8 Atmosphere and climate change

Introduction

The atmosphere is a common global resource, adversely affected by the by-products of anthropogenic activity. Its preservation is imperative for present and future generations. Agenda 21 proposes directions to achieve the dual objectives of economic progress and atmospheric protection.

This chapter studies policies which have an impact on atmospheric quality to examine the extent to which Agenda 21 concerns for the protection of the atmosphere have been addressed. The chapter begins with an assessment of the pressures on the global atmosphere, followed by a discussion of Agenda 21 concerns for its protection. The institutional set-up and legislative framework for addressing global atmospheric problems is examined next. Finally, a review and analysis of the existing policies for atmospheric protection is undertaken to study the convergence with Agenda 21.

This chapter focuses on the global atmospheric problems of climate change and ozone depletion. It must be noted that India is a developing country with a very small contribution to greenhouse gas concentration, and does not have emission reduction commitments at present. However, initiatives that address immediate national and developmental priorities will contribute significantly to the global effort towards atmospheric protection. Local air quality issues are dealt with in chapters on energy, transport, and industry.

Overview

Greenhouse gases

There is worldwide concerns about rising emissions of greenhouse gases from human activities such as power generation, industrialization, and deforestation. The main naturally occurring greenhouse gases are CO_2, CH_4, and N_2O, which trap radiation emitted by the earth, leading to higher temperatures, changed precipitation patterns, and rises in sea level.

The Third Assessment Report, 2001 of the Intergovernmental Panel on Climate Change (IPCC) predicts that global average temperatures could rise by 1.4-5.8°C over the period 1990-2100. This would have wide-ranging impacts including a decline in crop yields, inundation of land in coastal areas, increased frequency and intensity of extreme events, spread of vector-borne diseases, etc.

Climate change is primarily determined by the total stock of GHGs in the atmosphere and not by annual GHG emissions. Developed countries have been responsible for more than 60% of the total global stock of GHGs (Figure 8.1).

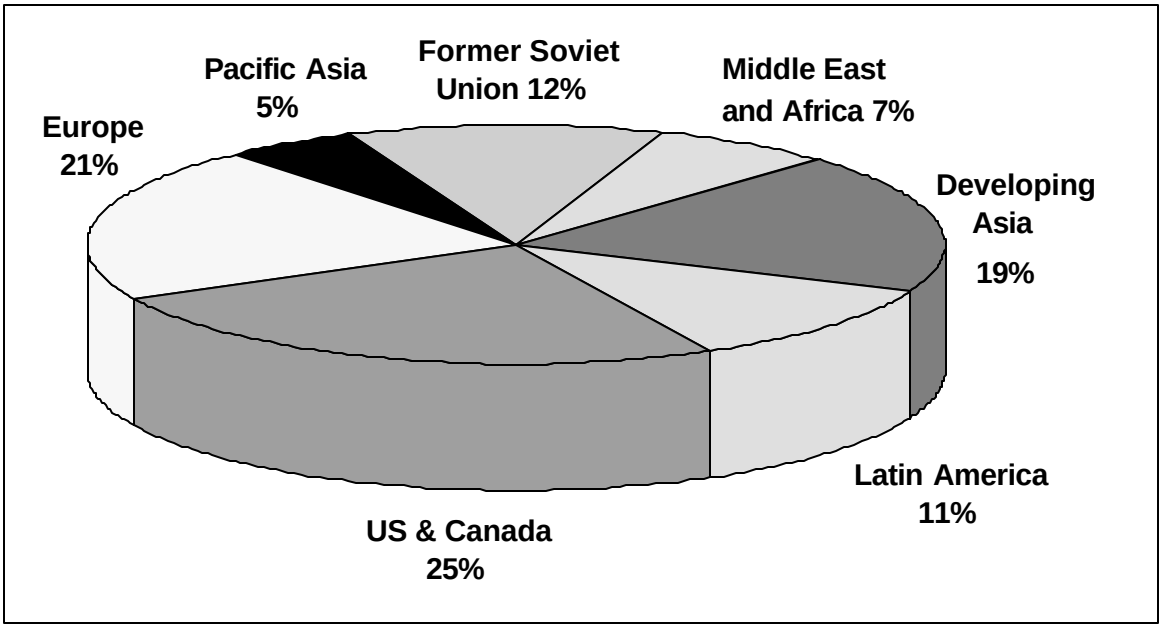

Figure 8.1 Regional contributions to cumulative CO_2 emissions from industrial sources and land-use change (1900-99)

Source. WRI (2001)

In 1990, total CO_2-equivalent[a] emissions from India were 1 001 352 Gg, which was approximately 3% of global emissions (Table 8.1).

