Environment- The concerns and strategies

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Introduction

The rapid increase in population and economic development has led to severe environmental degradation that undermines the environmental resource base upon which sustainable development depends. The economics of environmental pollution, depletion and degradation of resources has in fact been neglected as compared to the issues of growth and expansion. India has been no exception to this worldwide phenomenon, rather the trends of environmental deterioration in India, because of the substantial increase in its population, have been far more prominent as compared to other developing economies.

The country has indeed made substantial progress in most indicators of human development since independence when it was predominantly an agrarian economy with a stagnant national income. Encouraging achievements have been recorded in the age-specific mortality rates; expectation of life at birth; and aspects related to livelihood conditions like education, nutritional security and health. With the country's population having grown three-fold and the urban population itself quadrupling in four decades (1951-1991), the current infrastructure in most of the cases is not only over stretched but also inadequate. With a population of over a billion, India supports 16% of the world's population on 2.4% of the world's land resulting in a paucity of resources that jeopardises growth in the longer run.

Urban development in India is presently going through a very dynamic stage, the percentage of population in urban centres itself having increased from 14% in the 1940s to about 33% in 2000 (HSMI 2000). The unprecedented challenge of such an urban shift has resulted in Indian cities degenerating into slums and squatters camps. The rapid expansion of cities has brought to the fore acute problems of transport congestion, atmospheric pollution and unwise water and solid waste management resulting in the degradation of the quality of life. The deterioration of environmental quality in Indian cities is but one aspect of the threat to the quality of life, the other perhaps more pertinent issue being that of the sustainability of growth itself.

The much needed impetus to industrial development has resulted in huge residuals, having undesirable effects on the environment — air, water and land, disproportional to their contribution to overall economic growth. For instance, the iron and steel industry contributes 55% of the particulate matter load while adding 16% to the total industrial output. The industrial BOD load from chemicals and food processing industries is as much as 86% against the industry's contribution of 25% to the total industrial output.

These unsustainable growth trends increase the vulnerability of the economically weaker sections to environmental degradation and pollution, on account of their direct dependence on natural resources like land, forests and various common property sources for fuelwood, fodder, and water. In the absence of alternatives, the imbalanced competition for natural resources could significantly contribute to weakening the support base of the poor further and perpetuating poverty and a poor quality of life. Hence for a developing country like India, the key to poverty elimination is the country's ability to regenerate its environment and assist its masses to retain control over their living conditions.

Based on studies done at TERI (Tata Energy Research Institute) – Looking Back to Think Ahead (TERI 1998) ; DISHA (Directions, Innovations and Strategies for Harnessing Actions for Sustainable Development) (TERI 2001) and State of Environment — India (UNEP 2001) this chapter aims to highlight the key environmental concerns that have emerged in the country. Section I focuses on the prevalent status and causal factors of the major environmental concerns such as air, water resources and pollution, solid waste management and also touches briefly on the issues of land degradation and biodiversity. Baseline scenarios have been developed on how these trends are likely to unfold by the year 2025, considering the base year as 1997. Section 2 puts forward the strategies for a reform agenda that is more widespread and proposes its implementation at a considerably quicker pace. Alternative case projections for the year 2025 are presented accordingly, assuming that the proposed strategies are implemented in full within a well-defined time frame.

Growing environmental concerns — compulsions of economic development

This section focuses on the prevailing environmental concerns and the root causes of the degrading environment emphasising current effects on resource depletion and environmental degradation currently and expected future trends. Projections have been made as per BAU (business-as-usual) scenario for the year 2025 in view of the current socio-economic, policy and technological factors prevalent in India.

Air pollution

Air pollution in India has been aggravated over the years by developments that typically occur as economies become industrialised: growing cities, increasing traffic, rapid economic development and industrialisation, and higher levels of energy consumption. In India, air pollution is restricted mostly to urban areas, where automobiles are the major contributors, and to a few other areas with a concentration of industries and thermal power plants. The major sources of air pollution in the country are industries (toxic gases), thermal power plants (fly ash and sulphur dioxide), and motor vehicles (carbon monoxide, particulate matter, hydrocarbons and oxides of nitrogen). Major polluting industries and automobiles emit tonnes of pollutants every day, putting citizens, at great health risk. The national capital — Delhi, is already among the most polluted cities in the world.

The incidence of respiratory diseases in most of the major cities in India has also increased considerably over the years. In a study of 2031 children and adults in five major cities of India, of the 1852 children tested, 51.4% had levels of lead in their blood above 10 µg/dl. The percentage of children having 10 µg/dl or higher lead levels ranged from 39.9% in Bangalore to 61.8% in Mumbai. Among the adults, 40.2% had lead levels of about 10 µg/dl (George Foundation 1999, cited in CPCB 2000 a).

Box 1 below lists the principal sources and environmental effects of some of the major air pollutants.

