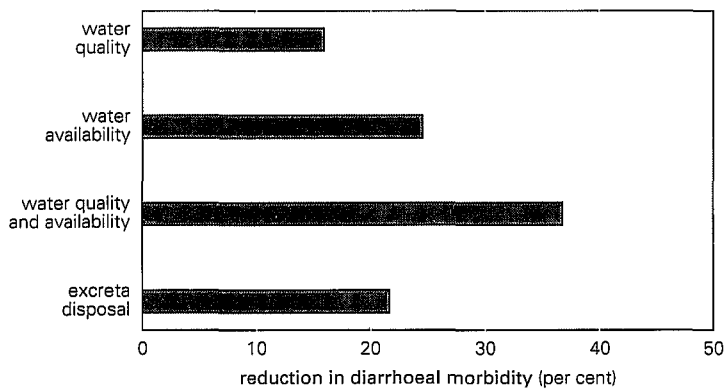
Figure 18.7
INCIDENCE OF CANCER
(Early 1980s)



Source: Based on data from (24).

pollutants. The fact that "prevention is better than cure" is illustrated by the achievements outlined in Fig. 18.8 below. Although the original goals of the IDWSSD were not met by 1990, the Decade did provide hundreds of millions of people with safe drinking water and sanitation facilities (Chapter 5). This has largely contributed to improvements in health conditions in the areas provided with such facilities. Fig.18.8 illustrates how improved water supply and sanitation can reduce diarrhoeal morbidity. The actions taken to reduce air emissions (Chapter 1) and to protect the ozone layer (Chapter 2) are further examples of preventive measures. However, there is still a long way to go to reduce the health risks of environmental pollution and deterioration. Much research is required to clarify the causes and effects of total human exposure to establish practical guidelines to protect human health. And there is a great deal to be done to reduce the incidence of communicable diseases in the developing countries.

Figure 18.8
EFFECTS OF IMPROVED WATER SUPPLY AND SANITATION OF DIARRHOEAL MORBIDITY



Source: Based on data from (25).

18.18 In the last two decades some communicable diseases have been brought under control. Smallpox has been e radicated. The incidence of onchoceriasis (river blindness) has been reduced sharply in West Africa. The increased use of oral rehydration therapy (ORT) has reduced the mortality of children under the age of five due to diarrhoeal diseases. In 1985, about 18 per cent of children with diarrhoea were treated with ORT; by 1989 the percentage of these children had reached 25 per cent (UNICEF, 1989) and this has saved the lives of some one million children each year (Hirschhorn and Greenough, 1991). The six vaccine-preventable diseases of childhood (polio-myelitis, tetanus, measles, diphtheria, pertussis and tuberculosis) have declined through increased immunization. In the 1970s, these diseases killed about 5 million children a year; in the 1980s, the figure dropped to about 3 million a year and it is being reduced through the expanded programme of immunization.

Chapter 19

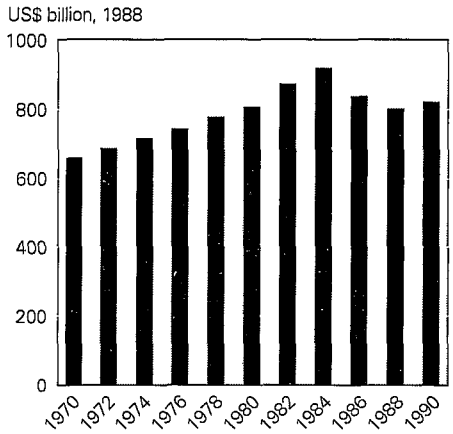
PEACE, SECURITY AND ENVIRONMENT

19.1 Violence is a prehistoric solution to disputes which time and culture have endowed with endless sophistication but have otherwise left unchanged. The recent centuries of enlightenment and science have merely enabled us to kill more people, more quickly and effectively than our medieval ancestors or our fellow primates and other mammals. Only recently has it been realized that war and preparations for war are inimical to development, because they squander scarce resources and erode the international confidence that is essential to promote development, conserve our scarce resources and protect the environment at the regional and global levels.

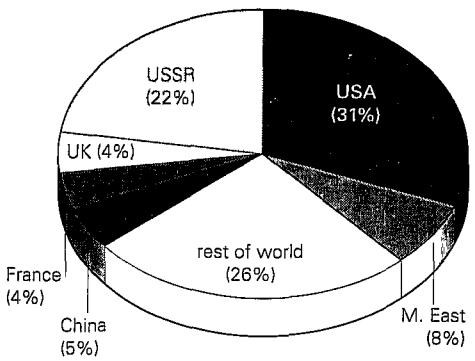
A World At War

19.2 In the last two decades the world has spent about $US 17 trillion, at 1988 prices and exchange rates, on military activity. In other words, global military expenditure was an average of $US 850 billion per year (2.33 billion per day - 97 million per hour or 1.6 million per minute). In current dollars, the annual global military expenditure reached more than $US 1,000 billion in 1990. (1, 2, 3) Military expenditure has consistently increased since 1970, although since the mid-1980s there was a slight deceleration (Fig. 19.1). Although military spending as a share of gross national product (GNP) has decreased slightly on a global basis and in industrialized countries, it has increased in most developing countries (Fig. 19.2). On a regional basis, Latin America devotes the smallest share of its GNP - about 1.5 per cent - to military spending. The Middle East and North Africa, on the other hand, spend the highest share of GNP (about 12.6 per cent) on military activities. (4, 5, 6) All in all, the world's military spending dwarfs any spending on development.

Figure 19.1
WORLD MILITARY EXPENDITURE

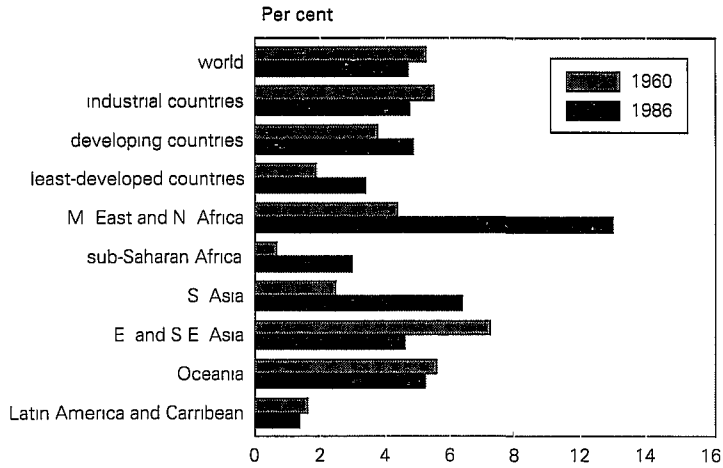


DISTRIBUTION OF WORLD MILITARY EXPENDITURE



Source: Based on data from (1, 3).

Figure 19 2
MILITARY EXPENDITURE AS A PERCENTAGE OF GNP

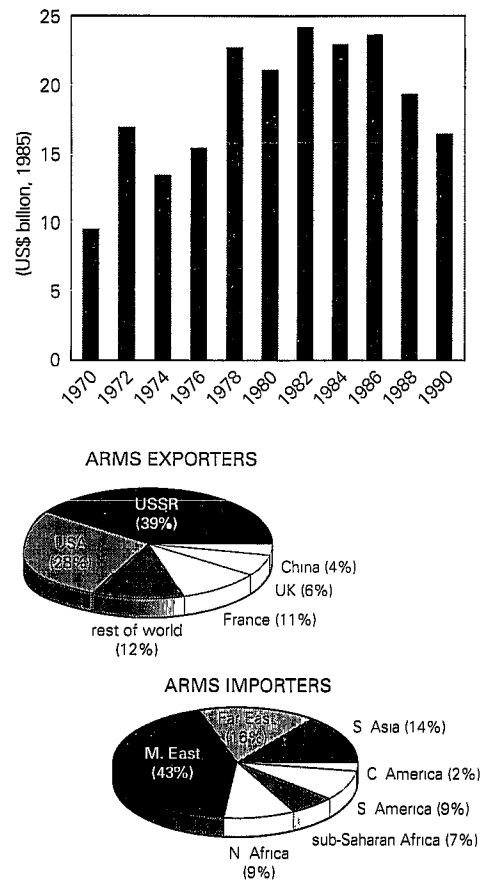


Source Based on data from (5, 6)

19.3 Associated with the increase in world militarization there has been a dramatic increase in the arms trade. In the last two decades, cumulative global arms sales have reached $US 410 billion, about $US 20 billion per year (Fig. 19.3). It has been estimated that about 50 per cent of all arms imports into developing countries have been financed by export credits. (7) The costs of such military credits amount to 30 per cent of all inflow of debt to the developing countries.

19.4 Militarization has also diverted considerable resources away from development activities. The military employs some 60-80 million people world-wide, (7) among them about 3 million scientists and engineers. Considerable land areas are set aside for military training and weapon testing. And in several countries prime land is used for the construction of military installations and service buildings, without due consideration for better opportunities to use such lands for national socio-economic development. The military uses also vast amounts of mineral resources and energy. It has been estimated that the global military demand for aluminium, copper, nickel and platinum has been greater than the total demand for these minerals for all purposes in Africa, Asia and Latin America combined. About 6 per cent of total world oil consumption is by the military - close to one half the total oil consumption of all the developing countries.

Figure 19 3
GLOBAL ARMS SALES



Source Based on data from (3)

War and Environment

19.5 Almost all wars have had one basic strategy: destruction of life-support systems so that armies and people succumb. Carpet bombing of towns and their infrastructure was widely used in World War II. Extensive bombing, chemical and mechanical destruction of forests and crops, and area denial measures were widely used in the Indochina in the war of 1961-1975 to drive the fighters and their farmer supporters out of their hiding and their villages. With advances in military technology, a whole array of guided weapons has emerged which can hit various targets more precisely, without causing considerable collateral damage. The extent of the destruction caused by such high-tech weapons was recently demonstrated by the conflict over Kuwait in 1991. Although the damage to the built environment created by all these conventional wars can be repaired, two types of war destruction are much more difficult to reconcile: damage to the natural environment and damage to the social fabric of the affected population.

19.6 The extensive use of chemical warfare (herbicides) in the war in Indochina between 1961 and 1975 illustrates the potential damage that could occur to the environment as a result of war. Millions of litres of different herbicides were sprayed over an area of about 1.7 million ha in Indochina in the period from 1961 to 1971, (8) resulting in large-scale devastation of crops and forests. This has led to widespread soil erosion, decimation of terrestrial wildlife, losses in freshwater fish and a decline in coastal marine fisheries. Since that time, recovery of the affected ecosystems has been slow. The impact on humans has varied from neuro-intoxications to increased incidence of hepatitis, liver cancer, spontaneous abortions and congenital malformations.