[a] This takes into consideration the fact that greenhouse gases have different global warming potentials.

Table 8.1 India's national greenhouse gas inventory for 1990 (**in Gg**)

GHG sources and sinks	CO_2 emissions	CO_2 removals	CH_4	N_2O	NO_x	CO	CO_2-equivalent (CO_2+CH_4+N_2O)[a]
I. Energy							
A. Fuel combustion	508600						
Energy and transformation industries					2684[b]	3493[b]	508600
Biomass burning	300460[c]		1579	11	400	11472	36569
B. Fugitive emissions from fuels							
Solid fuels			330				6930
Oil and natural gas			626				13146
Total emissions from energy sector (fuel combustion + fugitive emissions)	508600		2535	11	3084	14965	565245
II. Industrial processes	**24200**			**1**			**24510**
III. Solvents and other products							
IV. Agriculture							
Enteric fermentation			7563				158823
Manure management			905				19005
Rice cultivation			4070[d]				85470
Agricultural soils				240			74400
Prescribed burning of savannas							
Field burning of agricultural residues			116	3	109	3038	3366
Total emissions from agricultural sources			12654	243	109	3038	341064
V. Land-use change and forestry							
Change in forests and other woody biomass stock		-6171					-6171
Forests and grassland	52385						52385

[a] CO_2-equivalents are based on global warming potentials (GWPs) of 21 for CH_4 and 310 for N_2O. NOx and CO are not included since GWPs have not been developed for these gases. Bunker fuel emissions are not included in the national total.

[b] NOx and CO emissions are computed for the transport sector.

[c] CO_2 emissions from biomass burning are not included in the national totals.

[d] CH_4 emissions according to IPCC 1996 methodology.

conversion							
Abandonment of managed lands		-44729					-44729
Total emissions from land-use change and forestry sector	52385	-50900					1485
VI. Waste							
Solid waste disposal on land			334				7014
Domestic and commercial waste water			49				1029
Industrial waste water			2905				61005
Other waste							
Total emissions from waste			3288				69048
Total national emissions and removals	**585185**	**-50900**	**1847 7**	**255**	**3193**	**1800 3**	**1001352**

Source. ADB-GEF-UNDP (1998)

In 1990, in per capita terms, India emitted 1.19 tonnes of CO_2-equivalent, compared with 8.8 tonnes by Japan, and 19.8 tonnes by the United States. The energy sector was the largest emitter of CO_2 contributing to 55% of national emissions. These also include emissions from road transport, coal mining, and fugitive emissions from oil and natural gas. Agriculture is the second largest source of GHGs in India; methane emissions from enteric fermentation in domestic animals, manure management, rice cultivation, and burning of agricultural residues constitute 34% of national GHG emissions. The net uptake and emissions from the land use change and forestry sector were almost equal, resulting in negligible emissions (ADB-GEF-UNDP, 1998).

Table 8.2 shows the change in CO_2 equivalent emissions from fuel combustion over the period 1990-99 in India and other countries.

Table 8.2 CO_2 emissions from fossil fuel combustion

	Total million tonnes CO_2	
	1990	1999
World	21279.4 (100)	23172.2 (100)
USA	4845.9 (23)	5584.8 (24)
EU	3133.7 (15)	3106.1 (13)
Japan	1048.5 (5)	1158.5 (5)
India	591.12 (3)	903.82 (4)

a		
Chin		3051.11(13
a	2428.9(11)	)
Braz		
il	201.01 (1)	305.55 (1)

Note: Figures in brackets denote % of world total
Source. IEA (2001)

Figure 8.2 shows that in 1999 per capita emissions from fuel combustion from India were much lower than for the US, EU and Japan, and one-fourth of the world average.