Box 1 Principal sources and environmental effects of selected atmospheric pollutants

Pollutant	*Principal sources related to human activity*	*Effects*	*Remarks*
Carbon monoxide	Incomplete fuel combustion (as in motor vehicles)	Deprives tissues of oxygen. People with cardio-respiratory diseases more sensitive.	CO is one of the most widely distributed of all air pollutants – global emissions probably exceed the combined emissions of all other major air pollutants. Contribution of natural sources is small. The largest source is petrol-driven motor vehicles.
Sulphur dioxide	Burning of sulphur-containing fuels like coal and oil	Combined with smoke, increases risk and effects of respiratory diseases. Causes suffocation and irritation of throat and eyes. Combines with atmospheric water vapour to produce acid rain. Leads to acidification of lakes and soils. Corrodes buildings.	
Suspended particulate matter	Smoke from domestic, industrial, and vehicular sources	Possible toxic effects depend on specific composition. Aggravates effects of sulphur dioxide. Reduces sunlight and visibility. Increases corrosion.	Chemically, a most diverse group of substances. Natural sources include dust-storms and volcanic eruptions.
Oxides of nitrogen	Fuel combustion in motor vehicles, power stations, and furnaces	Possible increase in acute respiratory infections and bronchitis morbidity in children. Produce brown haze in city air. Causes corrosion.	Combustion oxidizes both the nitrogen in the fuel and some of the nitrogen present in the air, producing several oxides of nitrogen. However, only NO and NO_2 are known to have adverse environmental or biological effects.
Volatile hydrocarbons	Partial combustion of carbonaceous fuels, industrial processes, disposal of solid wastes.	React with other pollutants to produce eye irritants (acrolein, aldehydes). Ethylene is harmful to plants. Aerosol particles reduce visibility. May produce unpleasant odours.	
Oxidants and ozone	Emissions from motor vehicles. Photochemical reactions of nitrogen oxides and reactive hydrocarbons.	Cause eyes irritation and impaired pulmonary function in diseased persons. Corrode materials and reduces visibility. Ozone is one of the most damaging pollutants for plants.	Mainly derivative: products of atmospheric reactions between other pollutants. Ozone is a natural and essential constituent of the upper atmosphere.
Lead	Main source is emission from motor vehicles. Other sources include smelting and refining lead, producing batteries, paints, etc.	Adversely affects blood and human nervous system. Causes anaemia, brain dysfunctions and kidney damage.	Alkyl lead, used as an anti-knock agent in petrol, is released into the atmosphere as fine particles when petrol is burnt.

Sources: United National Environment Programme (1991), Centre for Science and Environment (1982)

Vehicular pollution

Vehicular emission is the major contributor to the rising levels of all major pollutants. It is an issue of prime concern since these emissions are from ground level sources and thus have the greatest impact on the health of the population exposed to it. The increase in the number of vehicles contributes significantly to the total air pollution load in many urban areas. The number of motor vehicles in India has increased from 0.3 million in 1951 to 40.94 million in 1998 (MoST 2000). CO (Carbon monoxide) and HC (hydrocarbons) respectively account for 64% and 23% of the total emission load due to vehicles in all cities considered together (CPCB 1995).

Table 1 highlights the types of pollutants from different sectors in Delhi (CPCB 1995) and reflects the significant share of the transport sector in the same.

Table 1 Sectoral contribution to emissions in Delhi **(tonnes/day)**

Pollutant	*Transport*	*Power*	*Industries*	*Domesı*	*Total*
TSP	13 (10%)	50 (37%)	60 (44%)	12 (9%)	138
SO_2	11 (6%)	121 (68%)	35 (20%)	12 (6%)	179
NO_X	157 (49%)	143 (44	20 (6%)	3 (1%)	323
HC	810 (76%)	8 (1%)	128 (12%)	117 (11%)	1063
CO	310 (97%)	2 (<1%)	6 (2%)	2 (<1%)	320

Source. CPCB 1995

Apart from the concentration of vehicles in urban areas, other reasons for increasing vehicular pollution include the types of engines used, age of vehicles, poor road conditions, outdated automotive technologies, poor fuel quality and traffic congestion resulting from clumsy traffic management systems.

Indoor air pollution

Fuel combustion from domestic sources affecting the quality of air indoors is another issue of concern in our country. Domestic emissions are potentially hazardous because their levels are high and people are exposed to them for extended periods. Burning of unprocessed biofuels in traditional inefficient devices emits large amounts of air pollutants such as CO (carbon monoxide), fine particles, and range of organic compounds including formaldehyde, benzene, and benezopyrene. Prolonged exposure to pollutants from biomass fuels leads to serious health problems. According to a recent estimate (Smith 1998), about 4000 000 to 6000 000 premature deaths among women and small children (younger than 5 years) can be attributed to indoor air pollution every year in India (the data were not adequate to estimate the lower risk to men and older children).

Air quality profile

In order to determine the air quality status and trends, assess health hazards, disseminate air quality data, and to control and regulate pollution, the CPCB (Central Pollution Control Board) initiated a nationwide framework of NAAQM (National Ambient Air Quality Monitoring) in 1984 with 28 stations at 7 cities. Presently, the network has 290 monitoring stations in 92 cities and towns throughout the country (CPCB 1998). The pollutants being monitored are mainly SPM (suspended particulate matter), SO_2 (sulphur dioxide) and NO_x oxides of nitrogen . SPM is one of the most critical pollutants in terms of its impact on air quality and is also the most common pollutant across all sectors. The ranges of SPM concentration (annual average) in the major metropolitan cities in India are shown in Table 2.

