# Review of Atmospheric Trends and Issues at Continental and Regional Level

Differences between regions in atmospheric trends and issues will inevitably be very important for the feasibility of global integrated assessment, and even more for the sort of political structures that will be relevant for tackling transboundary pollution at regional and global level. This paper therefore summarises relevant air pollution trends at continental and regional level, largely on the basis of UNEP's Global Environmental Outlook (GEO) project.

In response to the need for comprehensive, integrated, policy-relevant assessment of the global environment, UNEP launched the Global Environment Outlook (GEO) Project in 1995. The GEO process is a collaborative effort involving and supported by a range of partners around the world. The collaborating centres are responsible for almost all the regional inputs, thus combining top-down integrated assessment with bottom-up environmental reporting. GEO-1, the first report of the series was published in January 1997. It reviewed major environmental issues from regional and global perspectives. The second in the series, GEO2000 addresses three main areas: the state of the environment; trends and progress in policy development, including multilateral agreements; and the future, with a focus on emerging environmental issues and region-specific alternative policies.

## *1. Africa*

Poverty is both a cause and a consequence of environmental degradation in Africa, and mainly results from the political instability of many countries over the past few decades. Where such instability has resulted in civil war, the human and environmental effects have been even more devastating. Poverty also exists in spite of the wealth of Africa's natural resource, which many Africans are unable to benefit from due to complex reasons connected with Africa's socio-economic history over the past 100 years. Putting all this in perspective, the main cause of many environmental problems is the persistence of economic, agricultural, energy, industrial and other sectoral policies, which neglect, and fail to avoid, harmful impacts on the environment and natural resource base.

Major environmental challenges include deforestation, soil degradation and desertification, declining biodiversity and marine resources, water scarcity, and deteriorating water and air quality. Urbanisation is an emerging issue, bringing with it the range of human health and environmental problems well known in urban areas throughout the world. Growing 'environmental debts' in many countries are a major concern because the cost of remedial action will be far greater than preventive action.

### Atmosphere

Atmospheric pollution has emerged as a problem in most African countries only in the past few decades. Its severity and impacts are still largely unknown, although it is

believed that, in some areas, gaseous pollutants and acid rain have adversely affected vegetation, soils and water.

The main sources of atmospheric pollution are bush fires, vehicle emissions, manufacturing, mining and industry. Major industrial sources include thermal power stations, copper smelters, ferro-alloy works, steel works, foundries, fertiliser plants, and pulp and paper mills. If the projected growth of demand for vehicular transport and electricity is to be met with current technologies, emissions from thermal power stations are projected to increase elevenfold and from vehicles fivefold by 2003 (World Bank, 1992). The use of leaded fuel in vehicles is also a major concern. Lead pollution is worsened by the region's ageing vehicles, most of which are more than 15 years old. They are also said to emit five times more hydrocarbons and carbon monoxide, and four times more nitrogen oxides, than new ones (World Bank, 1995).

Air pollution is most significant in the more urbanised and industrialised countries of Northern and Southern Africa. In Southern Africa, air pollution is largely from thermal power stations; most of the electricity generation is from coal, much of it produced in South Africa where it accounted for 97 per cent of total electricity generation in 1994 (Sivertsen et al., 1995). As South African coal contains about 1 per cent sulphur, the country emits more sulphur dioxide than any other in the Southern African region. Moreover, South Africa is ranked as the 15th largest emitter of greenhouse gases in the world (USAID, 1997). During 1990-91, South Africa contributed 66 per cent of all sulphur emissions in the region, whereas Lesotho, Swaziland and Mozambique jointly contributed only 0.9 per cent (Sivertsen et al., 1995). As this dependence on coal-based thermal power will persist for years, sulphur dioxide pollution will remain a problem unless measures are taken to reduce the levels of sulphur in coal or provide incentives for developing alternative energy sources such as hydropower, wind, geothermal and solar.

Mining is a major source of income and also of air pollution in Southern Africa. Sulphur emissions from mining are high and are a growing concern, particularly among people with respiratory problems (SADC, 1992).

Indoor air pollution caused by the widespread use of biomass as a cooking fuel is also a major contributor to the high incidence of respiratory diseases because of the exposure to smoke and other pollutants in a confined space. In sub-Saharan Africa, biomass use is expected to provide nearly 80 per cent of the total energy used even in 2010. In Northern Africa, the corresponding figure is much lower with traditional fuel use only some 3 per cent of the total, even in 1995 (WRI, UNEP, UNDP and WB, 1998).

In West Africa, the Harmattan winds often result in high atmospheric dust loading and poor visibility, contributing to respiratory and other diseases. The continual build-up of mineral dust concentrations since the 1960s is likely to have a climatic impact through a land-atmosphere feedback mechanism (Ben Mohamed and Frangi, 1986; Ben Mohamed, 1985 and 1998).

Despite these problems, most African states have few or no specific air quality standards. City dwellers, in particular, are exposed to respiratory diseases such as asthma, bronchitis and emphysema as a result of industrial emissions and vehicle exhaust fumes (UNECA, 1996). Heat islands in urban areas have also been shown to affect weather and local climate (Hewehy, 1993).

Africa's emissions of the greenhouse gases that cause climate change are still low, estimated to be only 7 per cent of global emissions (World Bank, 1998). Africa presently emits only 3.5 per cent of the world's total carbon dioxide. South Africa alone contributes 44 per cent of the region's emissions. Total carbon dioxide emissions in the region are expected to increase to 3.8 per cent of the world total by the year 2010 due to increased industrialisation and urbanisation (Energy Information Administration, 1997). As they serve as a sink for carbon dioxide and mitigate greenhouse gas emissions, Africa's vast forest reserves play a key role in alleviating and balancing the emissions of the industrialised world. However, this crucial function is threatened by accelerating deforestation.

Climate change, resulting in sea-level rise and flooding or erosion of low-lying coastal areas and lagoons, will have serious adverse impacts on ecosystems, water resources, coastal zones and human settlements, particularly in the countries of Western and Central Africa, the Nile Delta and the Indian Ocean island states. Poverty makes many African peoples and countries particularly vulnerable to the impacts of climate change, especially in areas dependent on rain-fed agriculture. This vulnerability is increased by recurrent natural disasters such as drought, floods and cyclones. Increases in water stress and drought may also increase the incidence of vector-borne diseases and hunger. In 1998, the El Niño is thought to have been the cause of serious floods in Southern and Eastern Africa and exacerbated outbreaks of cholera, malaria and Rift Valley fever in Kenya and Somalia (CARE, 1998).