19.7 The conflict over Kuwait in 1991 resulted in a large oil spill and extensive fires in oil wells. The oil spilled from loading terminals, sunken and leaking vessels in the northern part of the Persian Gulf has been estimated at 4 to 8 million barrels. The spill damaged coastal areas in some countries and affected wildlife and aquatic life to varying degrees. (9) The fires that were set in 613 oil wells in Kuwait caused the burning of about 4 to 8 million barrels per day and resulted in massive clouds of smoke and gaseous emissions that spread over a large area in the northern Gulf. (9, 10, 11) Measurements showed that about 1-2 million tonnes of carbon dioxide were emitted each day, together with varying amounts of sulphur and nitrogen oxides, carbon monoxide and organic compounds. The amounts of particulates emitted averaged about 100,000 particles per cubic centimetre near the border of Kuwait. Most of the smoke mass was transported at an altitude of 2-3 km, for distances up to 2,000 km mainly eastwards and south-eastwards. The most direct impact of the smoke was to reduce incoming solar radiation, which lowered the surface temperature in some parts of the northern Gulf. Direct effects on health included some respiratory symptoms in sensitive groups, but a detailed assessment remains to be made. (9) By November 1991, the fires had been brought under control and all wells capped.

19.8 Millions of unexploded land mines, sea mines, booby traps, various types of munitions and bombs are left behind after the cessation of military hostilities (Box 19.1). Very scanty information is generally available on the number and location of such remnants of war, which makes clearance a difficult and risky undertaking. The remnants of war have endangered people, livestock and wildlife, and hindered the development of vast areas of land. (12)

BOX 19.1

REMNANTS OF WAR

* *In Poland, 14,894,000 land mines and 73,563,000 bombs, shells and grenades have been recovered since 1945.*

* *In Finland, over 6,000 bombs, 805,000 shells, 66,000 mines and 370,000 other high-explosive munitions have been cleared since the end of World War II.*

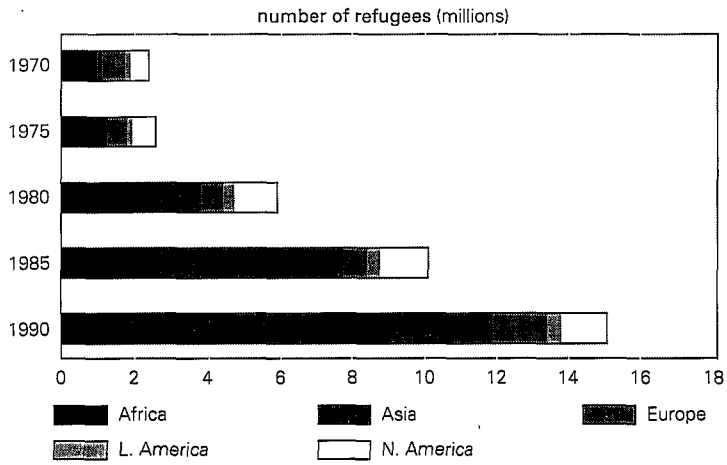
* *In Indochina, about 2 million bombs, 23 million artillery shells and tens of millions of other high explosive munitions were left unexploded after the war.*

* *In Egypt, following the 1973 Arab-Israel War, about 8,500 unexploded items were removed from the Suez Canal and more than 700,000 land mines were cleared from the terrain near the Canal. Yet hundreds of thousands of land mines and unexploded shells are still scattered around the Gulf of Suez and in Sinai.*

Source: (39).

19.9 Wars and conflicts have generated millions of displaced people (refugees) in the world. The exact number of refugees is not known, partly because of the lack of an internationally accepted definition of who is a refugee and who is not. (13) Estimates indicate that the number of refugees has increased from about 3 million in 1970 to about 15 million in 1990 (Fig. 19.4). These refugees have not only suffered economic losses - their whole social fabric and their lives have been disrupted. In most cases, these refugees live in camps in border areas, where living conditions and social disruptions are common. In some cases, the return of these people to their original places and their rehabilitation become virtually impossible and they continue to live in misery for decades.

Figure 19.4
ESTIMATED NUMBER OF REFUGEES



Source: Based on data from the Office of the United Nations High Commissioner for Refugees.

19.10 The introduction of nuclear weapons added entirely new dimensions to warfare. The two atom bombs dropped on Hiroshima and Nagasaki in 1945 had a yield of 12.5 kilotons TNT and 22 kilotons TNT, respectively. Their devastating effects are

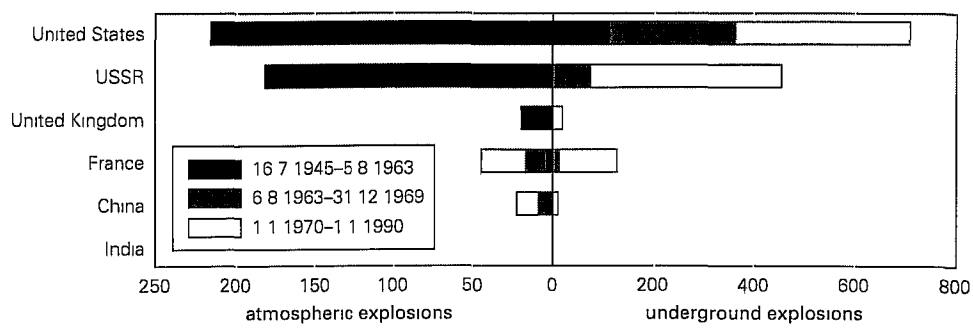
well documented. The nuclear weapons developed later represent a dramatic increase in destructive power (from kilotons to megatons). The number of nuclear warheads in the world has been estimated at between 37,000 and 50,000, with a total explosive power of between 11,000 and 20,000 megatons (equivalent to between 846,000 and 1,540,000 Hiroshima bombs). Despite widespread condemnation of nuclear weapons, their production and testing have continued. The total number of nuclear tests from 1945 to 1990 was 1,818, of which 489 were in the atmosphere and 1,329 were underground (Fig. 19.5). In the 1980s, several studies were carried out to predict the impacts of a large-scale nuclear war. (14 to 26) In spite of several uncertainties, different nuclear war scenarios estimate that about 30-50 per cent of the human population could be immediate casualties of a nuclear war. The 50-70 per cent of humans who might survive the direct effects of a large-scale nuclear war would be affected by the "nuclear winter". In the aftermath of a large nuclear war, darkened skies would cover large areas of the earth for perhaps weeks or several months, as sunlight would be blocked by large, thick clouds of smoke from widespread fires. (23, 24) Temperatures would drop to below freezing and rainfall in many regions of the world might be affected. Such climatic changes will affect agriculture and major ecosystems, such as forests, grasslands and marine ecosystems, with far-reaching impacts on food production and distribution systems.

19.11 In the 1970s there were speculations about the possibility of causing economic or other damage to the population or an enemy through environmental modifications. (27 to 30) Environmental warfare could, at least in principle, involve damage caused by manipulation of celestial bodies or space, the atmosphere, the land, the oceans, or the biota. Another concern has been the possibility of using biological weapons - the use of a living organism, generally a pathogenic micro-organism, for hostile purposes. Advances in biotechnology and genetic engineering have added to such concern. The effectiveness of existing biological agents could be enhanced and new, potentially more effective agents could be created.

Evolving Concepts of Security

19.12 Several studies of the relationship between the arms race and development (31 to 34) have stressed the fact that the arms race and development compete for the world's

Figure 19.5
NUCLEAR EXPLOSIONS
(5 August 1963: the signing of the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water)



Source Based on data from (3)

finite resources. And in the last two decades it has become evident that military means are no longer adequate to provide tangible security benefits. The security of nations depends to at least the same extent on economic well-being, social justice, and ecological stability. Environmental degradation imperils the nations' most fundamental aspects of security by undermining the natural support systems on which all human activity depends. Because environmental degradation and pollution respect no human-drawn borders, they jeopardize not only the security of the country in which they occur, but also that of others, near and far. Spurred by a stream of new scientific evidence, attention is now shifting to those aspects of environmental degradation that have an all-encompassing, global effect, from which no nation can insulate itself. Even though their full impact may be felt only years or decades from today, the depletion of the ozone layer (Chapter 2) and the global warming trend (Chapter 3) can no longer be considered to be hypothetical threats.

19.13 This thinking has lead to the evolution of new concepts of security. Expressions such as "balance of power", "deterrence", "peaceful coexistence", "collective security", "common security", etc. have been introduced (35) to emphasize that security consists of not only military, but also political, economic, social, humanitarian and human rights and ecological aspects.

19.14 Environmental stress is both a cause and an effect of political tension and military conflict. Nations have often fought to assert or resist control over raw materials, energy supplies, land, river basins, sea passages, and other key environmental resources. (36) Such conflicts are likely to increase as these resources become scarcer and competition for them increases. Disputes have also resulted between some countries on issues of use or pollution of shared water resources, acidic precipitation, marine pollution, downstream siltation and increased floods and management of groundwater resources.

Responses

19.15 Many conventions, treaties and agreements have been adopted to limit and/or prevent the devastating effects of warfare (Box 19.2). But the mounting military expenditure implies a general lack of conviction to keep constant the size of forces and arsenals, let alone reduce them. There is a further contradiction between the increasing demand for resources for development and the increasing allocation of such resources for military purposes. A major breakthrough in the field of disarmament would release vast financial, technological and human resources for more productive uses in both developed and developing countries in an international political climate of reduced tension.

19.16 The rechanneling of resources from the military to the civilian economy has been referred to as the "conversion process". Such conversion has political, economic and technical dimensions. (34) Unilateral measures to curtail military spending, and hence to initiate a conversion process, can be taken by any State. But in the real global political sense, disarmament has to be started by the major powers on the basis of mutual, verifiable agreements to reduce armaments and eliminate particular military capabilities. Conversion is more than a theory. In 1985, China decided to utilize part of the military industrial capacity to manufacture civilian goods. Civilian production now accounts for 20 per cent of the output of China's military factories; that share is projected to reach 50 per cent by 2000. (37, 38) Conversion produces more jobs and helps to meet the growing socio-economic needs of people, and it is of vital importance for the conservation of resources and for environmental protection. In the United States, for example, spending $US one billion

BOX 19.2

MAJOR MULTILATERAL ARMS CONTROL AGREEMENTS 1970-1990

* *Treaty on the prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the sea-bed and on the ocean floor and in the soil thereof (Sea-Bed Treaty).*

(Signed in 1971; entered into force in 1972).

* *Convention on the prohibition of the development, production and stockpiling of bacteriological (biological) and toxin weapons and on their destruction (BW Convention).*

(Signed in 1972; entered into force 1975).

* *Protocols I and II to the Geneva Convention of 1949 relating to the protection of victims of armed conflicts.*

(Signed in 1977; entered into force in 1989).

* *Convention on the prohibition of military or any other hostile use of environmental modification techniques (Enmod Convention).*

(Signed in 1977; entered into force in 1978).