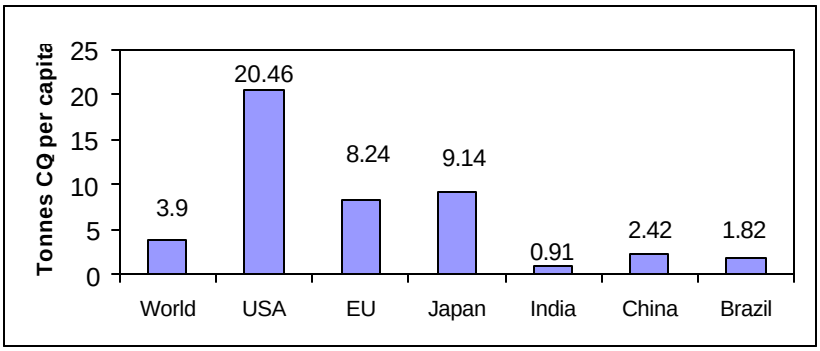

Figure 8.2 Per capita CO_2 emissions from fuel combustion (1999)

Source. IEA (2001)

Ozone-depleting substances

The ozone layer in the stratosphere is at risk from compounds containing different combinations of chlorine, fluorine, bromine, carbon, and hydrogen. These compounds (e.g. chlorofluorocarbons, hydrofluorocarbons, carbon tetrachloride, etc.) are collectively known as ozone-depleting substances (ODS) and are used in refrigeration, aerosol propellants such as body sprays, foam-blowing, and industrial solvents. They react with and deplete stratospheric ozone, allowing harmful UV radiation to reach the earth. This increased radiation can change genetic structure, affect immune systems, inhibit plant growth, and increase the incidence of eye cataract and skin cancer.

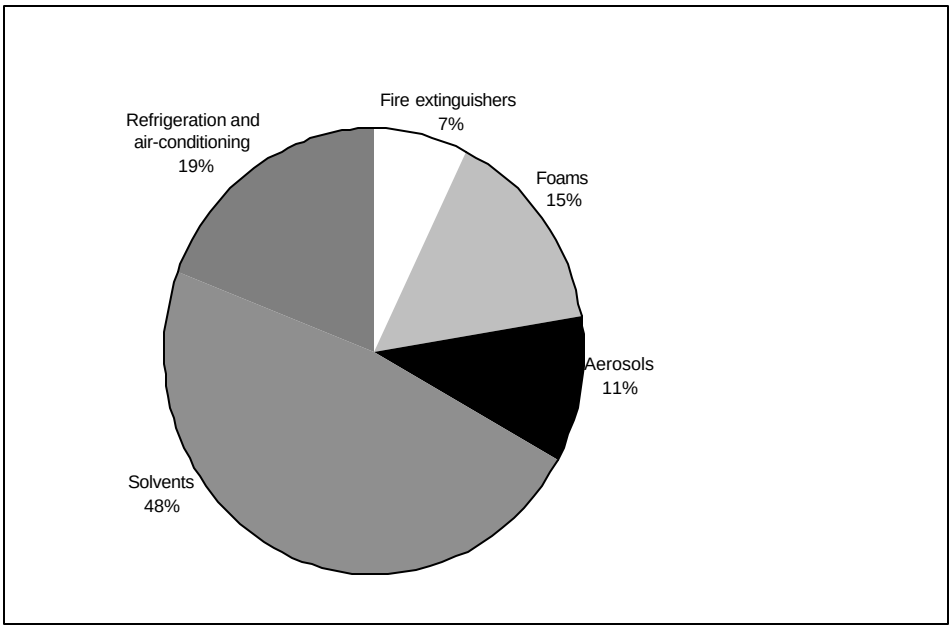

Figure 8.3 Sector-wise consumption of ODS in India (1991)

Source. GOI (1993)

In 1991, India's consumption of ODS was 10370 tonnes; of this, about 85% was produced domestically and 15% was imported. India's consumption amounted to about 1.2% of the global consumption of ODS, and less than 10g in per capita terms. The industry-wise consumption of ODS in 1991 is shown in Figure 8.3. Table 8.3 compares the change in consumption over the period 1991-1999, by type of ODS.