## *2. Asia and the Pacific*

Asia and the Pacific is the largest region and it is facing serious environmental challenges. High population densities are putting enormous stress on the environment. Continued rapid economic growth and industrialisation is likely to cause further environmental damage, with the region becoming more degraded, less forested, more polluted and less ecologically diverse in the future.

The region, which has only 30 per cent of the world's land area, supports 60 per cent of the world population. This is leading to land degradation, especially in marginal areas, and habitat fragmentation. Forest fires also caused extensive damage in 1997-98. Water supply is a serious problem. Energy demand is rising faster than in any other part of the world. The proportion of people living in urban centres is rising rapidly, and is focused on a few urban centres. Asia's particular style of urbanisation - towards megacities - is likely to increase environmental and social stresses. Other significant environmental problems include land degradation caused by deforestation and inappropriate agricultural practices, water loss, and mangrove clearance for aquaculture.

In addition, the natural disasters that regularly hit the region, especially the South Pacific island states, can have extremely damaging impacts on both the environment and fragile economies. Cyclones, floods, storm surges, earthquakes, droughts, landslides and volcanic eruptions affect many countries in the region causing great loss of life and extensive damage to property and infrastructure. These disasters seriously affect the pace of development. It is possible that global climate change may result in similar or even worse trends in the future.

**Atmosphere**

In the past quarter of a century, atmospheric pollution increased significantly in much of the region, largely as a result of escalating energy consumption due to economic growth and greater use of motor vehicles. The use of poor quality fuels with a high sulphur content such as coal, inefficient methods of energy production and use, traffic congestion, poor automobile and road conditions, leaded fuel and inappropriate mining methods have exacerbated the situation. Forest fires are also contributing significantly to air pollution. Significant health threats also exist from the use of low-quality traditional solid fuels, such as wood, crop residues and dung, for cooking and heating in lower-income urban households and rural areas.

In 1995, the region accounted for 26.8 per cent of the world consumption of commercial energy - half of it generated from coal burning. While global energy consumption fell by 1 per cent per year between 1990 and 1993, Asia's energy consumption grew by 6.2 per cent a year (ADB, 1997). Fossil fuels now account for about 80 per cent of energy generation in the region, with coal accounting for about 40 per cent. The region also accounted for about 41 per cent of global coal consumption in 1993 (EIA, 1995).

With the increase in the use of relatively high carbon content fuels such as coal and oil, emissions of $CO_2$ also increased rapidly - at twice the average world rate of 2.6 per cent a year during 1975-95 (CDIAC 1998). Since the 1970s, industrial emissions of $CO_2$ have grown 60 per cent faster in Asia than anywhere else (ADB, 1997). China and Japan are the first and second largest $CO_2$ emitters respectively in the region (WRI, UNEP, UNDP and WB, 1998). However, $CO_2$ emissions per capita are low, little more than half the world average and only 11.2 per cent of the level in North America in 1995. Past land clearing has also contributed a significant proportion of $CO_2$ emissions in some countries.

Sulphur dioxide emissions in Asia increased enormously from 1970 to 1986 at a rate at least four times the rate of any other region (Hameed and Dignon, 1992). Nitrogen oxide ($NO_x$) emissions from fossil fuel combustion increased by about 70 per cent (Hameed and Dignon, 1992). However, total emissions were significantly less than those of North America and Europe during the same period.

The severity of air pollution varies considerably across Asia. Even major urban areas of Australia, where the concentration of air pollutants is generally low, occasionally

experience levels of pollution that exceed air quality goals (Commonwealth of Australia, 1996; NSW EPA, 1997).

Two of Asia's giant economies, China and India, rely heavily on coal. Ninety per cent of China's $SO_2$ annual emissions come from coal burning (State Planning Commission, 1997). Overall, Asian emissions of $SO_2$ are at least 50 per cent higher than those of North America, Africa and Latin America (ADB, 1997). Three of Asia's 11 megacities exceed WHO guidelines for acceptable $SO_2$ levels (WHO and UNEP, 1992).

With increasing $SO_2$ emissions, acidification is an emerging issue. The most sensitive areas are in south China, the Southeast of Thailand, Cambodia and south Vietnam (Hettelingh et al., 1995). On the other hand, there is no evidence of significant acid deposition in Australia, which is not subjected to emissions from neighbouring countries and where fossil fuels have a low sulphur content (Commonwealth of Australia, 1996).

Transportation contributes the largest share of air pollutants to the urban environment with the total number of registered vehicles increasing dramatically year after year. Lead pollution is a particular problem in megacities of Southeast Asia. The introduction of unleaded fuels is reducing average lead levels, although the rate of decline is slower in Asia than elsewhere.

Ten of Asia's 11 megacities exceed WHO guidelines for particulate matter by a factor of at least three (WHO and UNEP, 1992). Levels of smoke and dust, a major cause of respiratory diseases, are generally twice the world average and more than five times as high as in industrial countries and Latin America (ADB, 1997). Recent forest fires in Indonesia are a further, notorious source of air particulates. According to WHO estimates, Bangladesh, India, Nepal and Indonesia together account for about 40 per cent of the global mortality in young children caused by pneumonia (WHO, 1993). In China, smoke and small particles from burning coal cause more than 50,000 premature deaths and 400,000 new cases of chronic bronchitis a year in 11 of its large cities (World Bank, 1997a). The negative impacts of domestic burning of solid fuels are not confined to developing countries. Winter air pollution, mostly from coal and wood-burning fires in private homes, is a persistent problem in New Zealand (New Zealand Ministry for the Environment, 1997).

Some countries have managed to gain partial control over air quality deterioration. During the past two decades, Japan successfully reduced emissions of $SO_2$, $NO_x$ and CO through technological innovation, institutional development, and co-operation by all levels of government and industry. $SO_2$ emissions, for instance, decreased nearly 40 per cent between 1974 and 1987 (WRI, UNEP and UNDP, 1992). Similar air pollution problems in the Republic of Korea have been reduced since the 1980s by increasing the use of low-sulphur oil and liquified natural gas (Government of Republic of Korea, 1998).