* *Convention on the prohibition or restrictions on the use of certain conventional weapons which may be deemed to be excessively injurious or to have indiscrimate effects (Inhumane Weapons Convention).*

(Signed in 1981; entered into force in 1983).

* *South Pacific nuclear-free zone treaty (Treaty of Rarotonga).*

(Signed in 1985; entered into force in 1986).

Source: (3).

on guided missile production creates about 9,000 jobs. Spending the same amount on air, water and solid waste pollution control creates 16,500 jobs; and on educational services, 63,000 jobs. A $40 billion conversion programme could bring a net gain of more than 650,000 jobs. (38) The trade-offs between military and social and environmental priorities can, indeed, be far-reaching (Box 19.3).

19.17 In the face of transnational environmental problems, national responses are likely to prove fruitless without international cooperation. It is true that all States have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other countries (Principle 21 of the Stockholm Declaration). But it is also true that environmental security critically depends on pragmatic internationalism. The Convention on long-range Transboundary Air Pollution (Chapter 1), the Montreal Protocol to protect the ozone layer (Chapter 2) and the conventions on biodiversity and climate change under negotiation are examples of international efforts to foster global

BOX 19.3

CONTRADICTIONS

* *The United Nations Environment Programme, the organization responsible for safeguarding the global environment, spent $US 450 million over the last ten years i.e. less than five hours of global military spending.*

* *The total annual official development assistance extended to the developing countries is $US 35 billion, i.e. 15 days of global military spending.*

TRADE-OFFS BETWEEN MILITARY AND SOCIAL AND ENVIRONMENTAL PRIORITIES

* *6-7 hours of world military spending ($US 700 million) = Eradication of malaria - the killer disease that claims the lives of one million children every year.*

* One-and-a-half days of global military spending ($US 3.10 billion) = Annual cost of protecting land unaffected by desertification and reclaiming those areas moderately affected.

* *3 days of global military spending ($US 7 billion) = Funding of tropical Forest Action Plan over 5 years.*

* *One Apache helicopter ($US 12 million) = Installation of 80,000 hand pumps to give Third World villages access to safe water.*

* *One Patriot missile system ($US 123 million, without missiles) = Establishment of 5,000 low-cost housing units to rid 5,000 families from life in slums.*

* *One day of the 1991 conflict over Kuwait ($US 1.5 billion) = Global 5-year child immunization programme against 6 deadly diseases, thereby preventing the death of one million children a year.*

Source: (37, 38, 40).

environmental security. On a regional level, the regional conventions for the protection of marine environment, the regional seas programmes (Chapter 4), and the cooperative programmes for the environmentally sound management of inland waters (Chapter 5) are all steps in the same direction.

19.18 What remains to be reviewed urgently by the world community is the status of the different international treaties dealing with the environment in case of war. In particular, the Hague Conventions II of 1899 and IV of 1907, the Protocol I of 1977, the Convention Concerning the Protection of the World Cultural and Natural Heritage of 1972, the Geneva Protocol of 1925 for the Prohibition of the Use in War of Asphyxiating Poisonous or Other Gases, and of Bacteriology Methods of Warfare, and the Enmod Convention of 1977 should be reviewed and strengthened. At the time of finalization of this report, the General Assembly of the United Nations, is dealing with this issue.

PART IV

PERCEPTIONS, ATTITUDES AND RESPONSES

Chapter 20

PERCEPTIONS AND ATTITUDES

20.1 People have always cared about the environment. Their perceptions of environmental issues and their attitudes have evolved over the centuries. In the earlier part of this century environmentalism was essentially synonymous with wildlife conservation and was considered to be the domain of a prescient and often privileged few. Since the 1960s, environmentalism has become a movement with widespread popular support and with a much broader scope of interest. The United Nations Conference on the Human Environment, convened in Stockholm in 1972, was the turning point in the history of environmental awareness. Growing public pressure, backed by scientific findings concerning the impacts of different pollutants and environmental degradation in the late 1960s and early 1970s, stimulated the necessary political will. The debate that took place in the early 1970s, which was based essentially on the air and water pollution felt by the public in the North, brought home the fact that environmental degradation is not only caused by industrialization, but by poverty and lack of development. The environmental movement has since become concerned with all aspects of the natural environment: land, water, minerals, all living organisms and life processes, the atmosphere and climate, the polar ice-caps and remote ocean deeps, and even outer space. Furthermore, the movement turned from looking at the natural environment *per se* towards the environment's interrelationship with human conditions and human well-being and with the status of international economic cooperation covering issues of debt, commodity prices, structural adjustments, subsidies and so on.

20.2 Environmentalism has not only grown in the past two decades, but has also altered its complexion to suit the requirements of the times. Modifications to social cost-benefit analysis, the onset of environmental impact assessment and environmental auditing, risk analysis, public inquiries, new legislative measures at the national and international levels, plus the activities of non-governmental groups have all helped to give policies and actions a more environmental tenor.

20.3 Recent years have seen the development of another phase of the environmental movement. This is characterized by the concern evinced and the organization taking place on a national and international scale with regard to some important, complex, and widespread problems. Examples are acid rain, the disposal of hazardous wastes, global warming, loss of biodiversity, depletion of the ozone layer, marine pollution, deforestation and the interaction between peace, security and environment. Effective action on these issues requires a wide range of skills: considerable academic knowledge on the part of those actively involved, organizational ability to effect activities in the often widely separated areas where the issue surfaces; political skill to deal with the Governments, industries, special interest groups, and individuals who play major roles in such issues; an ability to communicate; and concern and willingness to face the "big" issues. All these are characteristics of emerging environmentalist professionalism. (1)

20.4 Scientific groups and non-governmental organizations (NGOs) have played a major role in the environmental movement from its start. There are many types of environmental groups. Small ones are organized locally to fight local problems, often environmental disruption - immediate or potential – from pollution or some apparently inappropriate form of development. Others deal with a special issue, but on a national scale. Other national NGOs are primarily concerned with the use of the environment and who should benefit from it. Some have been described as "sustainable development" or "appropriate technology" groups. Over the last decades, the environmental NGO movement has become increasingly international, with the emergence of powerful bodies like Friends of the Earth, Greenpeace and the World Wide Fund for Nature (WWF). Since 1948, a unique link between the non-governmental and governmental sector has been provided by The World Conservation Union (IUCN), which links in membership some 55 States, 100 government agencies and 450 NGOs. The range of conservation, development and humanitarian NGOs and of industry groups concerned with the environment expanded steadily during the 1970s and 1980s, and contacts between the NGO and government sectors have also strengthened. Through environmental groups, therefore, individuals are increasingly able to influence national and world policy. But today the environmental movement is so diverse that a question arises as to whether it is really proper to give it a single name. Environmental organizations and their members often differ in their concern over particular environmental issues, in the values and attitudes advocated, in the goals and objectives to be achieved, and in the types of strategies and tactics. Yet what is shared by all these organizations is a concern about socio-environmental relationships. UNEP has responded to such diversification by its "outreach" policy of opening up a dialogue with industry, parliamentarian, relief, women's, youth, religious, and other groups that are receptive to the environmental message. This message is being accepted and adopted by more and more sections of society, and by more and more of the people in both developed and developing countries. The environment is still becoming an ever more popular issue. Perceptions and attitudes are changing and the changes are proving to be remarkably widespread and robust.

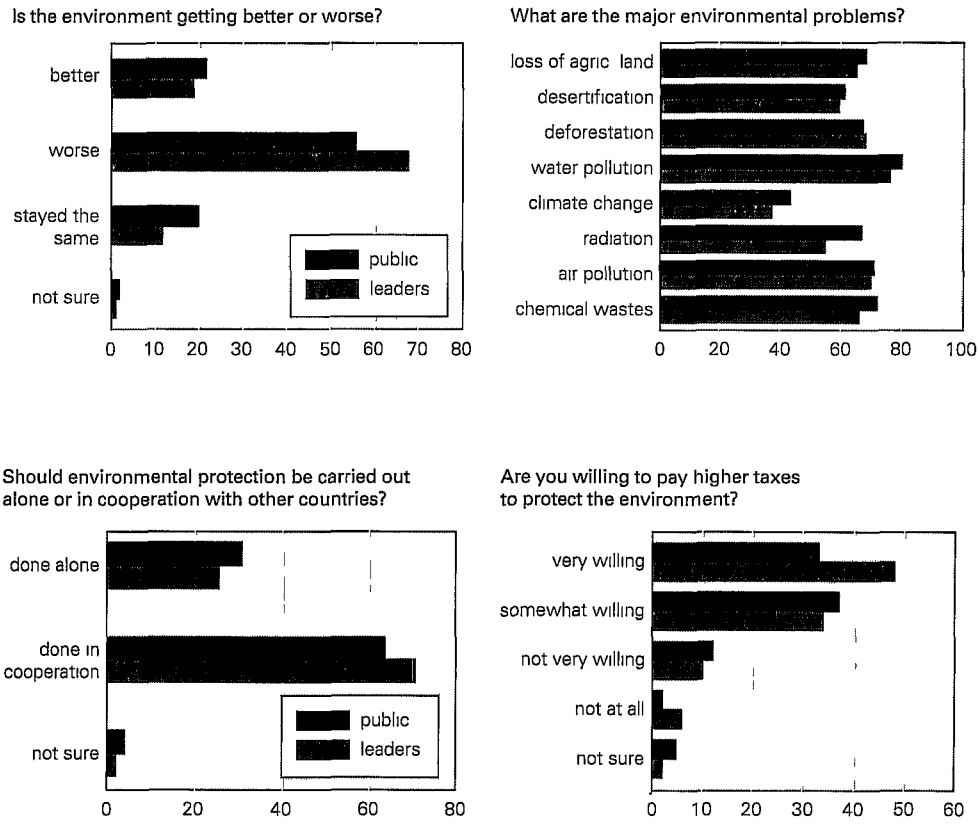
20.5 Public perceptions and attitudes towards environmental issues have been conditioned by cultural, traditional, socio-economic and political factors. Since the 1960s, perceptions and attitudes towards environmental issues have changed considerably. Students of modern environmentalism (2 to 7) have identified three types of perceptions. In the first, environmentalism is characterized by an emphasis on the need for strong environmental legislation and technological solutions (e.g. recycling) and by the idea that reforms to the system can be produced by idealism, determination, good will, and the efforts of individuals, local groups and committees. In the second, environmentalism is characterized by the realization that in modern society "things are not that simple". Consequently there has been a growth in the formation of pressure groups whose aim has been to influence the decision-making process. The third type of environmentalism, as now perceived by some groups, is characterized by the development of a critique of the technological and energetic basis of present society and calls for the development of alternative or "soft" technologies and increased self-reliance.