Table 8.3 ODS consumption in India

Name of ODS	Quantity in 1991 (metric tonnes)	Quantity in 1999 (metric tonnes)
CFC-11	1898	6167
CFC-12	2852	2050
CFC-13	321.5	-
Halon-1211	550	106
Halon-1301	197	47
Carbon	4003	14635
tetrachloride	550	1415[a]
Methyl	-	6.64
chloroform	-	8000[b]
Methyl bromide		
HCFC-22		

Source. UNEP-CUTS-SAWTEE (2001)

Atmosphere and Agenda21

Agenda21 states that the objective of protecting the atmosphere should be coordinated with social and economic development. It recognizes that this objective needs to be addressed in cooperation with national stakeholders – government, industry, the scientific community, and civil society – and with the aid of international financial and technological resources.

The main issues for protection of the atmosphere that are highlighted in Agenda21 are discussed below.

Addressing uncertainties

It is very important to enhance our understanding of the processes and consequences of atmospheric change, and of responses to address such changes. Agenda21 calls for improving the scientific basis for decision-making through measures including:

- Promotion of research on atmospheric processes and the crucial linkage between sustainable development and atmospheric change
- Extension of the scope of operation of systematic observation stations, and development and improved utilization of databases

[a] 1996 data
[b] 1998 data

- Cooperation in the development of early-detection systems concerning changes in the atmosphere
- International cooperation for building scientific capacity, scientific data exchange, and training

Promoting sustainable development

Integrating economic growth with atmospheric protection requires policies and programmes that promote greater efficiency in energy production and consumption, environmentally sound transportation and industrial development. The directions for future development are:

- Development of economically viable, environmentally sound energy sources, and increased availability of energy supplies for sustainable development, particularly in developing countries
- Research, development, transfer, and use of more efficient technologies and practices in energy, transport, and industrial systems
- Enhancement of institutional, scientific, and management capacity for energy planning, transport and urban planning strategies, and efficient use of materials and resources

Preventing stratospheric ozone depletion

Agenda21 emphasizes the need for continued efforts under the Montreal Protocol to phase out ODS through such measures as:

- Transfer of technologies to help developing nations comply with the obligations of the Protocol
- Active participation in the continuous assessment of scientific information, health and environmental effects, and technological/economic implications of stratospheric ozone depletion
- Consideration of measures to remedy the impact of ultraviolet radiation on health, agriculture, and the marine environment
- Replacement of CFC s and other ozone-depleting substances, with a holistic view of the suitability of substitutes

Review and analysis of policies and programmes related to global atmospheric issues

Highlights of legislation, policies and programmes

Relevant policies and legislation related to global atmospheric issues are briefly reviewed in Table 8.4.

Table 8.4 Review of polices and legislation in India governing global atmospheric issues

Year	Policies/ legislation	Salient features
1991	Vienna Convention for the protection of the ozone layer	▪ India became a party in June 1991
1992	Montreal Protocol on substances that deplete the ozone layer	▪ India acceded to the Protocol and its London Amendment in September 1992 ▪ Phase out of ODS production in India by 2010 in accordance with India Country Programme
1992	United Nations Framework Convention on Climate Change	▪ Signed by India in June 1992 and ratified in November 1993 ▪ Stabilization of GHG concentrations at a level that would prevent dangerous anthropogenic interference with the climate system ▪ No emissions reduction targets for developing countries ▪ Periodic reporting through National Communication to UNFCCC
1997	Male′ Declaration of the SAARC Environment Ministers Meeting on the Environment Action Plan	▪ Development, updating, and implementation of national environment action plans to address environmental concerns in SAARC region ▪ Development of legal instruments for cooperative efforts to protect the environment ▪ Increase in people’s involvement to find solutions for environmental problems ▪ Organization of finance and institutional mechanisms for implementation
2000	Ozone Depleting Substances (Regulation and Control) Rules	▪ Quantitative restrictions on production, consumption, sale, purchase and use of ODS ▪ Ban on export and import of ozone-depleting substances, except with countries specified in Schedule VI of the notification. ▪ Prohibition on new investments with ODS

Policy analysis

This section analyses the achievements of policies and the lacunae that remain in meeting Agenda 21 concerns regarding global atmospheric problems as described in section 3 (the atmosphere and Agenda21) above.