Demand for primary energy in Asia is expected to double every 12 years while the world average is every 28 years. High carbon-content fuels are likely to continue to dominate

the region's energy market. Coal will remain the fuel of choice throughout much of the region, because of its abundance and easy availability, especially in China, India and Mongolia, and demand is projected to increase by 6.5 per cent a year (World Bank, 1997c).

By the year 2000, $SO_2$ emissions from coal burning in Asia are expected to surpass the emissions of North America and Europe combined (World Bank, 1997a) and, if current trends in economic development continue without effective $SO_2$ control measures, will more than triple within the next 12 years. This is likely to result in a significant increase in acid deposition problems, especially within East Asia. The Korean peninsula will be seriously affected by cross-border acid rain. Mongolia may receive acid rain from its northwestern border with Russia. In addition, increasing emissions from transport will aggravate urban air pollution. A study of Nepal, for instance, estimates that total emissions will increase fivefold by 2013, about two-thirds of which are likely to come from the transport sector (Shrestha et al., 1996).

While the region's contribution to the greenhouse effect and total world emissions of atmospheric pollutants are currently limited, both are increasing fast. Air quality is proving detrimental to human health in many parts of the region. These trends are likely to continue.

### *3. Europe and Central Asia*

Environmental trends reflect the political and socio-economic legacy of the region. In Western Europe, overall consumption levels have remained high but measures to curb environmental degradation have led to considerable improvements in some, though not all, environmental parameters. Sulphur dioxide emissions, for example, were reduced by more than one-half between 1980 and 1995. In the other sub-regions, recent political change has resulted in sharp though probably temporary reductions in industrial activity, reducing many environmental pressures.

A number of environmental characteristics are common to much of the region. Acidification, pollution, drought and forest fires damage large areas of forests. More than half of the large cities in Europe are overexploiting their groundwater resources. Marine and coastal areas are susceptible to damage from a variety of sources. Road transport is now the main source of urban air pollution, and overall emissions are high - Western Europe produces nearly 15 per cent of global $CO_2$ emissions and eight of the ten countries with the highest per capita $SO_2$ emissions are in Central and Eastern Europe.

The European Environment Agency's recent report on the pan-European region: *Europe's Environment: the Second Assessment* (EEA, 1998) concludes that industry, transport, energy and agriculture are the key sectoral driving forces that impact on Europe's environment.

The relative contribution of industry to many environmental problems, while still very important, has decreased over the past decade. In Western Europe, emissions of

pollutants to air and water are falling as environmental objectives are increasingly integrated into decision making. In the other sub-regions, a considerable decrease in environmental pressures has resulted from the drop in industrial activity, especially in old, energy-intensive, heavy industries.

Transport plays an important role in climate change, acidification, summer smog and urban environmental problems. Throughout the region, the environmental impact of transport is increasing as technology and environmental policies are failing to keep up with the pace of growth. Some underlying factors are that private car use is growing at the expense of public transport, cars are getting larger, and there are fewer people per car. Air travel in Western Europe is growing more rapidly than any other transport mode. The rapid growth in passenger and freight traffic is partly a consequence of rapid integration processes but the related growth of environmental pollution, noise and health problems makes a timely transition to more sustainable transportation and settlement patterns imperative.

**Atmosphere**

Until the 1960s, coal was the primary source of energy in most parts of the region for electricity generation, industry and domestic heating. Air purification devices were practically non-existent. This led to high levels of air pollution, particularly in cities, with soot, dust, sulphur dioxide ($SO_2$) and nitrogen oxides ($NO_x$). Winter smogs, particularly the notorious episodes in London during the 1950s, had serious effects on health and also on building materials and historic monuments.

In Western Europe, after World War II, industry was restructured and oil, gas and nuclear power were increasingly used for energy production. This, together with the introduction of low sulphur fuels, natural gas, electricity and district heating schemes for domestic heating, contributed to the virtual disappearance of winter smog. Road transport, on the other hand, has grown inexorably and is now the main source of urban air pollution. In Central Europe, in the post-war period, a policy of self-reliance on domestic energy resources and the forced development of heavy industry resulted in the exploitation of local energy resources, often of poor quality and high sulphur content (for example, brown coal and oil shales). Power plants were built in clusters near coal mines to reduce transportation costs. This high concentration of plants caused major pollution problems, mainly with $SO_2$. The Black Triangle area - at the borders between the former German Democratic Republic, Czech Republic and Poland - as well as the Upper Silesia region in Poland and the Ostrava basin in the Czech Republic suffered most. During the post-war period, Eastern European and Central Asian countries relied increasingly on oil, gas, hydro and nuclear power for electricity generation, resulting in less air pollution than from the generally dirtier fuels used in Central Europe. But there were other sources of air pollution, such as the production of ferrous and non-ferrous metals, pulp and paper, and chemicals, which were often located close to cities.

Throughout the century, there has been a gradual shift in industrial emission 'hot spots' from northwestern Europe towards the east and south (EEA, 1995). During the past ten

years, the levels and patterns of air pollution in Europe have changed as a result of the adoption of important agreements aimed at reducing emissions and the dramatic changes occurring in Central and Eastern Europe and Central Asia (EEA, 1997).

The most drastic improvement in urban air quality throughout Western and Central Europe during the past 10 years has been the decline in pollution from $SO_2$. However, research suggests that about 25 million urban dwellers in Europe are still exposed at least once a year to levels above the WHO Air Quality Guidelines for health protection, mainly due to winter smog episodes in Central and northwestern Europe (EEA, 1998). Summer smogs, too, are of continuing concern in many cities: the number of people exposed to summer smog conditions above WHO guidelines is 37 million (EEA, 1998). Of the ten countries in the world with the highest $SO_2$ emissions per capita, seven are in Central Europe, one in Eastern Europe and two in North America.

Europe is responsible for approximately one-third of global greenhouse gas emissions. In Western Europe, per capita emissions of carbon dioxide fell slightly between 1990 and 1995, mainly due to economic recession, the restructuring of industry in Germany, and the switch from coal to natural gas for electricity generation. Emissions fell much more in Central and Eastern Europe during the same period, mainly as a result of economic re-structuring and the related drop in economic activity. $CO_2$ emissions are expected to start to rise again in all the sub-regions in the near future (RIVM/UNEP 1999). Emissions of most other greenhouse gases (methane, nitrous oxide and CFCs) have also fallen (EEA, 1998a). Emissions of CFC replacement gases, in particular HCFCs and HFCs (both greenhouse gases) are, however, increasing.