20.6 One way to get some indication of what people think about environmental issues is to ask them by referendum or poll. Despite various limitations (Ashby, 1987) linked to the size, structure and characteristics of the sample of the population surveyed, public opinion polls still provide the most useful measure of changing public attitudes. While public opinion polls carried out in the late 1960s and early 1970s concentrated mainly

on local environmental issues, those conducted more recently have often been expanded to include national, regional and global environmental issues, as well as issues related to socio-economics, politics, development and quality of life. (8)

20.7 High levels of public concern and consciousness about environmental issues have been recorded in all polls. (8 to 13) A multinational survey of public and leadership perception of environmental issues that covered 14 countries (Argentina, China, Federal Republic of Germany, Hungary, India, Jamaica, Japan, Kenya, Mexico, Nigeria, Norway, Saudi Arabia, Senegal and Zimbabwe) (14) showed a remarkable agreement between the public and the leadership about the state of the environment, the problems considered as "major", the need for international cooperation to deal with environmental problems, and even the division in opinion about the willingness to pay more to protect the environment (Fig.20.1). On the other hand, a recent study (15) revealed marked differences in opinion

Figure 20.1
VIEWS ON THE STATE OF THE ENVIRONMENT (AVERAGES BASED ON DATA FROM 14 COUNTRIES) (percentage)



Source: Based on data from (14).

between the public and experts about selected environmental issues. While the public expressed great concern about nuclear power, radioactive and hazardous waste and chemical plant accidents, the experts ranked these issues as medium- to low-risk. Conversely, issues ranked highly by the experts, such as pesticides, indoor air pollution, worker exposure to chemicals and global warming were regarded as medium- to low-risk by the public. There are several reasons for this divergence of opinion between the public and experts. The first is that the public did not have all the information that would help in establishing the appropriate perception. The second is the difference in the perception of hazards. Public concern generally becomes highly stimulated when a significant hazardous environmental accident occurs, and perceptions become highly influenced by mass media coverage of the incident. This is natural, because public perception of a hazard is heavily weighted by its severity and very little by its frequency. Perhaps irrationally, people often overestimate the frequency and seriousness of dramatic, sensational, dreaded, and well-publicized causes of death and underestimate the risks from more familiar, accepted causes that claim lives one by one (see also Chapter 9).

20.8 Such divergences have often frustrated decision makers and have led some experts to argue that the public's apparent pursuit of a "zero-risk society" threatens national, political and economic stability. Indeed, there is no such thing as "zero-risk". However sophisticated and advanced a technology may be, there is no foolproof technology and no safeguard against human error. Experts and decision makers should, therefore, understand how people think about and respond to risk rather than devoting their attention only to statistical estimates of it. Without such understanding, well-intended decisions and policies may become ineffective. In any case, the public should ultimately decide what risks to accept. If people are encouraged to become fully involved in planning and decision-making – through participation – both the people and the experts will learn from each other, society as a whole will benefit, and more durable policies will emerge.

20.9 The media have been instrumental in increasing public awareness of many environmental issues. But the media have generally been reactive rather than innovative. Coverage increased and fell in response to "trigger events", either disasters or threatened disasters. Events like smog episodes in London in 1952 and New York in 1963, the Seveso accident (1976), the Amoco Cadiz accident in 1978, the Three Mile Island nuclear power accident in 1979, the Bhopal tragedy in 1984, the Chernobyl accident in 1986, the Exxon Valdez in 1989 and others received extensive coverage by the press, radio and television, partly because they had inherent public appeal. This natural predisposition towards the dramatic ensures that the information provided by the media about risks is frequently inadequate. When environmental risk is reported, the emphasis is usually on its more alarming features. The stark language of news - that is, the words and pictures used to convey information - also leaves room for interpretation, especially in the absence of background information. (8, 16 to 21)

20.10 Improving the availability of environmental information to the media and then properly reporting such information to the public are critical for the management of environmental problems. Success in environmental communication is not to be measured by public acceptance of the solutions formulated by decision makers; it is achieved when the best solutions are knowingly chosen by a well-informed public. One of the most important roles of the media is to expand the audience for debate on a

particular issue. This frequently leads to redefining and broadening the scope of the problem and often creates new issues and more controversy. These new issues and the expanded audience for the policy discussions have frequently frustrated decision makers and made them feel that the resolution of problems has become more difficult. But, at the same time, all this has resulted in new thinking which takes into account the new dimensions that emerge from the debate of a wider audience. In the end, this usually leads to better, more enduring policies.

Responses

20.11 The evolution in public perceptions of environmental issues, the increased public awareness and the activities of different national and international NGOs have given impetus to many actions in the last two decades to protect the environment. All the responses outlined in the previous chapters and those given in Chapter 21 are generally the result of the public outcry for a better environment and better living conditions. In the early 1970s, some predicted that environmentalism would pass through an "issue attention cycle", in which it would leap into prominence, remain there for a short time, and then gradually fade from public attention as economic recession, developing country debt and regional conflict grew. (22) Yet, environmentalism has grown in every respect and it is here to stay. The 1990s are witnessing not only more vigorous interest, but also an important transformation in thinking. An increasing proportion of people in many countries now accept the need for development strategies that enable people to live off "nature's interest", rather than "nature's capital". (23) More and more, people are accepting the notion of intragenerational responsibility and intergenerational equity: that future generations should not inherit less environmental capital than the present generation inherited.

20.12 One manifestation of increased public concern for the environment, particularly in developed countries, is the increase in the individual's demand for information which will allow the choice of product's that are "friendly" to the environment. This rise in "green consumerism" (24 to 26) has led to the incorporation of environmental considerations into several national and international consumers' movements. One example is the return to refillable containers (other than continuing the use of cans) for soft and other drinks in some European countries, e.g., in Denmark. Another example is the increased use of recycled paper for packaging and other purposes.

20.13 The growth of the environmental movement has had a profound influence on industry. Whereas in the 1960s and 1970s industry tended to regard environmental concern as a peripheral nuisance to be evaded where possible, in the 1980s many companies have themselves become active in developing environmental policies. Corporate managers are beginning to see that improving the environment is the smart way of conducting business. Based on the premise that profit-making opportunities of the 1990s will be in manufacturing and marketing "environmentally sound" products and services, initiatives such as developing cleaner production processes, offering products that generate less waste, devising safer pest control strategies and cleaning up past damage are fast becoming top-priority investment areas. (27, 28) Recycling of waste (Chapter 10) and increasing the efficiency of water, energy and materials in manufacturing processes (Chapter 12) are examples of the response of industry to the environmental movement. Another important example is industry's cooperation in the phasing out of chlorofluorocarbons and other compounds that have been implicated in depleting the ozone layer (Chapter 2).

Chapter 21

RESPONSES

21.1 People and Governments have always responded to environmental deterioration. The ancient Chinese, for example, appointed inspectors to ensure that cultivated land was not being degraded through malpractice. Ancient Greek and Roman scholars wrote about soil husbandry and land management. Plato wrote in *The Laws* what can be considered as the earliest known enunciation of what we now describe as the "polluter-pays" principle:

> "Water is easily polluted by the use of any kind of drug. It therefore needs the protection of a law, as follows: whoever purposely contaminates water shall be obliged in addition to paying an indemnity, to purify the spring or receptacle of the water, using whatever method of purification is prescribed" *(The Laws, Book VIII, p.845).*

The first smoke abatement law was passed in England in 1273. (1) Cities passed many ordinances against refuse dumping in streets and canals. Environmental students of the nineteenth century expressed concern about the impacts of human transformation of the landscape and early geographers and geologists attempted to describe the changing face of the earth in its entirety. The destruction of natural areas stimulated the formation and growth of conservation measures; early conservationists worked in defence of natural reserves, ancient buildings and different habitats. It was not until the early 1960s, however, that the growing environmental movement (Chapter 20) placed increasing pressure on Governments to respond to different contemporary and emerging environmental issues. The responses outlined in the preceding chapters cover a wide range of activities undertaken in the past two decades, not only to curb environmental pollution at the national, regional and global levels, but also to conserve and manage different natural resources in a more rational way. The following is an analysis of the different categories of responses set in motion.

Science and Technology

21.2 In the last two decades scientific research has contributed a great deal to our understanding of the different processes that control and affect environmental systems. Much progress has been made in devising analytical methods and instruments to determine and monitor trace amounts of inorganic and organic pollutants, in better defining the processes of the transformation, interaction and fate of pollutants emitted into various media, and in establishing the effects of such pollutants on material and biota. Impressive insights have been gained into the biogeochemical cycling of elements essential for life, such as carbon, nitrogen, oxygen, phosphorus and sulphur. And we now understand better than two decades ago the mechanisms that could lead to ozone depletion and global warming. Many of these scientific advances have been achieved through national and international scientific research programmes. The activities of UNEP; the Scientific Committee on Problems

of the Environment (SCOPE), the Global Atmospheric Research Programme (a joint effort between WMO and the International Council of Scientific Unions); the World Climate Programme; the Unesco Man and Biosphere (MAB) programme; the International Programme on Chemical Safety (WHO/ILO/UNEP); the International Geosphere-Biosphere Programme (IGBP); the Consultative Group on International Agricultural Research (CGIAR), the International Federation of Institutes for Advanced Study (IFIAS), the International Institute for Applied Systems Analysis (IIASA), IUCN, the International Institute for Environment and Development (IIED), WRI and several United Nations bodies have contributed a great deal to our understanding of contemporary and future environmental problems.

21.3 Mathematical models have long been used to predict different geophysical, as well as some ecological processes. As a result of the increasing understanding of complex environmental systems and as a result of advances in computer technology, model performance has improved greatly in the last 20 years and there is now an increased degree of public acceptance of model-derived "futures". Examples of such models are those related to ozone depletion, climate change, acid rain, nuclear winter and impacts of environmental change on the biosphere. Other models that have been developed in the last two decades have dealt with the interrelationships between resources, population growth and environment (e.g. World I and II models, which formed the basis of "Limits to Growth", published by the Club of Rome; the Leontief model, published by the United Nations; the OECD Inter-Futures model; the Latin American Model, published by the Bariloche Foundation; the Global-2000 model, published by the United States Council on Environmental Quality; the IIASA models related to energy supply and demand; and several other regional and global models).

21.4 The last two decades have also seen the introduction of techniques of environmental impact assessment, cost-benefit analysis, risk analysis and management, natural resources and environmental accounting, technology assessment, environmental audits, the use of geographical information systems, and several other tools that have contributed to a better understanding of environmental processes and have helped to a marked degree in drawing up better policies to deal with different environmental problems. For example, the use of environmental cost-benefit analyses has brought about considerable improvements in the regulatory measures in the United States. The adoption of more stringent standards for lead in fuels brought a net benefit in health and welfare that has been estimated at about $US 6.7 billion. (2)

21.5 Many advances have also been made in technologies to protect the environment. For example, more efficient air pollution control equipment (e.g. electrostatic precipitators, flue-gas desulphurization, etc.) has been developed. Improved technologies have been introduced to treat both municipal and industrial wastewater, manage solid wastes, increase the efficiency of energy and water use, and use several wastes beneficially. Achievements have been made in developing more "cleaner" technologies. The actions taken by the world community to phase out chlorofluorocarbons that threaten the ozone layer have been accompanied by a notable response from research laboratories and chemical companies to develop more environmentally sound alternatives. Major advances have been made in developing many simple technologies to suit different purposes, especially in rural areas of the developing countries.