India has a detailed institutional and legislative framework for pollution abatement. Apart from policies, legislation and programmes there is also a strong institutional structure designed for the protection of the atmosphere. All these reflect an intention to integrate environmental considerations into decision-making at every level, with an emphasis on preventing pollution. It also brings to the fore, the government's strong intention to encourage increased interaction, move away from a strictly regulatory framework, and create an enabling environment for the adoption of cleaner technologies. This is further emphasized by the Ninth Plan statement that India's strategies for environmental protection are guided by Agenda21 principles.

Addressing uncertainties

Agenda 21 highlights the need to improve scientific understanding about processes that impact our atmosphere. Given its tropical location and its significant dependence on climate-sensitive sectors such as agriculture and forestry, India is vulnerable to climate change. It is, therefore, important to develop a better understanding of climate processes in the Indian subcontinent, assess potential socio-economic impacts, and build the capacity to adapt to climate change.

Current initiatives in this section include:

- A number of governmental and independent agencies are involved in climate change research in India. The India Meteorological Department (IMD) observes climatic parameters at surface and upper air observatories throughout the country. IMD's network includes 559 surface observatories, more than 8000 rainfall monitoring stations, 100 satellite-based data collection platforms in remote areas, 203 voluntary observing ships, 10 cyclone detection radars, and 17 storm detection radars (IMD, 2001). Since 1983, IMD has maintained a meteorological observatory at the Indian Antarctic station. This data is scrutinized and archived at the National Data Centre, Pune, and used to study, predict, and determine the effects of climate change.
- The existing cyclone detection radars all being replaced with state-of-art Doppler Weather Radars in a phased manner. The cities of Calcutta and Chennai have been the first ones to witness their use. An indigenous Doppler weather radar is being developed under a collaborative

programme of the IMD with the Indian Space Research Organisation (IMD, 2001).

- Satellite data received from INSAT provides cloud imageries in the visible and infrared channels, which are used to derive cloud motion vectors, sea surface temperatures, and outgoing longwave radiation.
- Indian scientists have played a key role in international climate research efforts such as the IIOE (International Indian Ocean Expedition), MONEX (Monsoon Experiment), INDOEX (Indian Ocean Experiment), World Climate Programme, Global Observing System, and International Geosphere-Biosphere Programme.
- IMD has also been undertaking ozone measurements since 1928. The Department has a network of ozone monitoring stations in the country, as well as one observatory at the Indian Antarctic station. IMD's National Ozone Centre at New Delhi is designated as Regional Ozone Centre for the Regional Association II (Asia) of the World Meteorological Organisation.
- The Government of India has supported the Asian Least-cost Greenhouse Gas Abatement Strategy (ALGAS) study, which developed a national inventory of GHG sources and sinks, and identified potential mitigation options. Country-specific emission factors have been developed for methane emissions from paddy cultivation, carbon dioxide emissions from Indian coal, etc.
- Much-needed information about the vulnerability to climate change is being generated under the ongoing Indo-UK Climate Change Impacts programme supported by the Ministry of Environment and Forests, Government of India. Several research organizations and academic institutions in the country are also engaged in research on climate change impacts. The Indian Institute of Tropical Meteorology, Pune, and the Indian Institute of Technology, Delhi are engaged in developing climate change scenarios for India.

There is need for detailed information about sectoral GHG emissions, country-specific emission factors, and monitoring methods. Further work in these areas is being undertaken as part of the preparation of the country’s first National Communication to the UNFCCC. The greenhouse gas inventory for the country is being prepared for the base year 1994, and will cover five sectors: energy, industrial processes, agriculture, forestry, and

waste. Vulnerability and adaptation assessment is also part of the National Communication project.

Promotion of sustainable development

The energy sector is the main source of greenhouse gases (Table 8.1). India is pursuing energy conservation, promotion of cleaner fuels, renewable energy technologies. The Energy Conservation Act is a noteworthy initiative in this regard. Other significant initiatives include the unbundling and privatization of the electricity sector, introduction of Bharat I and II norms in the transport sector[a], etc. Other significant measures in the transport sector include conversion of two- to four-stroke engines in two-wheelers, and demonstration of the use of electric- and battery-operated vehicles.