Emissions of acidifying substances in the region as a whole have decreased substantially. Between 1985 and 1994, $SO_2$ emissions in Western Europe, Central Europe and Eastern Europe fell by 50 per cent as a result of the Convention on Long-range Transboundary Air Pollution protocols (Olendrzynski, 1997). The main reasons for these reductions were the installation of low-sulphur coal and flue-gas desulphurisation equipment at large point sources in Western Europe and the renewal of power plants and economic restructuring in Eastern Europe.

Significant reductions in ammonia emissions have also been achieved, resulting from changes in agricultural policy in Western Europe and reduced agricultural activity in Central and Eastern Europe. $NO_x$ emissions have also been lower. Total nitrogen emissions ($NO_x$ plus ammonia) fell by 19 per cent between 1990 and 1995, the largest falls occurring in Central and Eastern Europe. The transport sector has become the largest source of $NO_x$ in Europe, contributing 60 per cent of the total in 1995. The use of vehicle exhaust catalysts is helping to reduce emissions in Western Europe but relatively slowly because of the low turnover rate of the vehicle fleet (EEA, 1998).

In Central and Eastern Europe, emissions of $NO_x$ from stationary sources fell due to the economic recession but this has been partially nullified by the sharp growth in the use of private cars, especially in large cities. During the recession years of 1990-94, the number of private cars in the Russian Federation increased by 143 per cent, in Ukraine by 130 per

cent, in Kazakhstan by 123 per cent, and in Armenia by 110 per cent (Statistical Committee of the CIS, 1996).

As a result of these reductions in emissions, the area of Europe where the deposition of acidifying compounds exceeds critical loads for ecosystems has been significantly reduced. Nevertheless, in Western and Central Europe, critical loads are still being exceeded for more than 10 per cent of ecosystems (EMEP, 1998).

Ozone concentrations in the troposphere over Europe (the layer of the atmosphere from the ground to 10-15 km) are typically three to four times their pre-industrial levels. Tropospheric ozone is the main contributor to the summer smogs that occur over large parts of Europe every year and which have been causing respiratory problems for several decades. The problem is most severe in parts of Western and Central Europe, and results mainly from emissions of the main precursor gases ($NO_x$ and non-methane volatile organic compounds) from industry and vehicles. Although emissions of these precursors fell in 1994 by 14 per cent in comparison with 1990, ozone concentrations remain high and often well above threshold limits set by the WHO. In the European Union, for example, about 330 million people are exposed at least once a year to levels that exceed these threshold limits (Malik et al., 1996).

According to the Kyoto agreements, greenhouse gas emissions in Western Europe should be reduced to 8 per cent below 1990 levels by 2010. Under 'business-as-usual' conditions, however, it is highly unlikely that this target will be met. Nevertheless, the technical potential for emission reductions is large enough in principle to allow the Kyoto target to be reached. Achieving this will be a major challenge for Western Europe in the coming decade. Most of the Central European countries committed themselves to reductions of between 5 per cent and 8 per cent which will probably require additional measures to be taken. The Russian Federation and Ukraine have to stabilise their emissions in 2010 compared to 1990. According to current expectations, this goal will be met without additional environmental policies (RIVM/UNEP, 1999).

With progress in reducing emissions of $SO_2$, emissions of nitrogen are gradually becoming a more important acidification factor (EEA, 1997). It is unlikely that the European Union's Fifth Environmental Action Plan target of a 30 per cent reduction of emissions of $NO_x$ by the year 2000 will be met, mainly due to the expected growth in road traffic, and further reductions will be required beyond 2000 to reduce acidification and tropospheric ozone (EEA, 1998).

Most of the recent air quality improvements in Central and Eastern Europe and Central Asia have been due to economic decline. Many air pollution problems are likely to persist, and worsen as economies recover, with industrial enterprises disregarding air pollution prevention measures, using the harsh economic situation or the fact that total pollution has already decreased as a justification for their lack of action. The generally weak environmental protection bodies in many countries are unlikely to be able to enforce effective air pollution reduction strategies in the near future, and measures aimed

at recovery from near or complete economic collapse are likely to take precedence over those aimed at protecting or improving the environment.

Overall, air quality in most cities has improved over the past few decades. Ozone, however, remains a major problem in some Western European cities. Transport has become the major contributor to several air pollution problems in Western Europe. Despite rigorous and effective measures to reduce car emissions, most air pollution in major cities still comes from automotive sources, and the number of cars continues to increase. At the same time, there have been some improvements in transport-related air quality; for example, atmospheric concentrations of lead are falling due to the reduction of the lead content in petrol (EEA, 1997).

### *4. Latin America and the Caribbean*

Two major environmental issues stand out in the region. The first is to find solutions to the problems of the urban environment - nearly three-quarters of the population are already urbanised, many in mega-cities. The air quality in most major cities threatens human health and water shortages are common. The second major issue is the depletion and destruction of forest resources, especially in the Amazon basin. Natural forest cover continues to decrease in all countries. A total of 5.8 million hectares a year was lost during 1990-95, resulting in a 3 per cent total loss for the period. This is a major threat to biodiversity. More than 1,000 vertebrate species are now threatened with extinction.

The region has the largest reserves of cultivable land in the world but soil degradation is threatening much cultivated land. In addition, the environmental costs of improved farm technologies have been high. During the 1980s, Central America increased production by 32 per cent but doubled its consumption of pesticides. On the plus side, many countries have substantial potential for curbing their contributions to the build-up of greenhouse gases, given the region's renewable energy sources and the potential of forest conservation and reforestation programmes to provide valuable carbon sinks.

Environmental emergencies have had a significant impact on the well-being of Latin Americans. Earthquakes, forest fires, volcanic eruptions, hurricanes and other events often devastate local infrastructure and destroy crops, causing further setbacks in the development process. The El Niño event of 1997-98 caused drought in Amazonia and many parts of Meso-America, and led to the death of thousands of cattle, crop losses and widespread forest fires. At one point, for example, the State of Sonora in Mexico had only 2.5 per cent of its normal water withdrawal capacity and enough water to serve its population for a mere month (La Nación, 1998a). Forest fires have caused serious health problems, airport closures and destroyed hundreds of thousands of hectares of natural forest (La Nación, 1998b). While most such disasters cannot be prevented, up-to-date environmental information, widespread preparation and education can reduce their impacts.