The efficiency of converting of dung into biogas and fertilizer has been improved by changes in the design of the digesters; more efficient wood-burning stoves have been developed; various types of hand-pumps for water supply have been introduced, and simple latrines have been designed to improve sanitation conditions. Several technologies have also been developed to harness renewable sources of energy, especially solar and wind power, for specific purposes such as crop drying, water pumping, etc.

Education and Training

21.6 Parallel to the scientific and technological progress there has been a remarkable increase in environmental education – both formal and non-formal – in almost all countries. The environmental subjects that used to be embodied in common courses such as chemistry, biology, botany, etc. now constitute separate environmental courses in many schools and universities. Special courses on the environment (undergraduate and postgraduate) are now given at many universities around the world. Training programmes on many environmental issues have been held at universities and research centres. Since 1975, the Unesco/UNEP International Environmental Education Programme (IEEP) has been associated with such world-wide efforts to incorporate environmental dimensions into educational systems. The widespread use of non-formal information channels (especially television and the press) has contributed a great deal to an increase in public awareness of different environmental issues.

Institutional Measures

21.7 The task of designing and implementing environmental protection programmes rests with national Governments. In the early 1970s, few countries – mainly developed countries - had government departments that were concerned with aspects of environmental management. Sweden established a National Environmental Protection Board in 1969; the United States established its Council on Environmental Quality and Environmental Protection Agency in 1970, under a National Environment Policy Act. The United Kingdom established a Royal Commission on Environmental Pollution and a Department of the Environment in 1970, and Canada established its Department of Environment in the same period. In 1971, Japan established its Environmental Agency, and France established a Ministry for the Environment and the Protection of Nature. It was not until after the Stockholm Conference that departments of environment and cross-sectoral coordinating machinery for environmental affairs were established in many countries. At present, nearly all countries have environmental machinery of some kind. Some countries have established ministries for environment and/or natural resources; others have established environmental protection agencies and/or departments, either as independent bodies or affiliated to particular ministries. The responsibilities of these environmental bodies vary from one country to another. In general, their function is to design programmes to protect the national environment through the enactment of legislation, the establishment of standards for levels of various emissions, the creation of monitoring programmes to identify where problems are most serious and to measure the success of the control programmes in dealing with them, and so forth. The success of such national environmental machinery in discharging its responsibilities has varied considerably from one country to another. In many countries, especially developing countries, inter-departmental conflicts have often arisen, resulting in the weakening and limitation of the functions and coordinating role of the environmental machinery.

21.8 Although, prior to 1972, some United Nations bodies, such as FAO, Unesco and WHO, dealt - within their mandates - with different issues related to the environment, it was not until the Stockholm Conference and the establishment of the United Nations Environment Programme that a major driving force was created to give impetus to most United Nations bodies, not only to incorporate the environment into their activities, but also to create units or departments to deal with environmental issues. The United Nations Environment Programme, with its catalytic and coordinating role, has contributed a great deal to that driving force. The major United Nations conferences that followed the Stockholm Conference explored in depth the issues related to food, fresh water, human settlements, desertification, renewable sources of energy, and other topics and led to a broadening of the mandates of different United Nations bodies and/or the creation of additional intergovernmental and secretariat organs within the United Nations system to deal with different defined contemporary and emerging issues. These developments also gave impetus to broadening and strengthening the mandates and activities of global institutions such as IUCN, ICSU (especially its Scientific Committee on Problems of the Environment – SCOPE), WWF and others. Global NGOs, such as the International Institute for Environment and Development (IIED), the World Resources Institute, Greenpeace, Friends of the Earth and others have been established and are now instrumental in providing independent advice on different environmental and resource issues.

21.9 At the regional level, the Economic and Social Commissions of the United Nations established special units to deal with environmental issues. In South-East Asia, joint action by the South Pacific Commission, the South Pacific Bureau for Economic Cooperation, the Economic and Social Commission for Asia and the Pacific (ESCAP) and UNEP led to the establishment of the South Pacific Regional Environmental Programme in 1982. The African Ministerial Conference, convened in Cairo in 1985, led to the adoption of a regional programme of action and the establishment of a secretariat to follow-up on its implementation. The Conference of the Arab Ministers responsible for Environment, convened in Tunis in 1986, also adopted a regional programme of action and established a ministerial council to follow upon its implementation. Other regional intergovernmental bodies, such as OECD, CMEA and others, have established units and various committees at different levels to deal with regional environmental issues.

21.10 Another important development in the last two decades has been the increasing recognition of the importance of incorporating environmental considerations into development policies and development assistance. Accordingly, in 1980 nine development assistance agencies and UNEP signed the Declaration of Environmental Policies and Procedures Relating to Economic Development. They pledged to set up systematic environmental assessment and evaluation procedures for all development activities and to support projects that improve the environment and natural – resource base of developing nations. The Committee of International Development Institutions on the Environment (CIDIE) was established to review the implementation of the Declaration regularly. The World Bank has established a department to deal with environmental issues pertaining to its activities, and almost all regional development banks have incorporated environmental impact assessment into the development projects they support. Recently, a multilateral fund involving UNEP, UNDP and the World Bank was established to help developing countries meet the costs of complying with the revised

Montreal Protocol and to provide for the necessary transfer of technology (Chapter 2). The Global Environmental Facility - a joint venture between the World Bank, UNDP and UNEP - with financing of some $US 1.3 billion also became operational, in order to address priority global environmental issues.

Regulatory Measures

21.11 Although several countries formulated laws many decades ago to improve the quality of their environment, most of these laws have been amended or clarified in recent years. In some cases, changes were required, because problems were found to be more serious than had originally been thought. In other cases, the adjustments were to make the environmental protection programmes more effective. Much national environmental law has been concerned with regulating activities that have the potential to cause environmental hazards, with authorizing discharges into the environment and with setting the standards for emissions. Another dimension of environmental law is concerned with the procedures that must be adopted before development projects are implemented or before products are marketed. This includes requirements for environmental impact assessment of projects and prior screening and approval of products such as pharmaceuticals, pesticides and other particular classes of compounds and products. A final area of recent legislation concerns public access to information and the rights of the public to sue companies or others who cause environmental damage or who, by their activities, put the environment at risk.

21.12 The emergence of an increasing body of environmental law and regulation has been paralleled by changes in the way in which legal instruments are interpreted and enforced. Conflicts often arise and it has been rather difficult to implement national environmental regulations, especially in developing countries. Sometimes the environmental machinery in a country does not have sufficient information to recognize the extent to which polluters do or do not comply with the rules. In many developing countries, environmental regulations are formulated in such a way as to emulate those in developed countries, and therefore cannot be implemented because of the considerable differences in environmental and socio-ecomomic conditions. For example, attempts to enforce regulations governing auto emissions similar to those implemented in the United States or in some European countries have failed in several developing nations.

21.13 The recognition that environmental pollution is not restricted to national boundaries and can cross frontiers to cause regional and global problems has prompted the formulation of different regional and international conventions. Before 1972, there were 58 international treaties and other agreements in the field of the environment; between 1972 and 1991, 94 such agreements were adopted regionally and globally (see UNEP Register of International Treaties and other Agreements in the Field of the Environment, 1991). These international agreements deal with a wide range of issues, ranging from marine pollution, and protection and conservation of different natural resources, to agreements that deal with anticipation and future issues (such as early warning in the case of nuclear accidents and protection of the ozone layer). The world community's increasing concern about global warming and its future potential impacts on different ecosystems has prompted the start of rounds of negotiations to draft a global climate convention. Similarly, negotiations are under way to elaborate an international convention on the conservation and rational use of biological diversity (see Chapters 1 to 10). In spite of the large number of legal instruments in the field of the environment, the efficiency and effectiveness of environmental legal regulation leave much to be desired. Lack of compliance with

existing legal commitments and the inherent weakness of enforcement procedures are two major concerns. Although international environmental agreements as a rule incorporate obligations to report on implementation, the questions of verification of implementation of such agreements and the resolution of environmental conflicts that may arise are still to be adequately and effectively institutionalized.

Economic Measures

21.14 Over the past 20 years an increasing number of countries have recognized that economic instruments can be an effective means of improving the environment and then maintaining a high level of environmental quality. Several guiding principles have evolved since 1970. The first of these was the "polluter pays principle – or PPP", which essentially states that the costs of pollution should not be externalized. An industry or municipality should itself, without subsidy, bear the costs of the actions needed to meet environmental standards and avoid environmental damage. As a consequence, market prices should reflect the full costs of environmental damage arising from pollution or, more appropriately, of the costs of preventing such damage. Similarly, the "user pays principle – UPP", which is a development of the "PPP", requires that prices reflect the full social cost of use or depletion of a resource.

21.15 In the OECD countries, several economic instruments are in use. The first are charges, which include effluent charges, user charges, product charges, and administrative charges to discourage polluting activities and/or to provide financial assistance to achieve reductions in pollution. The second are subsidies, in the form of grants, soft loans and tax allowances, which may be used to encourage less polluting behaviour. The third type of economic measure is the deposit-refund scheme to encourage re-use (e.g. of beverage containers) or a more environmentally friendly disposal of waste. The fourth type is the market creation arrangement such as a trading arrangement to encourage more efficient and cost-effective use of emission permits. The fifth category of economic measures comprises financial enforcement incentives, such as non-compliance fees and performance bonds, which provide an additional financial inducement to comply with existing environmental regulations. (3) By 1988, 153 different economic instruments were said to be in use in the different OECD countries. Of these, 81 involved charges of various kinds, 41 were subsidies, and 31 were of other kind. (3) As illustrations of national actions: France has an effluent charge related to air pollution; Finland and Sweden have introduced a carbon tax on fossil fuel use. Australia, Belgium, the Netherlands and the United States levy effluent charges on wastes. Denmark, Finland, Germany, the Netherlands, New Zealand, Sweden, Switzerland and the United Kingdom impose different levels of taxation on leaded and unleaded gasoline, and Germany, Japan, the Netherlands and Sweden, use taxation as an instrument to promote low-pollution vehicles. (3)

21.16 Economic measures have also been implemented in many developing countries. The oldest of these are charges for the collection of domestic garbage, the deposit-refund schemes (especially for beverage and other containers), and several types of fines for illegal dumping of waste (e.g. waste resulting from the construction sector). In the past 20 years an increasing number of countries have reduced or removed subsidies on agricultural chemicals, for example pesticides, leading to more efficient use of these compounds and/or the increasing adoption of integrated pest management techniques (Chapter 11). However, the application of economic measures to curb pollution in the industry and/or transport sector has been more difficult.