The Government of India has been consistently promoting power generation from renewable sources. Today, India has one of the largest renewable energy programmes in the world, and is the world's fifth-largest producer of wind energy, with an installed capacity of 1507 MW. The government offers several fiscal and financial incentives to encourage the adoption of such technologies as bagasse-based cogeneration, biomass consumption, grid connected solar photo-voltaic (PV) application, wind battery chargers, wind pumps etc. These are described in the chapter on Renewables.

The Technology Information, Forecasting and Assessment Council established under the Department of Science and Technology facilitates the transfer of environmentally sound technology. It has conducted a study on clean coal technologies, which are critically important given the large share (nearly 70%) of coal-based power generation in India, and the high ash content of the Indian coal.

In addition to these measures, India also pursues policies promoting afforestation and wasteland development. Under the UNFCCC, developing countries such as India do not have GHG mitigation commitments in recognition of their small contribution to the greenhouse problem as well as low financial and technical capacities. The Ministry of Environment and Forests is the nodal agency for climate change issues in India. It has constituted a Working Group on the UNFCCC and Kyoto Protocol to deliberate upon issues emerging from the climate change negotiations. It has

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[a] Bharat I norms have been implemented from April 1st 2000. These are applicable to the two- and three-wheeler segment and are stricter than Euro II norms. Bharat II norms will be applicable from April, 2005.

also established a task group on Activities Implemented Jointly (AIJ) to consider and recommend bilateral and multilateral projects aimed at GHG reduction. India is also going to host the eighth session of the Conference of Parties (COP-8) to the UNFCC during October 23-November 1, 2002.

The Kyoto Protocol to the UNFCCC was adopted in 1997 and requires developed countries listed in Annex B of the Protocol to reduce their GHG emissions to 5.2% below 1990 levels on average. Under the Clean Development Mechanism (CDM) introduced in the Protocol, developing countries such as India can participate in joint GHG mitigation projects. India has not yet signed the Protocol. The Government of India has, however, indicated its support of the CDM in a decision made prior to the sixth Conference of Parties to the UNFCCC (COP-6) in 2000. Priority projects are being identified for CDM investment in sectors such as power generation and renewable energy. At the resumed session of the seventh Conference of Parties (COP-7), it was agreed to adopt fast-track procedures for the approval of small-scale CDM projects in renewable energy and energy efficiency, which also matches India's interests.

The country's experience with Activities Implemented Jointly (AIJ), (Table 8.5) and Global Environment Facility (GEF) projects is also valuable in this regard.

Table 8.5 Pilot phase AIJ projects underway in India (as of December 2001)

Project	Location	Investor	Host
Integrated agricultural demand-side management	Andhra Pradesh	World Bank/Norway	Andhra Pradesh State Electricity Board
DESI power: biomass gasification	20 sites	The Netherlands	DESI Power, Development Alternatives
Hybrid Renewable Energy Project	Rajasthan	Australia	Brahmakumaris Academy for a better world

Source. TERI (2001)

India has GEF projects in the following areas.

- Coal-bed methane recovery and commercial utilization
- Development of high-rate biomethanation processes as a means of reducing GHG emissions
- Optimizing development of small hydel resources in hilly areas
- Alternative sources of energy
- Biomass energy for rural India

- Selected options for stabilizing GHG emissions for sustainable development
- Solar thermal-electric
- Energy efficiency
- Fuel cell bus development in India

COP-7 also agreed upon increased replenishment of GEF, the establishment of an adaptation fund, and a special climate change fund. This last fund will finance activities that are complementary to those funded by the GEF, including:

- Adaptation
- Technology transfer
- Mitigation in energy, transport, industry, agriculture, forestry and waste management
- Economic diversification in countries adversely affected by climate change response measures

Despite the above initiatives, India requires substantial new and additional resources to implement a less-polluting and carbon-intensive path. In the long run, stabilization of GHG emissions requires the convergence of per capita emissions from developed and developing countries towards a common range. Adequate institutional capacity-building is critical to meeting the requirements of mitigation, adaptation, and CDM operationalization.

Preventing stratospheric ozone depletion

India acceded to the Montreal Protocol along with its London Amendment on 19 June 1992. The India Programme for the phase-out of ODS under the Montreal Protocol was approved in November 1993. The MoEF has established the Ozone Cell and the Steering Committee on the Montreal Protocol to facilitate implementation of the objectives of the India Country Programme. India's efforts to protect the ozone layer are guided by the need to minimize economic dislocation, encourage indigenous production of substitutes, and address the special requirements of small and medium enterprises.