If today's central challenge in Latin America and the Caribbean is to build a political consensus that will maintain stability and economic growth, the accelerating social and

environmental problems listed above must also be strongly addressed. Current improvements in accessing environmental information are an important asset in this respect.

The first priority is to find solutions to the problems of the urban environment, which now houses nearly three-quarters of the region's population. Improved housing, sanitation, transportation and employment in large urban areas are badly needed. The second priority is to find ways of promoting the sustainable use of tropical forests and biodiversity. There are many examples of what should not be done but forest conservation and reforestation has at last become a political priority in many countries.

**Atmosphere**

Most Latin American countries find it difficult to obtain reliable information from which to prepare emission inventories of greenhouse gases (GHG). Emission factors specific to a particular region or system are scarce, forestry and land use change are difficult to characterise, and many of the data either do not exist or must be derived from related statistics or even from anecdotal evidence. The trends emerging from completed (Uruguay and Argentina) and preliminary (Costa Rica, Mexico and Venezuela) inventories suggest that more than 50 per cent of emissions come from industrial production and energy generation. In Brazil and Chile, gross emissions of GHG due to energy consumption are considerably lower than emissions from deforestation, land use change and agriculture (Bonduky et al., 1995).

The region is responsible for 4.3 per cent of the world's total carbon dioxide emissions from industrial processes, and for 48.3 per cent of emissions from land-use changes. Methane emissions from anthropogenic sources correspond to 9.3 per cent of the world's total. The average per capita emission of carbon dioxide for 1995 was 2.55 tonnes, well below the 11.9 tonnes estimated for the high-income economies, and also below the world average of 4.0 tonnes (CDIAC, 1998).

The main anthropogenic source of emissions is deforestation, and Amazonia is an important natural source of methane and nitrogen oxides. Conversion of primary tropical forests to agriculture and to secondary vegetation is a significant change on a global scale. In the Amazon basin, which covers nearly 7 million $km^2$, biomass burning and the establishment of new types of vegetation cover will have significant ecological implications for the region, the continent and the planet (LBA, 1996).

In 1993, about 70 per cent of Brazilian electricity came from hydropower (Rosa et al., 1996). In Central America more than 50 per cent of the energy produced is generated by hydropower. However, there is increasing conflict over access to and use of water because of the vulnerability of hydropower to climatic variability. Uruguay, for example, generates most of its energy from hydropower but severe droughts over the past few years have given rise to water allocation problems which have affected agricultural production. In addition, there is a trend in, for example, Argentina, Brazil and Colombia to move from renewable forms of energy to fossil fuels, in both the electric power and the

transportation sectors, as a result of the deregulation of the energy sector (Rosa et al., 1996). Deregulation and privatisation of energy could increase emissions since market forces will probably not favour biomass and hydropower. Private investment tends to prefer fossil fuel power plants to hydroelectric plants because capital costs are lower and the return on the investment is faster - even though energy costs are higher (Tolmasquim, 1996).

Many countries have substantial potential for curbing carbon emissions, given the region's renewable energy sources of biomass and hydropower, and the potential of forest conservation and reforestation programmes to provide valuable carbon sinks. The use of ethanol as a substitute for gasoline can also reduce carbon dioxide emissions.

Increasing population density and economic activity have led to increased pollution in many cities. Santiago, for example, is now one of the most polluted urban areas in the world; the main sources of air pollution are urban transport, and small and medium-sized industries (IMO, 1995). Air pollution is causing severe respiratory problems among city dwellers, with higher rates of pneumonia than in many other cities, and many premature deaths from respiratory diseases. Mexico City, São Paulo and Bogota are also suffering from severe air pollution. The Brazilian programme of adding alcohol to gasoline has, despite reducing carbon dioxide emissions by some 30 per cent and decreasing air pollution, not been sufficient, and São Paulo now restricts private car circulation, as do Mexico City and Santiago. In São Paulo and Rio de Janeiro, 27 million people are exposed to high levels of particulate air pollution estimated to cause 4,000 annual cases of premature mortality (CETESB, 1992).

Lead emissions are also a major problem. The main sources of exposure are emissions from vehicles that use leaded gasoline, industrial production, particularly of paints and batteries, and food. The effects of leaded gasoline are felt most in urban environments. Residents of areas with high levels of traffic generally have a much higher level of lead in the blood than those exposed to less traffic. However, over the past decade or so, the lead content of gasoline has been decreasing in most countries, and lead-free gasoline has been introduced. Countries with the largest share of lead-free gasoline are Brazil (100 per cent), Costa Rica (100 per cent), Guatemala (80 per cent) and Mexico (46 per cent) (Christopher et al., 1996).

## *5. North America*

North Americans use more energy and resources per capita than people in any other region. This causes acute problems for the environment and human health. The region has succeeded, however, in reducing many environmental impacts through stricter legislation and improved management. Whilst emissions of many air pollutants have been markedly reduced over the past 20 years, the region is the largest per capita contributor to greenhouse gases, mainly due to high energy consumption. Fuel use is high - in 1995 the average North American used more than 1600 litres of fuel a year (compared to about 330 litres in Europe). There is continuing concern about the effects of exposure to pesticides, organic pollutants and other toxic compounds. In the longer term, global

warming could move the ideal range for many North American forest species some 300 km to the north, undermining the utility of forest reserves established to protect particular plant and animal species. Locally, coastal and marine resources are close to depletion or are being seriously threatened.

The environmental policy scene is changing in North America. In Canada, most emphasis is on regulatory reform, federal/provincial policy harmonisation and voluntary initiatives. In the United States, the impetus for introducing new types of environmental policies has increased and the country is developing market-based policies such as the use of tradeable emissions permits and agricultural subsidy reform. Voluntary policies and private sector initiatives, often in combination with civil society, are also gaining in importance. These include voluntary pollution reduction initiatives and programmes to ensure responsible management of chemical products. The region is generally active in supporting and complying with regional and global MEAs. Public participation has been at the heart of many local resource management initiatives. Environmental policy instruments are increasingly developed in consultation with the public and the business community. Participation by NGOs and community residents is increasingly viewed as a valuable part of any environmental protection programme.