Table 2 Range of annual averages of SPM in major Indian cities

S. No.	*City*	*Area land use*	*Range of annual average of SPM (μg/m³) 1990-98*		*Mean of annual averages (μg/m³)*
			Minimum	*Maximum*	
1.	Delhi	Residential	300	409	355
		Industrial	314	431	381
2.	Mumbai	Residential	196	327	230
		Industrial	150	276	224
3.	Calcutta	Residential	205	491	327
		Industrial	286	640	434
4.	Chennai	Residential	72	118	99

		Industrial	53	147	123
5.	Bangalore	Residential	60	239	158
		Industrial	99	153	125
6.	Ahmedabad	Residential	198	316	261
		Industrial	201	306	243
7.	Hyderabad	Residential	135	184	158
		Industrial	72	259	153

Source. CPCB 2000a

As against to the maximum permissible limits laid down by CPCB for annual average concentration of SPM in ambient air - 70 $\mu g/m^3$ in sensitive areas, 140 $\mu g/m^3$ in residential areas and 360 $\mu g/m^3$ in industrial areas, it is clearly evident that the SPM levels are high in most of the metropolitan cities in India.

Projections for integrated air pollution loads — BAU (business as usual) scenario

The future scenario of air pollution in India has been calculated considering the integrated impact from major contributing sectors, i.e. domestic, transport, manufacturing industries and power. In the absence of a comprehensive emission inventory, projections have been made only for SPM, which is the most common pollutant across all sectors and is critical for air quality in many cities.

- Emissions from the transport sector have been calculated based on projections for a count of vehicles, in line with the projections for growth in population and economic activity.
- Air pollution from the manufacturing sector has been worked out on the basis of emission load per unit of output for some of the resource intensive and highly polluting industries-copper, aluminium, steel, cement, fertilisers, textiles and PVC (poly-vinyl chloride).
- Projections for pollutant loads from power generation have been arrived at, considering a continued reliance of the power sector on coal-based generation, resulting a higher SPM load. It is further assumed that all coal-based power plants will have installed ESPs (electro-static precipitators) to limit SPM emissions.
- The SPM contribution of the domestic sector takes into account a shift towards cleaner gaseous fuel and fewer emissions from the residential sector.

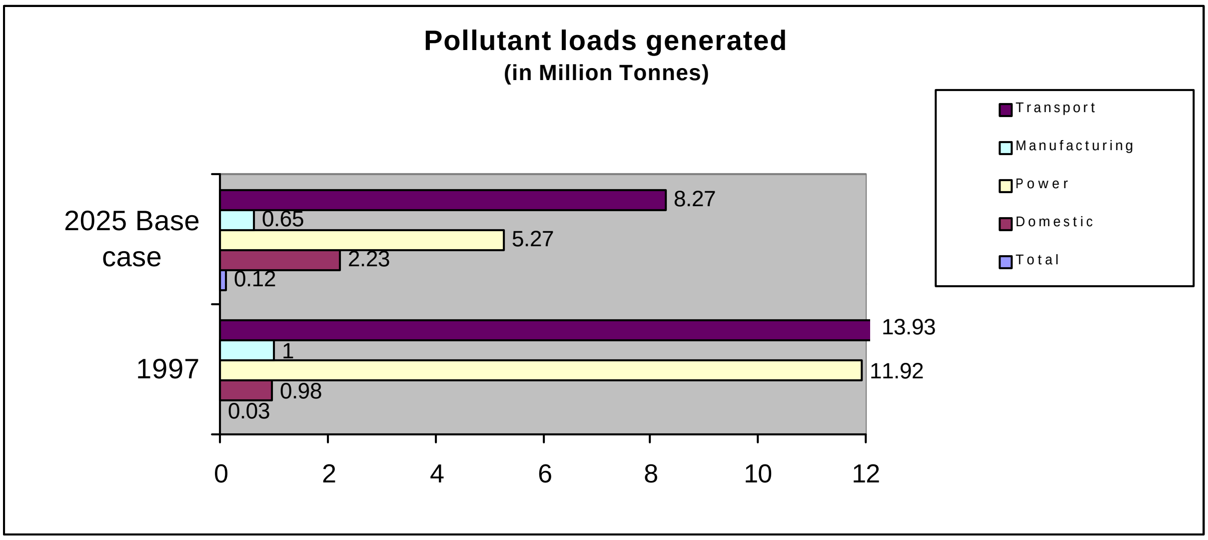

Figure 1 highlights the projections for the pollutant load generated from each of the sectors.

Projections indicate that the overall SPM load is likely to get reduced in the time frame 1997-2025 at around 2% per annum, although a bulk of the load would continue to emanate from power generation (64% in 2025). The drop in pollution loads from the domestic sector is on account of a likely shift to commercial fuels in rural India.

Water

India receives an average annual rainfall equivalent of about 4000 cubic kilometres. This is unevenly distributed across different parts of the country and most of the rainfall is confined to the monsoon season, from June to September. Thus, while India is considered to be rich in terms of annual rainfall and total water resources, water is spatially and temporally very unevenly distributed. Based on per capita water availability[1], some river basins fall in the category of water scarce[2] and water stressed regions, and several others suffer from absolute scarcity. Though water resource availability is estimated to be 1085.9 billion cubic metres, annual average utilisable per capita water resources vary considerably from as high as 3020 in the Narmada basin to as low as about 180 cubic metres and less in the Sabarmati basin, as against a desired availability of 1700 per capita per year. The estimated per capita water availability has also declined from 6008 cubic metres a year in 1947 to 2266 cubic metres in 1997, as per TERI's 'Green India 2047' study (TERI 1998). This declining figure gives a broad indication of the growing water scarcity in the country in the last fifty years since independence.