PART V

CHALLENGES AND PRIORITIES FOR ACTION

Chapter 22

CHALLENGES AND PRIORITIES FOR ACTION

"Delays have dangerous ends"

(W. Shakespeare; Henry VI, Part I, 1589/90)

Introduction

Ten years ago UNEP's publication "The World Environment 1972-1982" concluded with the observation that:

> "At the Stockholm conference it was generally assumed that the world's system of national Governments, regional groupings and international agencies had the power to take effective action ... By the early 1980s there was less confidence in the capacity of national and international managerial systems to apply known principles and techniques, or in the effectiveness with which international debates lead to action ... Restoration of confidence and consensus in these areas may be the greatest challenge for those seeking to improve the world environment in the 1980s". (1)

It is disturbing that the same statement is still valid a decade later. Indeed, many of the concerns identified in the earlier report remain the same. There are still serious gaps in our understanding of the environment, our ability to estimate the cost of repairing the damage we have done to it, and our knowledge of the cost of failing to take rapid action to halt its degradation. Twenty years after Stockholm, it is still not possible to describe the state of the world environment comprehensively or to say with confidence that the Governments of the world have the knowledge or the political will to deal with the global problems which we already know exist.

The most significant concerns remain the lack of many of the prerequisites for informed decision-making and good environmental management, in particular:

* The database is still of variable quality, with a shortage of data from developing countries. As a result comprehensive data on the major environmental problems cannot be compiled and 'best estimates' are all that are available.

* Despite great advances in science, remote sensing and the technical ability to monitor the world environment, these have not been generally applied, mainly because of a lack of equipment and trained personnel in many countries.

* There has been no general agreement on the socio-economic indicators of a healthy relationship between people and their environment or on standards for a decent environment.

* Comprehensive assessments of the environmental situation and of the earth's carrying capacity are, in consequence, still difficult.

Despite these concerns there has been clear progress in a number of areas during the past decade. The scientific assessment of stratospheric ozone depletion and understanding of the processes involved have progressed very rapidly and been matched by international and national actions to redress the situation. A strong scientific consensus is now emerging on climate change and loss of biodiversity, their causes and the need for a collective response. Some progress has been made in dealing with the problems of hazardous wastes and toxic chemicals. And there are more and better overall assessments of the environment backed by improved data compendia.

The first section of the present volume outlines the ten major environmental issues, the trends during the last two decades in each, their impacts on people and possible responses to them.

* Urban air pollution has been improving in most cities in the developed world, but deteriorating markedly in developing countries. Further work and much greater international cooperation are needed to deal with the issues of transboundary and global pollution of the atmosphere.

* Rapid advances in scientific understanding of stratospheric ozone depletion and its causes indicate that further actions to protect the ozone layer will be required if Governments are to avert significant health and economic effects.

* Despite the uncertainties inherent in such a complex system, increased understanding of the causes and possible effects of climate change indicates a range of global strategies which should be adopted urgently to ameliorate its effects.

* Access to fresh water and the quality of available water supplies are key factors in development, particularly in arid or semi-arid areas. Urgent action is needed to improve both knowledge and management of fresh water resources and to establish cooperative manage-ment of freshwater basins so as to avoid the potential for conflict.

* While progress has been made through a number of regional seas action plans to halt the further degradation of coastal zones, seas and oceans, urgent action is needed to deal with the problems of land-based sources of marine pollution, unsustainable use of marine resources and rehabilitation of degraded areas.

* Degradation of arid lands – and desertification in particular – is a grave and growing problem and its socio-economic as well as its physical causes must be addressed urgently. A realistic programme of corrective action and rehabilitation in land already subject to desertification must begin.

* Deforestation, the destruction of wetlands, and other forms of habitat loss are threatening the stability of local and regional environments and wasting valuable resources. Regional, sub-regional and national actions, within agreed global targets, are urgently needed to halt and reverse the pattern of deforestation and habitat loss in all regions.

* The loss of biological diversity, expressed in the current rapid extinction of species and reduction of genetic variability, is an unnecessary waste of irreplaceable resources needed for sustainable development. Urgent action is needed to save, study and use rationally the world's biological riches.

* Human activity has increased both the range and the scale of environmental hazards to which people are exposed.

Action is needed both to reduce the risk of disasters (particularly from human causes) and to improve our ability to respond to those which cannot be avoided.

* The generation and disposal of hazardous wastes and the production of toxic chemicals pose significant threats to human well-being. International action to improve our knowledge and control of them is urgently needed.

These issues arise from human actions and are of concern principally because their effects impinge on human well-being – either directly or by undermining the life-support systems of the environment.

I. Environment and Development

22.1 The concept of development is a multidimensional one, encompassing the economic, social, cultural and political aspects of human society. The preceding chapters have illustrated how, through the development process, humans interact with and affect the natural environment, and how the state of the environment determines the path of development. The world community is confronted by a closed cycle: economic problems cause or aggravate environmental despoliation which, in turn, makes economic and structural reform difficult to achieve. If the world continues to accept disappearing tree cover, land degradation, the expansion of deserts, the loss of plant and animal species, air and water pollution, and the changing chemistry of the atmosphere, it will also have to accept economic decline and social disintegration. In a world where progress depends on a complex set of national and international economic ties, such disintegration would bring insecurity and human suffering on a scale that has no precedent.

22.2 Until the early 1970s, it was familiar for the debate about environmental policy to be couched in terms of economic growth versus the environment. The basic idea was that one could have economic growth –

BOX 22.1

The kind of environmental problems that are of importance in developing countries are those that can be overcome by the process of development itself.

The Founex Report (1971) (2)

The protection and improvement of the human environment is a major issue which affects the well-being of peoples and economic development throughout the world.

The Stockholm Declaration (1972) (3)

The problem today is not primarily one of absolute physical shortage but of economic and social maldistribution and misuse.

The Cocoyoc Declaration (1974) (4)

It is essential that the mutually dependant relationships between development and environment be fully and explicitly taken into account.

Choosing the Options (1980) (5)

Health, nutrition and general well-being depend upon the integrity and productivity of the environment and resources.

International Development Strategy for the Third United Nations Development Decade (1980) (6)

measured by rising real per capita income– or one could have improved environmental quality. Any mix of the two involved a trade-off – more environmental quality meant less economic growth, and vice versa. However the Founex Seminar on Development and Environment in 1971; the United Nations Conference on the Human Environment, convened in Stockholm in 1972, the Cocoyoc Symposium on Patterns of Resource Use, Environment and Development Strategies, organized by UNEP and UNCTAD in Mexico in 1974, and other fora and studies began to clarify the links between environment and development. Since then, the discussion has tended to shift the focus away from "growth versus the environment" to one of the potential complementarity of growth and environment.

22.3 The 1970s, therefore, saw the emergence of a major revision in development thinking that presents a fundamental challenge to the conventional consensus on economic development. Expressions such as "*alternative patterns of development and lifestyles*", "*ecodevelopment*", "*environmentally sound development*", "*development without destruction*", "*sustainable development*" and others have been introduced to convey essentially the same message: that environment and development are closely interdependent, and are in fact mutually supportive.

22.4 Over the past two decades, the concept of sustainable development has been increasingly stressed. Although there are many definitions of sustainable

BOX 22.2

Ecodevelopment ... is a style of development which stresses specific solutions for the particular problems in each eco-region taking into account ecological and cultural contexts as well as present and long-term needs.

Report to UNEP Governing Council (1974) (7)

Development without destruction - the maximization of the production of food without destroying the ecological basis to sustain production...

M. K. Tolba, Statement to World Food Conference 1974 (8)

Environmental management implies sustainable development ...

UNEP Governing Council (1975) (9)

Special attention from now on must be placed on ... adjusting lifestyles to a more rational use of resources with particular emphasis on the present and future resource and environmental needs of the ... developing countries.

Choosing the Options (1980) (5)

BOX 22.3

Sustainable development ... meets the needs of the present without compromising the ability of future generations to meet theirs ... on the basis of prudent management of available global resources and environmental capacities and the rehabilitation of the environment previously subjected to degradation and misuse. ... Although it is important to tackle immediate environmental problems, anticipatory and preventive policies are the most effective and economical in achieving environmentally sound development.

Environmental Perspective to the Year 2000 and Beyond (1987) (12)

Critical objectives for environment and development policies that follow from the concept of sustainable development include:

* *reviving growth;*
* *changing the quality of growth;*
* *meeting essential needs for jobs, food, energy, water and sanitation;*
* *ensuring a sustainable level of population;*
* *conserving and enhancing the resource base;*
* *re-orienting technology and managing risk;*
* *merging environment and economics in decision-making.*

Our Common Future (1987) (11)

development, (10) it is generally understood to involve the key elements identified in the report of the World Commission on Environment and Development (11) and the Environmental Perspective to the Year 2000 and Beyond. (12)

22.5 At the core of the concept of sustainable development is the requirement that current practices should not diminish the possibility of maintaining or improving living standards in the future. In other words, economic systems should be managed to maintain or improve the resource and environmental base so that future generations will be able to live equally well or better. Sustainable development does not require the preservation of the current stock of natural resources or any particular mix of human, physical and natural assets. Nor does it place artificial limits on economic growth, provided that such growth is both economically and environmentally sustainable.

BOX 22.4

Growth must be revived in developing countries ... where the links between economic growth, the alleviation of poverty and environmental conditions operate most directly.

The process of economic development must be more soundly based on the stock of capital that sustains it.

Our Common Future (1987) (11)

22.6 Sustainable development, therefore, raises concern for a new type of fairness and equality rarely considered previously: "intergenerational equity". In the past, it was commonly assumed that the next generation would take its chances on a planet very similar to the one inhabited by the current generation, perhaps with new technology to make life safer, healthier and easier. This is no longer a justifiable assumption. The present generation is the first to have the power to alter planetary ecosystems radically, to present its offspring with a planet very different from the one it inherited from its own forebears - different atmosphere, soils, water regimes, plants and animals.

nature and human activity in the future. But most of these advances have yet to be institutionalized into Governments' and development agencies' policy and planning systems. In fact the concern has been that only few countries take adequate account of environmental considerations when making policy or planning development. Few allocate or regulate uses of their living resources so as to ensure that they are environmentally appropriate and sustainable. Many lack either the financial or technical resources, or the political will, or adequate legislative, institutional, or public support for conservation and tackling environmental problems. The result has been that, at the

BOX 22.5

To defend and improve the environment for present and future generations has become an imperative goal of mankind - a goal to be pursued together with, and in harmony with, the established and fundamental goals of peace and of world-wide economic and social development.