Trends in environmental quality in North America are mixed. On the positive side are improvements in some aspects of air and water quality, and reduced levels of soil erosion in much of the region. On the negative side are sharp declines in fish stocks in major marine fisheries, continued logging pressures on old-growth forests, growing invasions of exotic species and other threats to biodiversity, and increasing outbreaks of toxic organisms in estuaries and coastal zones associated with excess run-off of nutrients. Success in reducing emissions of some toxic industrial materials must be compared with continued high levels of industrial use of such materials and slow progress in cleaning up toxic waste sites. Success in phasing out production of CFCs and other ozone-depleting gases must be balanced against failure to reduce emissions of carbon dioxide, the primary greenhouse gas, and hence the region's growing contribution to the risk of climate change.

**Atmosphere**

The dynamic socio-economic transformations occurring in North America over the past century have led to dramatic changes in the atmosphere, including local air pollution and urban smog, transboundary pollution problems such as acid precipitation, and global impacts such as stratospheric ozone depletion and global climate change. These changes have had profound impacts on human and environmental health in North America, as well as on human populations and the environment worldwide.

The release of contaminants into the atmosphere followed the introduction of motor vehicles and industrial expansion across the region within the past century. Although pollution was traditionally concentrated in larger cities and industrial areas, the explosive growth of automobile use facilitated the dispersion of economic activities and human settlements. By the 1960s, the effects of pollution on both local and regional air quality

were acute in some parts of North America, with effects on human health, particularly the respiratory system, and the quality of ecosystems (Dockery et al., 1996, US EPA, 1996).

Low fuel costs and the development of an energy-intensive economy have resulted in the burning of large amounts of fossil fuels in North America, particularly in the United States. After a decline in $CO_2$ emissions in the early 1980s due to oil price increases, emissions continued to climb. The United States is the world's largest emitter of greenhouse gases and also emits more per capita than any other country in the world.

Acid precipitation is a serious transboundary air pollution concern in North America. It results from emissions of $SO_2$ and $NO_x$, largely from industries and power plants in the US midwest, carried northward by prevailing winds. Thousands of lakes in Southeast Canada and Northeast United States have become so acidic that they no longer support healthy fish populations. The problem was not addressed until the mid-1970s, by which time precipitation acidity over eastern North America was ten times the pre-industrial value. Changes in industrial processes, fuels and legislation, as well as bilateral Cupertino between Canada and the United States, have resulted in declining emissions. $SO_2$ emissions were generally reduced in eastern Canada and US. $NO_x$ emissions, however, experienced a little increase and only 10 per cent of the lakes in Quebec and the Atlantic Provinces showed reduced acidity by 1994 (International Joint Commission, 1997).

Smog is also a serious transboundary air pollution issue with major environmental and human health effects. Canada and the United States have agreed to develop a Joint Plan of Action on Transboundary Air Pollution that will address the major components of smog - ground-level ozone and particulates - and which will include the negotiation of a new ozone annex to the bilateral Air Quality Agreement in 1999. Ground-level ozone is a secondary pollutant formed by reactions between $NO_x$ and volatile organic compounds (VOCs), particularly during the summer months. Pollutants from Mexican cities, some of which are subject to severe smog, are often blamed for non-attainment of air quality standards in nearby US cities.

Over the past decade, there has been a notable decline in the North American production of chlorofluorocarbons (CFCs), the most important ozone-depleting gases, in response to the Montreal Protocol on Substances that Deplete the Ozone Layer, which entered into force in 1989. As a result of co-operation among governments, CFC producers and industry, atmospheric concentrations of CFCs have levelled off (Elkins et al., 1993). Nevertheless, CFC production is still legal in developing countries, including Mexico, and a thriving black market has developed for CFCs in North America. This has become a potentially important emerging environmental issue.

There have also been some improvements in local and regional air quality over the past decade, although significant problems remain. In the United States, except for increased $NO_x$ emissions of about 14 per cent, emissions of CO, VOCs, particulates and $SO_2$ decreased between 1970 and 1994 (Council on Environmental Quality, 1997; US EPA, 1995). Lead emissions had the most spectacular decline (98 per cent over the same period), due to the adoption of unleaded fuels. But despite declining emissions, air quality

is still a public health concern. Particulate pollution is causing increased hospital admissions for the treatment of respiratory and heart diseases, and respiratory infections are causing absence from both schools and work (US EPA, 1996; Shprentz, 1996). Similarly, high levels of ozone are blamed for irritating the respiratory tract and impairing lung function, causing coughing, shortness of breath and chest pain (Ozkaynak et al., 1996).

Over the next 10 years, air quality may improve in some cities but is likely to decline further in others, particularly those with growing populations and increased automobile use. Greenhouse gas emissions in both Canada and the United States in the year 2000 are expected to exceed 1990 levels and to continue to rise as energy consumption increases and automobile transportation expands. By supporting the adoption of the Kyoto Protocol to the Climate Change Convention, both Canada and the United States have shown that they intend to address their high levels of greenhouse gas emissions. The protocol specifies that Canada should reduce its emissions by 6 per cent and the United States by 7 per cent below 1990 levels, during the period 2008-12. However, by exceeding 1990 emissions in the year 2000, Canada and the United States will not meet the 'aim' of the Convention of returning emissions in 2000 to 1990 levels. Higher than expected economic growth, lower energy prices, slower gains in energy efficiency and slower adoption of renewable energy sources have raised US emissions more quickly than anticipated even a few years ago (US Department of Energy, 1997).

### *6. West Asia*

The region is facing a number of major environmental issues, of which degradation of water and land resources is the most pressing. Groundwater resources are in a critical condition because the volumes withdrawn far exceed natural recharge rates. Unless improved water management plans are put in place, major environmental problems are likely to occur in the future.

Land degradation is a serious problem, and the region's rangelands - important for food security - are deteriorating, mainly as a result of overstocking what are essentially fragile ecosystems. Drought, mismanagement of land resources, intensification of agriculture, poor irrigation practices and uncontrolled urbanisation have also contributed. Marine and coastal environments have been degraded by overfishing, pollution and habitat destruction. Industrial pollution and management of hazardous wastes also threaten socio-economic development in the region with the oil-producing countries generating two to eight times more hazardous waste per capita than the United States. Over the next decade, urbanisation, industrialisation, population growth, abuse of agrochemicals, and uncontrolled fishing and hunting are expected to increase pressures on the region's fragile ecosystems and their endemic species.