Water demand vs availability

The unprecedented increase in the country's population, from about 343 million at the time of independence to over 1 000 million in 2000, accompanied by growth of agriculture, rapid urbanisation, economic growth and improved access to basic services has resulted in increasing demand for water. A requirement of 555 BCM against the availability of 1086 BCM indicates a state of surplus at the national level, however spatial and temporal variations give rise to shortages in some regions. The Western plains, the Kachchh region, and some pockets in the Northern plains face acute water shortages. The country's total water requirement is projected to grow to 1422 BCM by the year 2050 as against 518 BCM in 1990 (MoWR. 1999). This would be much in excess of the available utilisable average water resources of 1086 BCM. The widening gap between demand and supply has led to a substantial increase in the share of groundwater for consumption by the urban, agricultural and domestic sectors. Further, the quality of water sources is threatened due to inadequate provisions for treatment of wastewater.

The growing gap between demand and supply has led to overdevelopment of groundwater, making its overuse emerge as a major concern in a few states. Against a critical level of 80%, the level of exploitation is over 98% in Punjab and about 80% in Haryana. The problem is also becoming increasingly serious in Tamil Nadu, where the level of exploitation exceeds 60%, and in Rajasthan, where it is 53% (Central Groundwater Board 1994). Between 1984/85 and 1994/95, the number of dark blocks with groundwater exploitation greater than 85% increased on an average by over threefold in a few states (Table 3).

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[1] Per capita water availability is calculated on the basis of total resource availability of 1085 billion cubic metres and a population of 1 billion

[2] When the annual per capita availability, in cubic metres, falls below 1700, it is held to be a situation of water stress, availability of less than 1000 is labeled as water scarcity, and of less than 500 is termed absolute scarcity (Engelman and Roy 1993)

Table 3 Blocks with intensive exploitation of groundwater (utilization exceeds 85% of the annual utilisable potential)

State	*% of blocks using groundwater intensively*	
	1984/85	*1994*
Gujarat	3	25
Punjab	54	62
Rajasthan	9	29
Tamil Nadu	14	26

Source. Saleth 1996

Water pollution

The problem of fresh water pollution in India came to the forefront towards the beginning of 1970's with the domestic sewage and industrial waste discharges being the most critical sources of pollution in cities. This resulted in the promulgation of the Water (Prevention and Control of Pollution) Act, 1974 and establishment of the National Water Quality Network in 1979. The sources of water pollution include point and non-point sources like discharges from industries and storm water respectively. While pollution from point sources can be controlled, it is difficult to control pollution from non-point sources such as agriculture run-off, leaching from waste disposal sites and storm water.

The total wastewater generation from domestic sources in class I towns is 16.27 billion litres and of this a mere 25% is treated. The increase in treatment capacities have also not shown a commensurate increase as the share of waste water which is untreated and disposed into our surface water bodies, has increased from 61% in 1978-79 to 76% in 1994-95 (CPCB 2000). It was also observed that class-I cities and class-II towns of Maharashtra, Delhi, Uttar Pradesh, West Bengal and Gujarat are the major contributors of wastewater contributing to 59% of the total wastewater generated in the country. The infrastructure to collect and treat wastewater in these states is as given in Table 4. Furthermore, the facilities constructed to treat wastewater do not function properly and remain closed most of the time due to improper design and poor maintenance, together with a non-technical and unskilled approach.

Table 4 Status of wastewater (w/w) generation, collection, and treatment in major contributing states **(million litres per day)**

State	Type	Number of cities/towns	w/w generated (mld)*	w/w collected (mld)	%age w/w collected	w/w treated (mld)	%age w/w treated
Gujarat	Class-I	21	1175.8	936.7	78.6	676	51.3
	Class-II	27	191.2	137.8		25	
Maharashtra	Class-I	27	3593.4	3139	85.6	481.4	13.3
	Class-II	28	160.4	73.8		18	
Uttar Pradesh	Class-I	41	1557.7	1048.9	66.7	246.2	13.4
	Class-II	45	275.5	174		-	
West Bengal	Class-I	23	1623.1	1183	72.2	-	-
	Class-II	18	66.9	36.7		-	
Delhi	Class-I	1	2160	1270	58.8	1270	58.8
Total		231	10804	8000	74.04	2716.6	25.14%

* Also includes information gathered on industrial wastewater, **Source.** CPCB 2000a

Water pollution, in the industrial sector is concentrated within a few subsectors mainly in the form of toxic wastes and organic pollutants. Of the total pollution load generated by industrial subsectors, 40%–45% is contributed by the processing of industrial chemicals. In terms of the total organic pollution, expressed as BOD, nearly 40% arises from the food industries followed by industrial chemicals and the pulp and paper industry (World

Bank 1996). Other major sector of concern is that of small-scale industries with more than 2 million units where pollution abatement has been neglected so far. Depending on the traditional crafts and culture of the area, small-scale industries like chemical, textiles, food processing and tanneries are found in large clusters in different states. States with over a lakh registered small-scale industries include Andhra Pradesh, Gujarat, Madhya Pradesh, Punjab, Tamil Nadu, Uttar Pradesh, and West Bengal. Of these very few of the clusters have opted for CETPs (Common Effluent Treatment Plants) to control water pollution but most of these CETPs either do not function at all or do not treat effluents to the desired quality.