The Stockholm Declaration (1972) (3)-

But intergenerational equity is a difficult goal, in that unborn generations are not present to make their concerns known. Thus, environmentally sound and sustainable development requires that this generation accept responsibility for future generations. Making this goal a reality may be the foremost challenge facing policy makers in the closing years of the 20th century and beyond.

22.7 Although the subject of integration of environmental management with concerns about economic and social development has been raised at the Stockholm Conference, it is still a major arena of debate. There have been many developments in the last two decades which pretend major changes in the way societies will think about the management of the relationship between

level of project planning and design, unwanted environmental impacts have arisen from inadequate attention having been paid to environmental consequences and from the lack of knowledge and information necessary to predict them; other causes have included ignorance of cost-effective preventive or mitigating measures, and failure to consider alternative project designs or locations. (13)

II. Environment and Economics

22.8 Classical economic theories and practices have treated nature as an infinite supply of physical resources (i.e. raw materials, energy, water, soil and air) to be used for human benefit, and as an infinite sink for the by-products of the development and consumption of these benefits, in the

form of various types of pollution and ecological degradation. Hence, the economy became disembodied from nature, in theory and in practice. The dominance of this approach began to weaken in the late 1960s, when pollution became a major concern in the industrialized nations. And soon it was realized that the process of self-regeneration of natural resources is a rather slow and complicated one; if some natural resources are overexploited, the stock will fall rapidly, leading ultimately to the complete destruction of the resource. It has also been realized that air and water have limited assimilative and carrying capacities and that pollution control measures must be instituted to safeguard the environment and the quality of human life.

22.9 It is therefore important, if sustainable development is to be achieved, to evaluate the environmental costs and benefits of any development process. But such evaluation is not easy. Some of the environmental effects of development can be easily identified and evaluated quantitatively; others cannot. Nevertheless, an economic analysis of the environmental effects of alternative development processes, partial though it must necessarily be, is important because it creates awareness of the fact that natural resources ought not to be treated as free goods. Environmental costs arise either through the damage done as a consequence of resource exploitation or through the effort expended to redress the damage.

22.10 In the last two decades several studies have attempted to estimate the economic costs of damage caused by environmental pollution. For example, the annual damage caused by air, water and noise pollution in the Netherlands was estimated at $US0.6 to 1.1 billion in 1986 (about 0.5 to 0.9 per cent of GNP). In Germany, the damage from the same sources of pollution was estimated at about $US34 billion per year from 1983 to 1985, or about 6 per cent of annual GNP. (14) Generally speaking, the economic cost of pollution damage in developed countries varies between 3 and 5 per cent of the GNP. It should be noted that this costing of the damage due to irrational use of natural resources and/or pollution is far from complete. Environmental damage is often selective and unequally distributed in time and space and among societies. Many of the physical, biological and socio-economic consequences of large development projects are inadequately known and some can be quantified while others cannot. Examples of the latter are when landscapes or historic monuments are threatened with irreversible change. Even if all the consequences could be enumerated and their likelihood assessed, placing a price tag on them would pose further difficulties. Consider, for example, the problems of placing a value on a human life. The traditional economic approach has been to equate the value of a life with the value of a person's expected future earnings. Many problems with this index are readily apparent. For one, it undervalues those in society who are underpaid and places no value at all on people who are not in income earning positions. In addition, it ignores the interpersonal effects of a death which may make the loss suffered much greater than any measurable financial loss.

22.11 The cost of pollution abatement and control in the developed countries has been estimated to vary from 0.8 to 1.5 per cent of annual GDP. (15) For developing countries, the figure is much lower and varies markedly from one country to another.

22.12 Pollution abatement studies deal essentially with the direct costs of dealing with pollution problems such as air and water pollution and management of waste. In most cases they do not include the cost of environmental deterioration, of loss of natural resources or of the impacts of all this on

economic development and on human health and well-being. Such studies, therefore, generally show the cost of action to protect the environment and its natural resources but not the cost of inaction. The important point to be made here is that the costs of environmental policies are in fact an investment for the future. The costs are generally more than compensated for by the benefits accrued from reducing the damage and from conservation of resources. For example, it has been estimated that the net benefits from air and water pollution control in the United States would amount to about $US26 billion per year. (14) In the developing countries, the construction of drinking water and sanitation facilities could reduce the incidence of infectious diseases by 50-60 per cent or even more. (16) Such an improvement in human health would lead not only to an increase in productivity and time on the job (both of which contribute to increased GNP, but also to a lower expenditure on goods and services delivered by the medical sector, most of which are imported.

22.13 In the last two decades some attempts have been made to adjust national income accounts to register both the direct costs inflicted by environmental degradation and the "depreciation" of natural resources capital to allow for losses in future production potential. Although the national accounts record the income earned from harvesting resource stocks (e.g. fish catch, timber, minerals, etc.), the loss of future income through declining resource stocks and deteriorating environmental quality is excluded. By allowing for such "depreciations" in the natural capital stock, the net contributions of resource depletion to national income are much lower, and more accurately reflect the impact on economic welfare. (17) For example, Japan attempted to correct its national income figures for a variety of factors, including environmental ones. Accordingly, it has been found that instead of the GNP growing by a factor of 8.3 per cent per year between 1955 and 1985, it grew by an average of 5.8 per cent per year. (14) In Indonesia, if the physical depletion, as well as net additions to petroleum, forest and soil assets are taken into consideration, it has been estimated that the GDP grew by 4.0 per cent per year in the period 1971 to 1984, instead of the reported gross value average of 7.1 per cent per year. (18) However, there are many difficulties in the process of adjusting national accounts that remain to be solved. For one, measuring the stock of economic capital and its rate of depreciation in many developing countries is a complicated task. Some natural resources, such as soils and watersheds are not easily measurable "stocks" as such. Another problem is that the depreciation of natural resource stocks may not always include all the off-site environmental quality effects. For example, the total environmental costs of deforestation and timber extraction should include the economic costs of soil erosion, siltation of waterways, flooding and impacts on climate.

BOX 22.6

For society as a whole, environment is a part of its real wealth and cannot be treated as a free resource.

The Founex Report (1971) (2)

Incomplete accounting occurs ... especially in the case of resources that are not capitalised in enterprise or national accounts: air, water, and soil.

Our Common Future (1987) (3)

III. The Changing World Scene

22.14 The world has not been standing still while the debate on environment and development gathered momentum and ideas, and concepts and issues emerged, were clarified and reiterated. The two decades since 1972 have seen major political, economic and social changes. The global political and economic landscape has altered, not gradually but in a number of dramatic and unforeseeable upheavals. As a result, the ideological and economic world maps of 1972 are no longer accurate in 1992, the geopolitical assumptions which accompanied them do not hold true today and the predictions of social change which were based on them have been proved inaccurate.

The Challenge

22.15 The most dramatic and obvious political changes have been the most recent. The movement towards democratic pluralism and the rejection of Marxist-Leninist economic theory in Eastern Europe have gripped world attention and often dominated the news media since the introduction of 'perestroika' in the USSR in the mid-1980s. However, the causes are to be found earlier, in more subtle changes to the prevailing philosophies in both East and West, which have had more profound consequences than was immediately obvious. The change from an essentially bipolar world in which two superpowers and their supporters faced each other across an ideological and political abyss has created both opportunities and uncertainties. It may be some time yet before the geopolitical map 'post-perestroika' is finally drawn, but the nature of that map and the world it represents will owe more to the fundamental causes of those changes than to the changes themselves.

22.16 The radical optimism of the early 1970s gave way under the pressure of the global economic recession that followed the second oil shock in 1978. The belief, which under-pinned the Second United Nations Development Decade and the call for a "New International Economic Order", that institutional solutions could be found to human and social problems was replaced by a more individualistic, inward-looking, market-oriented philosophy. Paradoxically, the same improvements in mass communications which have liberated individuals and fuelled popular demands for political reform have also led to an increased sense of individual helplessness in the face of mounting environmental crises and to greater popular distrust of politically-generated solutions to social, economic and environmental problems.

22.17 The few value-added products that are generated in developing countries are often blocked by lack of market access, as developing countries' commodity exports are affected by the "new protectionism" which followed the recession of the early 1980s. Non-tariff barriers, voluntary export restraints, direct and indirect subsidies and other obstacles have made the developing countries' access to Northern markets extremely difficult. According to the World Bank, the percentage of OECD country imports covered by non-tariff barriers almost doubled between 1966 and 1986. Moreover, the percentage of trade affected by highly restrictive non-tariff measures is greater for developing countries than for industrialized countries. Subsidies on agricultural produce within the OECD are in the vicinity of $300 billion per annum. It had been estimated that trade protectionism in developed countries cost the global South around $55 billion in 1980 (in 1990 dollars). (19)

22.18 Over the past 20 years, both the World Bank and the IMF have shifted development priorities from import substitution to export-led growth, accompanied by

BOX 22.7

Environmental issues may come to exercise a growing influence on international economic relations. They ... could influence the pattern of world trade, the international distribution of industry, the competitive position of different groups of countries, their comparative costs of production, etc. ...
Some environmental actions by developed countries ... are likely to have negative effects on developing countries' export possibilities and their terms of trade.

The Founex Report (1971) (2)

GATT, among other international organizations, could be used for the examination of the problems [of trade and the environment], specifically through the recently established Group on Environmental Measures and International Trade.

Stockholm Plan of Action (1972) (3)

Awareness of the environmental aspects of international economic relations has increased but it has not yet found adequate expression in institutional practices and national policies. [...]

Environmentally related regulations and standards should not be used for protectionist purposes.

Environmental Perspective to the Year 2000 and Beyond (1987) (12)

severe structural adjustment programmes. For most developing countries with scant industrial capacities there is little to export but natural resources, making them almost totally reliant on commodity exports. However, commodity prices have fallen steadily since the early 1970s. By 1986, average real commodity prices were at their lowest recorded levels this century (with the single exception of 1932, the trough of the Great Depression). Prices of two critical export crops - cocoa and coffee - fell even further between 1986 and 1989 (by 48 and 55 per cent respectively). The World Bank forecasts that commodity prices are unlikely to rise during this decade, with intensified South-South competition in saturated markets.

22.19 The combined effect of debt servicing and reduced aid is a net financial flow from the South to the North. In 1989 developing countries paid $59.5 billion in interest on their debts, (20) and received official development assistance of $34.1 billion. (21) In the same year the official debt of low- and middle-income countries grew by an average of four per cent. (19) Increasing interest payments on a spiralling debt burden can only be met by increasing exports. For countries that are almost totally dependant on commodity exports in a hostile market this means placing greater pressure on the environment and a further reduction in living standards for their people. With a projected one billion additional people sharing scarce resources in the global South in the near future, the pace of environmental degradation seems certain to increase unless the debt crisis is resolved and greater equity is introduced into the world's commodity markets.