Other major environmental issues include deteriorating conditions in human settlements and urban sprawl; the loss of biodiversity; industrial pollution; inappropriate management of toxic chemicals and hazardous waste; and degradation of the cultural heritage.

## Atmosphere

Until the middle of this century, the only source of air pollution was dust and sandstorms. Transportation was limited to a few cars, buses and trains and no efforts were made to identify or measure air pollutants.

After World War II, the development of the oil industry, coupled with rapid socio-economic development and high rates of industrial and population growth, led some countries to become high energy consumers: by 1990, Qatar, the United Arab Emirates and Bahrain were the leading per capita consumers of commercial energy in the world (WRI, UNEP and UNDP, 1992).

There was an equally fast increase in the number of vehicles inside cities, which compounded the problem. Environmental and safety standards were exceeded in many cities, especially in the Mashriq sub-region, as a result of the growth of industries using heavy fuels, power stations and cement factories. For example, in 1995 Lebanon was estimated to be emitting an annual 3 million tonnes of $CO_2$, 100 000 tonnes of $SO_2$, 44 000 tonnes of $NO_x$ and 3 000 tonnes of suspended particulates (Government of Lebanon, 1997). In the countries bordering the Persian Gulf, air pollution occurs mainly during rush hours and under conditions of air stability and thermal inversion. Air contamination has risen to alarming levels, especially in cities with more than one million inhabitants such as Baghdad, Damascus and Beirut. $SO_2$ levels of more than 100 $\mu g/m^3$ are not unusual near industrial areas with refineries and power stations. Traffic also contributes to air pollution, emitting 5 per cent of total $SO_2$, 37 per cent of $NO_x$, 10 per cent of suspended particulates and more than 80 per cent of CO and hydrocarbons. It also contributes up to 90 per cent of lead emissions (World Bank, 1994). The use of leaded gasoline in old and inefficient cars has made lead exposure a major health problem.

The climate plays a major role in increasing the intensity of pollution in urban areas. Sunshine and high temperatures prevail throughout most of the year. These two parameters play major roles in converting primary pollutants to secondary pollutants, such as ozone and sulphates, which can be more damaging to the environment and human health than the primary pollutants (Bahrain Environmental Protection Committee, 1995). Concentrations of ozone higher than the WHO and USEPA accepted limits have been reported in cities such as Baghdad (Kanbour et al., 1987), Bahrain (Bahrain Environmental Protection Committee, 1995) and Dubai (Dubai Municipality Health Department, 1993).

Seasonal dust storms also degrade the environment. The presence of suspended particulates in the air is a health risk, especially to people with asthmatic troubles (Al Awadi, 1983). The risk is increased by the presence of other particulates emitted by industry and vehicles. Concentrations of total suspended particulates in several major cities have been found to be three times higher than the accepted WHO limit (Kanbour et al., 1985; Environment Protection Department, Kuwait, 1984; Bahrain Environmental Protection Committee, 1995 and Dubai Municipality Health Department, 1994).

Vehicles are the major source of air pollution in urban areas. Lead additives are still being used in petrol throughout the region but most urban areas report the lead concentration to be within the WHO limit (Kanbour et al., 1985; JMOH, 1996; Dubai Municipality Health Department, 1994; Vreeland and Raveendran, 1989) except sometimes during heavy traffic congestion (Kanbour et al., 1985).

Most West Asian countries are net energy exporters (except for Jordan, Lebanon and the National Palestinian Territories) and the petroleum and petrochemical industry is expected to grow further in the next decade. This need not necessarily increase air pollution alarmingly; in fact, it is feasible to increase industrial output up to threefold without increasing emission loads. A precedent has already been set by some heavy industries such as the Aluminum Bahrain Company (ALBA) which has reduced fluoride emissions from its factories by more than 98 per cent and suspended particulates by 95 per cent (Ameeri, 1997). Refineries in Kuwait, Saudi Arabia and the United Arab Emirates have pledged to reduce sulphur emissions, gas flaring and other hydrocarbon releases as part of the drive towards efficiency and environmental protection.

## *7. The Polar Regions*

The Arctic and Antarctic play a significant role in the dynamics of the global environment and act as barometers of global change. Both areas are mainly affected by events occurring outside the polar regions. Stratospheric ozone depletion has resulted in high levels of ultraviolet radiation, and polar ice caps, shelves and glaciers are melting as a result of global warming. Both areas act as sinks for persistent organic pollutants, heavy metals and radioactivity, mostly originating from other parts of the world. The contaminants accumulate in food chains and pose a health hazard to polar inhabitants. Wild flora and fauna are also affected by human activities.

The Arctic and Antarctic are literally poles apart. While they share some characteristics, such as high latitude, cold and remoteness, they also exhibit significant differences. A large deep central ocean surrounded by land masses dominates the Arctic. The Antarctic is a large, partially ice-covered land mass surrounded by ocean. The Arctic corresponds to the Arctic area internationally accepted through the Arctic Council's Arctic Monitoring and Assessment Programme (AMAP). For the Antarctic, the Polar Front or Antarctic Convergence provides an oceanographically- and biologically-useful natural boundary. The Antarctic is thus defined as the area south of the Antarctic Convergence, unless otherwise specified.

The polar areas play a significant role in the dynamics that affect the global environment and are a good indicator of global change, particularly climate change, although more research is required to understand fully the processes involved and their effects (AMAP, 1997). The consequences of an increase in global temperatures and local changes in precipitation and snow cover are not fully understood, but could be leading to the melting of polar ice caps, ice shelves and glaciers, the retreat of sea ice, sea-level rise, thawing of permafrost resulting in increases in the emissions of greenhouse gases such as methane

and carbon dioxide to the atmosphere and changes to the radiation balance. In the Arctic, while temperatures have increased in some areas (such as central Siberia and western Canada), in others (such as Greenland) they have decreased (Chapman and Walsh, 1993).