Presently the institutional mechanisms to address pollution in the agriculture sector are also missing, as the sector is out of the ambit of the pollution control boards. The problem is acute in the riparian states of Punjab, Haryana, Uttar Pradesh and Tamil Nadu. Excessive use of fertilizers has led to an increase in the levels of nitrates in the shallow groundwater sources. The nitrate content of well water in a few districts of Uttar Pradesh, Haryana, and Punjab is far beyond the standard prescribed safe limit of 45 mg/litre (Kansal, Grewal, and Dhaliwal 1994). Severe degradation of ground water sources is also resulting from dumped solid wastes and human waste in dug wells.

Water quality profile

Pressures due to inadequate collection and inefficient treatment of domestic wastewater, discharge of highly complex wastes from industries and the polluted runoff from agricultural fields, have resulted in considerable degradation in the quality of water sources. Indicators of this deterioration include depletion of oxygen, excessive presence of pathogens, settling of suspended material during lean flow conditions, and bad odour.

The quality of river water is monitored at 480 stations under different programmes such as MINARS (monitoring of Indian national aquatic resources), GEMS (global environmental monitoring systems), and GAP (Ganga action plan). A number of physical, chemical, biological and bacteriological parameters are being measured under the programme, but the important ones include BOD (biochemical oxygen demand), DO (dissolved oxygen), and TC (total coliform) count. Heavy metals are however not included under the monitoring programme. Some of the polluted river stretches, their critical parameters and possible sources of pollution are listed in the Table 5 below.

Table 5 List of polluted river stretches [a]

River	*Polluted stretch*	*Desired class*	*Existing class*	*Critical parameters*	*Possible source of pollution*
Sabarmati	Immediate upstream of Ahmedabad upto Sabarmati Ashram	B	E	DO, BOD, Coliform	Domestic and industrial waste from Ahmedabad
	Sabarmati Ashram to Vautha	D	E	DO, BOD, Coliform	Domestic and industrial waste from Ahmedabad
Subarnarekha	Hatia dam to Bharagora	C	D/E	-do-	Domestic and industrial waste from Ranchi and Jamshedpur
Godavari	Downstream of Nasik and Nanded	C	D/E	BOD	Wastes from sugar industries, distilleries and food processing industries
Krishna	Karad to Sangli	C	D/E	BOD	Wastes from sugar industries and distilleries
Sutlej	Downstream of Ludhiana to Haike	C	D/E	DO, BOD	Industrial wastes from hosieries, tanneries, electro-plating and engineering industries and domestic waste from Ludhiana and Jalandhar
	Downstream of Nangal	C	D/E	Ammonia	Wastes from fertilizer and chloralkali mills from Nangal
Yamuna	Delhi to confluence with Chambal	C	D/E	DO, BOD,	Domestic and industrial wastes

River	Polluted stretch	Desired class	Existing class	Critical parameters	Possible source of pollution
				Coliform	from Delhi, Mathura and Agra
	In the city limits of Delhi, Mathura and Agra	B	D/E	DO, BOD, Coliform	Domestic and industrial wastes from Delhi, Mathura and Agra
Hindon	Saharanpur to confluence with Yamuna	C	D	DO, BOD, Toxicity	Industrial and domestic wastes from Saharanpur and Ghaziabad
Chambal	Downstream of Nagda and downstream of Kota	C	D/E	BOD, DO	Domestic and industrial waste from Nagda and Kota
Damodar	Downstream of Dhanbad	C	D/E	BOD, Toxicity	Industrial wastes from Dhanbad, Durgapur, Asansol, Haldia and Burnpur
Gomti	Lucknow to confluence with Ganges	C	D/E	DO, BOD, Coliform	Industrial wastes from distilleries and domestic wastes from Lucknow
Kali	Downstream of Modinagar to confluence with Ganges	C	D/E	BOD, Coliform	Industrial and domestic wastes from Modinagar

Source. CPCB 1999

[a] Water quality and the desired water quality is expressed in classes A, B, C, D, and E, which reflect the best use of that water. Class A indicates that water is fit for drinking without conventional treatment but after disinfection; Class B that it is suitable for outdoor bathing; and Class C, that it is suitable for drinking after conventional treatment. Class D water is suitable for propagation of wildlife and fisheries and Class E water can be used for irrigation, industrial cooling, and controlled waste disposal.

Concerns related to water resource management

- Inequitable access to basic services

Huge disparities exist in the provision of basic services. For instance, only 77 of the 299 class-I cities have 100% water supply coverage and other 203 of the 345 class-II towns have low per capita supply of less than 100 lpcd.