To meet India's commitments under the Montreal Protocol, the Government of India has also taken some major policy decisions.

- Goods required to implement ODS phase-out projects funded by the Multilateral Fund are fully exempt from payment of duties. This benefit has been also extended to new investments with non-ODS technologies.
- Commercial banks are prohibited from financing or refinancing investments with ODS technologies.
- Indian industry is considering different substitutes for ODS. For instance, in the refrigeration and air-conditioning (RAC) sector, HFC-134a and hydrocarbons are being looked at as alternative refrigerants, and cyclopentane as an alternative foam-blowing agent for insulation. In the aerosols sector, HAP (hydrocarbon aerosol propellant) has been the preferred choice, in the foams sector, HCFC-141b, and other CFC-free technological options have been adopted. The choices available in the solvents and halons sector vary widely depending on the specific application.
- Various projects in the five ODS-consuming sectors, aerosols, foams, halons, RAC, and solvents, have been submitted to the Multilateral Fund seeking assistance for a changeover to ozone-friendly substitutes. To date, 276 projects worth approximately 93 million dollars have been approved, also including a project on the phase-out of the domestic production of CFCs. The largest number of projects is in the foams sector, followed by RAC and aerosols. During 2000, the Multilateral Fund approved 35 investment and 11 non-investment projects for India worth about 10.8 million dollars which will phase-out 9158 ODP tonnes when completed.

Strategies for sustainable development

Agenda21 brings to the fore key concerns for the preservation of the atmosphere – both, regarding global problems such as climate change and stratospheric ozone depletion, and the pressing issues of local air quality, a priority for developing countries. By exploiting the synergies that exist between local and global environmental priorities, India can optimize the use of international resources for national development.

There exists a detailed policy framework in India to address these concerns, with appropriate legislation being formulated in the pre-Rio as well as post-Rio periods. The Approach Paper to Tenth Five-Year Plan, like its predecessor, recognizes the need for a cleaner atmosphere and states that efforts should be made to reduce air pollution in each of the sectors that creates pressures on the atmosphere.

The challenge, however, is to improve the enforcement of these policies by institutional strengthening and capacity-building, improved monitoring and reporting systems, and adoption of appropriate market-based instruments. International cooperation should be promoted for the transfer of financial resources and cleaner technologies. In keeping with the suggestion of CSD-IX, attempts will be made to explore ways of increasing financial resources and create innovative financing solutions also by debt relief. Where possible, efforts should be made to facilitate foreign investment, reverse the downward trend in ODA, and fulfil the commitments undertaken to reach the accepted United Nations target of 0.7 per cent of gross national product (GNP) as soon as possible.

References

Agenda 21, United Nations
http://www.un.org/esa/sustdev

ADB-GEF-UNDP. 1998
Asia least-cost greenhouse gas abatement strategy: India
Manila: Asian Development Bank

GoI. 1993
India: sustaining development
New Delhi: Government of India

IEA. 2001
CO2 emissions from fuel combustion 1971-1999
Paris: International Energy Agency

IMD. 2001
www.imd.ernet.in
Accessed on 8 November 2001

MoEF. 1993
Country programme: phase-out of ozone-depleting substances under the Montreal Protocol
New Delhi: Ministry of Environment and Forests, Government of India.

Ninth Five-Year Plan: 1997-2002
Vol. 2: Thematic Issues and Sectoral Programmes
New Delhi: Planning Commission. 1059 pp.

Planning Commission. 2001
Approach Paper to the Tenth Five-Year Plan (2002-07)
New Delhi: Government of India, Planning Commission. 49 pp.

TERI.2001
Survey on potential of model projects for increasing the efficiency use of energy in India
Prepared for New Energy Industrial Technology Development Organization, Bangkok
New Delhi: Tata Energy Research Institute

UNEP-CUTS-SAWTEE. 2001
South Asian consultation on atmospheric issues

WRI. 2001
The U.S., developing countries, and climate protection: leadership or stalemate?
Washington, DC: World Resources Institute