Both the Arctic and Antarctic are valued for their relatively clean environments. Polar biota have adapted to the extreme conditions found there, characterised by large variations in temperature and light, and the effects of snow and ice. These adaptations have made some plants and animals more sensitive to human impacts on the environment. Both polar areas are affected by events that occur outside the region. In particular, they act as sinks for a variety of contaminants originating from more temperate latitudes, including persistent organic pollutants (POPs), heavy metals, radioactivity and acidifying substances. There is growing concern that some of these contaminants pose a serious health hazard to some Arctic inhabitants, because of their bioaccumulation and biomagnification in terrestrial and aquatic food chains. Ecosystems may also be at risk from increased levels of UV-B resulting from stratospheric ozone depletion.

Ozone depletion is much more severe in polar areas than nearer the equator. Over the poles both a general lowering of total ozone amounts and the development of 'holes' in the stratospheric ozone layer manifest it.

Until now, the Arctic ozone reduction has been significantly weaker than that of the Antarctic. This may be due to the fact that mean winter temperatures in the Arctic are higher than in the Antarctic, the abundance of polar stratospheric clouds is lower, and the vortex is more variable and breaks down earlier in the winter than in the Southern Hemisphere. Whilst a large, distinct and persistent hole appears in the Antarctic ozone layer every spring, Arctic ozone depletion is characterised by the development of smaller holes, generally up to a few hundred kilometres in diameter, which last only a few days (AMAP, 1997). As the latter are never as severe as those in the Antarctic, there is still disagreement on whether the Arctic version should be termed holes at all. The loss of ozone over the South Pole is due mainly to chemical reactions that take place inside the Antarctic polar vortex. Chemical destruction of ozone also occurs over the Arctic during winter and spring. In addition, Arctic ozone lows occur outside the polar vortex as a result of influxes of low-ozone air from middle latitudes.

The Antarctic ozone hole is formed when there is a sharp decline in total ozone over most of Antarctica during the Southern Hemisphere spring. A seasonal hole has developed every year since its advent in the late 1970s, with strong occurrences in 1992, 1993, 1996 and 1997. In 1998, the maximum area of the ozone hole was more than 26 million $km^2$ and it covered some populated areas of the Southern Hemisphere (WMO 1998).

## *8. The Arctic*

The Arctic atmosphere contains relatively low amounts of contaminants compared with the other media. However, the atmosphere is the fastest transport mechanism for delivering contaminants to the Arctic. Transport times can be days or weeks from more

temperate agricultural and industrialised areas. The time of year and the prevailing weather systems determine the fate of contaminants in transport. Transport to the Arctic is more prevalent during winter and spring when an intense high pressure system over Siberia pushes the Arctic front far to the south. Large polluted areas of Eurasia are then within the Arctic air mass, the lower one to two kilometres of which can move contaminants across the pole. This activity is further amplified by the lack of clouds and precipitation during this time; thus the contaminants travel into the Arctic before they can be deposited in precipitation. These air flows transport a range of contaminants, including sulphur and nitrogen compounds, POPs, heavy metals and radionuclides, from parts of Eurasia, Japan and North America into the Arctic

The AMAP assessment is a compilation of current knowledge about the Arctic region, an evaluation of this information, and a statement of the prevailing conditions in the area. The assessment was prepared in a systematic and uniform manner to provide a means for inter-comparisons of regional environmental conditions and for assessing the nature and extent of anthropogenic influences on larger (global) scales.

The main issues that the Arctic region faces are:

*Radioactivity.* Military activities and the testing of nuclear weapons have been a major source of radioactive contamination of the Arctic. Most atmospheric testing was carried out before 1962, with the Russian island of Novaya Zemlya being the major Arctic testing site. Fallout levels peaked in the 1960s and testing stopped in 1980. The accident at the Chernobyl nuclear power station in 1986 particularly affected Fennoscandia and northwestern Russia. The initial threat was through the contamination of milk by iodine 131. This was quickly replaced by the threat from caesium 137 with its longer-term contamination of berries, mushrooms and animals grazing on lichen and moss. After the accident, indigenous people in some parts of the Arctic had significantly increased radioactive levels (AMAP, 1998).

*Persistent Organic Pollutants (POPs)* are a group of chemicals that can travel long distances and resist degradation in the environment. They can be passed through the food web and thereby accumulate in animals. POPs have been in use since the 1950s when substances such as dichlorodiphenyl trichlorethane (DDT) appeared on the market. Circumpolar countries have banned the use of many of the more toxic pesticides. The appearance of these chemicals thus indicates transport by long-range pathways - pathways that concentrate POPs in particular areas, sometimes those of high biological productivity. Polychlorinated biphenyl (PCB) and DDT levels appear high around Svalbard, in the southern Barents Sea, and in eastern Greenland. Canada has higher levels of the pesticide lindane, and other forms of hexachlorocyclohexane (HCH).

*Heavy metals.* Some of the highest values of cadmium ever recorded in birds have been found in the livers of willow and rock ptarmigan from northern Norway and the Yukon Territory in Canada. These levels may reflect local geological conditions, although the reasons are not fully understood. Effects on the birds have not been studied but it is believed that concentrations can exceed values known to cause kidney damage. The same

geographic variations are seen in kidney concentrations of reindeer and caribou. The main source of heavy metals for land mammals and birds is the food they eat (AMAP, 1997).

*Acidification.* Whilst acidification has affected parts of the Arctic for much of the 20th century, the problem did not receive adequate attention until the 1960s. The most important substances are oxides of sulphur which form when sulphide ores are smelted or fossil fuels burnt. At present, acidification is mainly a local problem, notably around the nickel-copper smelting plants on the Kola Peninsula of northwestern Russia, and at Norilsk in central Siberia where trees, dwarf shrubs and lichens have been severely affected. Other areas of the Arctic are sensitive to acidification, and continue to receive low levels of acidifying substances as a result of long-range transport from sources to the south. However, no effects have yet been observed in these areas (AMAP, 1998).

*Arctic haze.* Weather reconnaissance planes first identified the phenomenon of Arctic haze in the 1950s. The haze, which is densest in spring, consists mostly of sulphate with some soot and dust originating from anthropogenic sources outside the Arctic. Most of the particles originate in Eurasia from coal burning. Arctic haze has helped prove that emissions from Eurasia are transported into the Arctic and, in some cases, over into North America. Haze particles can also carry heavy metals and other contaminants, helping to explain how the long-range transport of pollutants into the Arctic is so efficient.