- Inefficiency in resource use/management

Water has conventionally been considered a free commodity and government policies have provided little incentive to encourage efficient use of the resource. The distribution losses of treated water for instance range between 25% and 40%. Besides other inefficiencies also persist at the supply end –in the form of overstaffing, high administrative costs, and time and cost overruns.

- Pricing policies

Water being a state subject, the price for its use in different sectors is fixed by the state governments and varies from state to state. Typically, water rates for agriculture and domestic consumption, do not cover even the working expenses of providing the services, let alone capital costs. In the irrigation and urban sectors, the percentage recovery of working expenses through gross receipts in recent years is only about 10% and 30% respectively. The subsidy regime has on the one hand encouraged inefficient use of the resource and on the other, led to poor financial health of the service sector resulting in poor quality of services and user dissatisfaction.

- Institutional set up and legal framework

Planning and implementation of water development projects is currently cumbersome with a number of organisations involved both at the centre and state levels, in the duplication and ambiguity of functions. Few states have defined water policies and set up organisations for planning and allocating water for various purposes. While there is an extensive legislative framework to address water pollution, there are no regulations on water abstraction. Groundwater authorities attempt to regulate groundwater withdrawals through licensing but do not define any limits for withdrawals, thereby not addressing inequitable and unsustainable groundwater withdrawals. Implementation of environmental laws in general remains weak, mainly on account of inadequate financial resources and capacity.

Projections for water requirements — BAU scenario

Demand for fresh water will continue to grow from all sectors, due to additional requirements from agriculture and increased migration to urban areas. To project the water requirement by the year 2025 under a baseline scenario, four major water-consuming sectors have been considered and the cumulative water requirement has been estimated based on:

- *Agricultural* cropping intensity of 157% with 60% of the gross cropped area under irrigation.
- Per capita *domestic* supply of 135 litres a day in the urban areas and 40 litres per day in rural areas.
- An estimated 3% increase in water consumption by the *industrial sector* in line with the projections for growth in economic activity.
- Projections for water requirements in the *power sector* assume an increase in dry collection practices and better process operations for fly ash collection and steam generation respectively.

Based on the above, total water demand under the BAU scenario is as Table 6.

Table 6 Total water demand projections: base case **(billion cubic metres)**

Year	*Irrigation*	*Domestic*	*Manufacturing*	*Power*	*Total requirements*
1997	528.85	23.52	1.6	1.39	555.36
2025	789.50	39.76	4.79	3.75	837.80

These projections for water demand when compared to the estimated availability of 1085.9 billion cubic metres indicate an overall net marginal positive balance of only 248 billion cubic metres by the year 2025. However, given the uneven distribution of the resource, as discussed, it is projected that the country will go, from the present state of water stress, to a state of water scarcity, with an average annual per capita availability of 750 cubic metres by 2025. Further, due to wide inequality in the consumption patterns of different sectors, competition for water from different sectors may trigger disputes among these sectors as well.

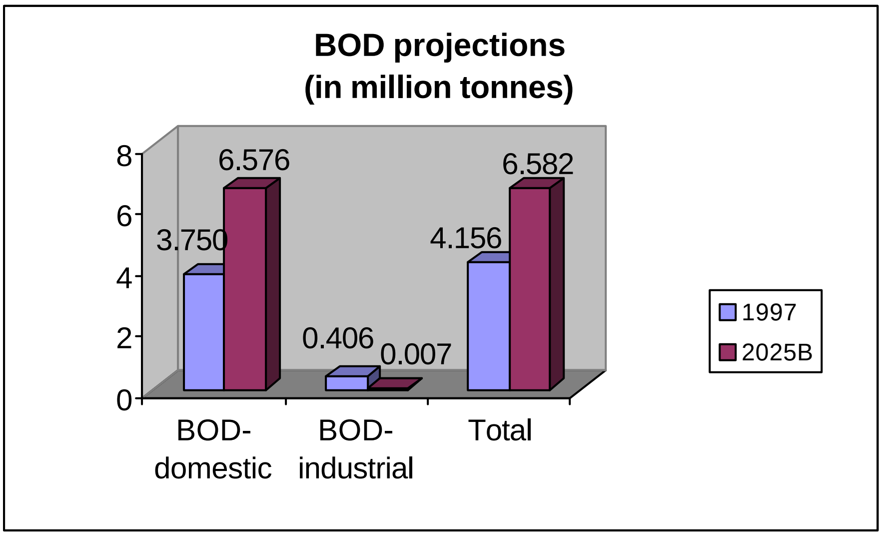
Projections for water pollution loads – BAU scenario

The current state of infrastructure marked with inadequate collection networks and treatment capacities forces discharge of untreated or partly treated waste water into natural drains joining the rivers, lakes, and sea. The polluted rivers and other water bodies is a direct consequence of the inadequate level of collection and treatment in Indian cities.

BOD projections from the urban domestic sector assume an overall wastewater collection efficiency of about 70% in 2025. It is also assumed that all production units would have facilities to control pollution in accordance with the CPCB's year wise analysis of the polluting units and strict compliance due to stringent environmental regulations. The estimated pollutant load, in terms of BOD, from the untreated wastewater from the domestic sector (urban and rural areas) and industrial sector under the base case is presented in Figure 2. These estimations assume domestic wastewater collection and treatment efficiencies of

70% and 40% respectively for 2025 as against current efficiency levels of 60% and 30% respectively.