The Opportunity

22.20 To concentrate only on the negative statistics of the last two decades and ignore promising present trends and recent events would give a distorted and overly negative picture. While we must accept the reality that the two decades since the Stockholm Conference have seen a considerable degradation of the global environment and a further squandering of the world's stock of productive natural resources, there are also some grounds for optimism. A growing appreciation of the global nature of environmental problems and their implications – not just for the quality of life, but for its very sustenance - has led to a new and more serious approach to environmental issues since the mid-1980s. Governments have displayed a greater willingness to act together to address environmental threats on a global basis, as was demonstrated by the successful negotiation, between 1985 and 1987, of the Montreal Protocol on Substances that Deplete the Ozone Layer, its dramatic strengthening in 1990 and the large number of countries which have ratified it. This rapid and decisive action (at least in terms of international treaty negotiations) and the steps taken since then towards negotiation of conventions on control of hazardous wastes and their disposal, on climate change and on biodiversity would have been hard to predict even a decade earlier. This willingness to act has been accompanied by an encouraging movement away from confrontation and towards a more cooperative approach by Governments in forums dealing with environmental issues. It has thus been possible to develop new and innovative means (for example the funding mechanism established under the Montreal Protocol and the Global Environmental Facility) to address issues such as the transfer of environmentally sound technology to developing countries and to deal with major environmental problems.

IV. International Cooperation

22.21 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 befundamentally restructured, and there will have to be a quantum leap in international cooperation. 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.

22.22 The expectations for multinational cooperation raised at different forums over the last two decades have not been fulfilled. The global negotiations, whose immediate launching has been called for, have not materialized. The results of the Sixth United Nations Conference on Trade and Development have been disappointing for many, particularly the developing countries, and a similar disappointment has been felt over the failure to translate into concrete action the prescriptions for global economic recovery made at various summit meetings.

22.23 In the field of environment, the preparedness of Governments to translate good intentions into action has been more positive. The trade in endangered species, wetlands and world heritage conventions and the Montreal Protocol to protect the ozone layer (Chapter 21) have provided examples of major instruments for co-operation between and among developed and developing countries. But there is still an urgent need for the world community to solve a number of problems and to translate good intentions into practical actions to set the stage for sustainable and environmentally sound development.

22.24 There is, for example, a growing concern that conflicts are growing between international trade and environmental objectives. There are many countries that rely on imports of natural resources from developing countries which frequently do not have alternative products to sell in international markets. For example, Côte d'Ivoire, Gabon, Indonesia, Malaysia and the Philippines supply some 80 per cent of the world market in tropical hardwoods. Yet it is clear that the tropical forests supplying these products are being used unsustainably. (14) In so far as economic progress in the wealthier countries can be said to be sustainable, it could be said that the sustainability is in part being achieved by "importing" it through unsustainability in other nations. Thailand exports its entire cassava production - 90 per cent of it goes to the European Community. This production, taking up about 1.5 million ha of land, has led to the rapid degradation of natural resources in Thailand. (15) Since 1982, the EC has tried to restrict its imports from Thailand, but thus far this has not led to a decrease in production. In general, trade by industrialized countries and their trade-related policies have indirectly affected the environment and the use of natural resources in developing countries. A number of factors have contributed to an unsustainable use of natural resources, soil degradation, excessive use of fertilizers and pesticides, and pollution in many developing countries. These factors include developing countries' debt and/or balance of payment problems; industrialized countries' protectionism against goods manufactured in developing countries; preferential treatment of raw materials from developing countries; domestic agricultural subsidies in a number of developed countries; and price fluctuations on the world market. (15) There are also fears that the recent trends in international trade liberalization may have considerable negative consequences for the environment.

22.25 Twenty years ago development assistance agencies and financial institutions gave little attention to environmental protection. Recently, however, many of these agencies and institutions have established formal procedures for assessing the environmental impacts of their development

BOX 22.8

States have ... 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 their national jurisdiction.

The Stockholm Declaration (1972) (3)

It cannot be too much or too often emphasized how crucial the dialogue between and amongst the developed and developing countries is for the appropriate solutions of environmental problems.

State of the Environment Report (1984) (22)

The responsibility for ensuring a better environment should be equitably shared and the ability of developing countries to respond be taken into account.

Langkawi Declaration (1989) (23)

If the multiple bonds that characterize interdependence are convincingly present in any field, it is in that encompassing development and the environment. ... But the transition is not occurring smoothly and harmoniously; it is turbulent and beset with conflict.

Report of the South Commission (1990) (24)

assistance activities. Although these measures are welcomed to help developing countries chart their future development in an environmentally sound manner, it is feared that they constitute a new "conditionality" on providing development and/or technical assistance. In this respect, it should be emphasized that every country has the sovereign right to manage its own natural resource base, as well as the responsibility to protect its own environment and to ensure that its development activities do not harm the environment of its neighbours.

V. Priorities For The Next Two Decades

22.26 Environmental problems cut across a range of policy issues and are mostly rooted in inappropriate development patterns. Consequently, environmental issues, goals and actions cannot be framed in isolation from the development and policy sectors from which they emanate. Against this background, the Stockholm Conference produced an Action Plan for the Human Environment which was endorsed in General Assembly Resolution 2994 (XXVII) of 15 December 1972. The 109 recommendations in the Plan fall into three groups, concerned, respectively, with environmental assessment (evaluation and review, research, monitoring and information exchange); environmental management; and supporting measures (education and training, public information, financing and technical cooperation).

22.27 In the last two decades, the Stockholm recommendations have constituted the basis for action by the United Nations system and other international bodies. Over the years, specific goals were set up to implement these recommendations. These goals were revised and refined as our scientific knowledge of the different issues evolved and improved. This process led to the formulation of the Environmental Perspective to the Year 2000 and Beyond, (12) and its adoption by the General Assembly of the United Nations in 1987 (resolution 42/186 of 11 December 1987). That document reflects an intergovernmental consensus on growing environmental challenges to the year 2000 and beyond in six major sectors: population, food and agriculture, energy, industry, health and human settlements, and international economic relations. In addition, the document discusses briefly four issues of global concern (oceans and seas, outer space, biological diversity and security and environment) and considers the different instruments of environmental action. Also welcomed by the General Assembly (General Assembly resolution 42/187 of 11 December 1987) was "Our Common Future", the report of the World Commission on Environment and Development. (11) That document specifically addressed the need for sustainable development and the legal principles on which it should be based.

22.28 Taking into consideration the recommendations made and priorities outlined in various documents, including those mentioned in the present chapter, and the goals and targets presented to the Governing Council of UNEP in 1987, the time is now ripe to sharpen the focus on a number of issues that should be addressed by the world community in the coming two decades. Some specific, achievable actions to translate words into deeds are outlined in Box 22.9. The targeted actions proposed for consideration in this box do not constitute an exhaustive list. Nor are they intended merely to address the symptoms to which they relate. They provide a practical basis for direct action for environmental improvement and for the design and implementation of national and international policies and programmes to reconcile social, economic and environmental objectives in development. They represent goals that can be achieved through

integrated development planning which addresses the underlying causes of environmental degradation and lack of human development: unmanageable population growth, grinding poverty, crushing debt and unfair international economic relations on the one hand; and unsustainable lifestyles, unnecessary over-consumption and irresponsible use of scarce human and financial resources on the other. These priorities are based on pronouncements already made by Governments, documents noted by them, and existing studies, publications and global strategies (for example, the World Conservation Strategy (25) and Caring For The Earth. (26))

BOX 22.9

Priorities for action

REGULATORY MEASURES:

By 1995:

* *A global agreement on reforestation targets for each decade of the 21st century in each of the world's eco-regions.*

* *A global plan to combat marine pollution from land-based sources, with a target to reduce, by the year 2000 marine pollution from such sources to the 1990 level, and an agreed programme for further reductions after 2000.*

* *International agreement to ban all exports of hazardous wastes to developing countries, and a timetable to reduce the generation of such wastes.*

* *A global convention for the exchange of information on chemicals in international trade and establishment of an intergovernmental mechanism for chemical risk assessment and management.*

* *A global convention on prevention, notification and mutual cooperation in mitigating the effects of major environmental emergencies.*

* *An international code of conduct to apply internationally agreed guidelines for the transfer of technology, particularly to developing countries.*

* *An international agreement on the guidelines for application of environmental impact assessment, especially with regard to human activities with potential transboundary effects.*

* *Establish an international non-governmental body to help in monitoring breaches of environmental treaties and national actions leading to or likely to lead to major environmental deterioration.*

By 2000:

* *Agreement on the means of ensuring compliance with environmental treaties and establishment of appropriate institutional mechanisms to verify their implementation.*

BOX 22.9 (cont.)

ASSESSMENT:

By 1995:

* *Assess the environmental impacts of known new and alternative sources of energy.*

By 2000, complete the following:

* *Comprehensive assessment of air quality in all urban areas.*
* *Comprehensive assessment of global freshwater resources and their quality.*
* *Comprehensive assessment of land and soil degradation in the world.*
* *Environmental impact assessment of existing new technologies.*
* *Environmental impact assessment of existing new materials.*

By 2010:

* *Complete a survey of the world's habitats known to be unique, rich in biodiversity, or at risk.*

ENVIRONMENTAL MANAGEMENT:

By 1995:

* *Approve three concrete 5-year programmes to combat land degradation in drylands (desertification), which have been costed and for which the sources of funding have been identified.*
* *Establish a UN Centre for Response to Environmental Emergencies.*

By 2000:

* *Achieve a 30-per cent reduction in the amount of hazardous waste generated, compared with the 1990 level.*
* *Adoption by major development financing institutions of policies and procedures that ensure that their financial support to activities does not lead to environmental deterioration.*
* *All countries to adopt environmental and natural resource accounting as part of their system of national accounts.*
* *Capital flows in the form of natural resource imports and exports to be included in international trade statistics.*
* *All countries with real GDP per capita above US$5,000 to produce a plan to reduce their consumption of non-renewable natural resources.*
* *All countries with per capita annual energy consumption over 80 gigajoules to stabilize consumption at 1992 rates and establish programmes to reduce energy use to the 80 gigajoule level.*

By 2 000-2010:

* *To end net global deforestation.*

BOX 22.9 (cont.)

ENVIRONMENT AND ECONOMICS:

By 1995:

* *Estimates of the global costs of failing to deal with climate change ozone layer depletion, loss of biodiversity, marine and coastal deterioration from land based sources of pollution, and continued production of hazardous wastes.*

* *Production of revised estimates of the additional resources needed for the transfer of knowledge, information and specific environmentally sound technologies to developing countries and countries in transition, to allow them to participate meaningfully in dealing with their national as well as global environmental problems. By the same time, agreement should be reached on sources of funding and mechanisms for the transfer of technologies.*

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