Annual discharge of the order of 6.58 million tonnes from the domestic sector, as projected is beyond the self-cleansing capacity of the water bodies, rendering them unfit for several beneficial uses.



Solid waste management

Municipal solid waste

The growth in MSW (municipal solid waste) generation in India has outpaced the growth in population in the recent years. The daily per capita generation of municipal solid waste in India ranges from about 100 g in small towns to 500 g in large towns. The recyclable content of waste ranges from 13% to 20% (CPCB 1994/95). The survey conducted by CPCB puts total municipal waste generation from Class I and II cities to around 18 million tonnes in 1997 (CPCB 2000b). The reason for this escalating trend is a mix of the changing lifestyles, food habits and changes in standard of living.

The TERI 'Green India 2047' study made the following observations on the situation of municipal solid waste management in the country (TERI 1998):

- Increasing urbanisation and changing lifestyles has led to, the solid waste generated in Indian cities having increased from 6 million tonnes in 1947 to 47.8million tonnes in 1997.
- The production and consumption of plastic increased over 70 times between 1960 and 1995.
- The collection of municipal solid waste is inefficient (more than 25% of the total is not collected at all), its transport is inadequate, and its disposal is unscientific.
- More than one-fourth of the municipal solid waste is not collected at all, and the landfills to dispose of the waste are neither well equipped nor managed efficiently.

The characteristics of MSW collected from any area depends on a number of factors such as food habits, cultural traditions of inhabitants, lifestyles, climate, etc. Table 7 below presents the changes in the characteristics of waste in past two decades. It clearly indicates the increasing share of plastics in the MSW which is likely to persist in future. The changes in the relative shares of different constituents of waste in the past several decades, as shown by the data, can be attributed largely to changing lifestyles and increasing consumerism.

Table 7 Physico-chemical characteristics of MSW

Component	*% of wet weight* *1971-73†* *(40 cities)*	*1995‡* *(23 cities)*
Paper	4.14	5.78
Plastics	0.69	3.90
Metals	0.50	1.90
Glass	0.40	2.10
Rags	3.83	3.50
Ash and fine earth	49.20	40.30
Total compostable matter	41.24	41.80
Calorific value (kcal/kg)	800-1100	<1500
Carbon-nitrogen ratio	20-30	25-40

Source. † Bhide and Sundaresan 1983, ‡ EPTRI 1995

Disposal of waste is a major issue of concern in India. Respective municipalities collect MSW in cities and transport it to the designated disposal sites, which is normally a low-lying area on the outskirts of a city. The choice of a disposal site is more a matter of what is available than what is suitable. Only a few cities follow good practices such as organized dumping of wastes, using mechanized equipment for leveling and compacting the wastes, and covering the top layer with earth before compacting it further. Of late, some cities have also started to practice composting the organic fraction of waste.

Management of biomedical waste is another issue of concern for municipalities. This waste produced in hospitals generally has high contamination of pathogens, making it hazardous. It also includes scalpels, needles, bandages, and other wastes from operating theatres and laboratories as well as infectious items, e.g. amputated body-parts, body fluids, cultures of contagious viruses, excreta from patients with highly contagious diseases, etc. Though waste from hospitals and nursing homes are required to be collected and treated separately, in most cities and towns such waste continues to form a part of the MSW in absence of any dedicated disposal facilities for hospital waste. The MoEF, Government of India has issued the Municipal Solid Wastes (management and handling) Rules in the year 2000, which identify the CPCB (Central Pollution Control Board) as the agency to monitor the implementation of these rules. For the management of bio-medical waste, the MoEF has notified Bio-Medical Waste (management and handling) Rules in 1998 under sections 6, 8 and 25 of the Environment (Protection) Act of 1986.

Industrial solid waste

Industries can be broadly classified into those that produce non-hazardous waste and those that produce hazardous waste. Non-hazardous waste can be either biodegradable or non-biodegradable. The major industries in urban areas that generate substantial amounts of biodegradable solid waste are fruit processing, cotton mills, paper mills, sugar mills, and textile factories. The major generators of non-biodegradable industrial solid waste are thermal power plants producing coal ash, integrated iron and steel mills producing blast furnace slag and steel melting slag, such non-ferrous industries as aluminum, zinc, and copper, which produce red mud and tailings, and fertilizer and allied industries which produce gypsum.

Some of the wastes generated by industries are deemed to be hazardous wastes because they contain substances that are toxic to plants and animals or are flammable, corrosive, explosive or highly reactive, chemically. Box 2 lists the categories of hazardous waste as specified under the Hazardous Wastes (management and handling) Rules.

Box 2	Types of hazardous waste
Waste Category Nos	**Types of waste**
No. 1	Cyanide waste
No. 2	Metal finishing, waste
No. 3	Waste containing water soluble chemical compounds of lead, copper, zinc, chromium, nickel, selenium, barium, and antimony
No. 4	Mercury, Arsenic, Thallium and Cadmium-bearing wastes
No. 5	Non-halogenated hydrocarbons including solvents
No. 6	Halogenated hydrocarbons including solvents
No. 7	Waste from paints, pigments , glue, varnish and printing imk
No. 8	Wastes from dyes and dye-intermediates containing inorganic chemical compounds
No. 9	Wastes from dyes and dye-intermediates containing organic chemical compounds
No. 10	Waste oil and oil emulsions
No. 11	Tarry wastes from refining and tar residues from distillation or pyrolytic treatment
No. 12	Sludge arising from treatment of wastewaters containing heavy metals, toxic organics, oils emulsion and spent chemicals and incineration ash
No. 13	Phenols
No. 14	Asbestos
No. 15	Wastes from manufacturing of pesticides and herbicides and residues from pesticides and herbicides formulation units
No. 16	Acids/ alkalies / slurry
No. 17	Off-specification and discarded products
No. 18	Discarded containers and container-liners of hazardous and toxic waste

Source CPCB 1998

The major industries that produce hazardous wastes include metals, chemicals, drugs and pharmaceuticals, leather, pulp and paper, electroplating, refining, pesticides, dyes, rubber goods and so on. In total, at present around 7.2 million tonnes of hazardous waste is generated in the country of which 1.4 million metric tonnes is recyclable, 0.1 million metric tonnes is incinerable and 5.2 million metric tonnes are destined for disposal on land (MoEF 2000). Improper storage, handling, transportation, treatment and disposal of hazardous waste has an adverse impact on ecosystems including the human environment. When discharged on land, heavy metals and certain organic compounds are phytotoxic and can adversely affect soil productivity for extended period of times at relatively low levels of concentration. For example, uncontrolled release of chromium contaminated wastewater and sludge resulted in contamination of aquifers in the North Arcot area in Tamil Nadu. These aquifers can no longer be used as sources of freshwater. Box 3 highlights a case study on the adverse impact of hazardous wastes in Maharashtra.

Box 3 Case Study from Maharashtra illustrating adverse impact of hazardous wastes

The Thane-Belapur industrial area, in Maharashtra where about 1200 industrial units are housed on a 20 km stretch close to New Mumbai produces more than 100 tonnes of solid waste every day. About 85% of this waste is either acidic or alkaline in nature. The area also produces 5 tonnes of waste every day, which is difficult to treat because of its halogen content. The bulk of hazardous waste in this area is co-disposed with municipal waste in municipal waste dumpsites. The water bodies in the vicinity of this industrial area are polluted. The sediment in the Ulhas river has registered high levels of mercury and arsenic. The river empties into the Thane Creek at its northern end. As a result, the Thane Creek is one of the most polluted parts of the sea in the country.

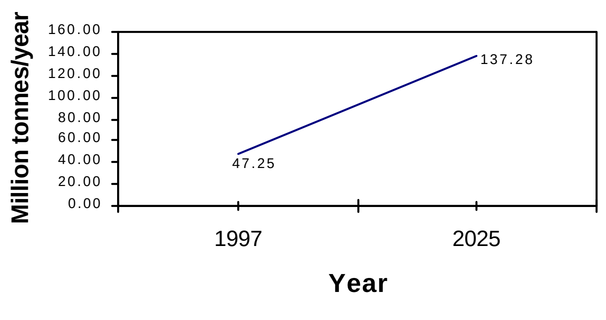
Source (Shankar, Martin, Bhatt and Erkman 1994)

Reliable data on the quantity of solid wastes generated by small-scale industries are scarce as these industries have mushroomed widely; it is however assumed that they generate as much industrial waste as that generated by medium- and large-sized industries.

Projections related to Municipal solid waste — BAU scenario

Waste generation trends. The per capita quantity of waste generation tends to increase with time due to factors as increased commercial activities and higher standard of living. In India, the amount of waste generated per capita is estimated to increase at a rate of 1%–1.33% annually (Shekdar 1999). The projected quantities of municipal solid waste for 2025 have been estimated and the scenario under the base case appears that the total waste generation in 2025 will exceed 137 million tonnes (Figure 3).

Figure 3 Municipal solid waste generation in cities

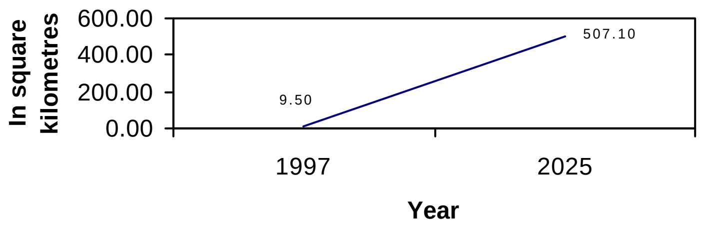


On account of the expected increase in waste generation as discussed above, the number of technical difficulties in treating and disposing this waste scientifically will continue to increase. The impact of the generation of such quantities of municipal solid waste can be analysed under two important parameters — land requirement for disposal of waste, and the amount of methane emissions generated from the landfill sites.

Land requirement. It has been estimated that the cumulative requirement of land for disposal of municipal solid waste in the base year 1997 is nearly 9.5 square kilometres, which will increase to about 507 square kilometres by 2025 (Figure 4).
These land requirement estimates for the base case have been calculated based on the following assumptions.

- The waste collection efficiency on an average is assumed to be 72.5% over the years.
- The average depth of landfill site 4 meters .
- The average waste density is 0.9 tonne per cubic metre (NIUA 1989).

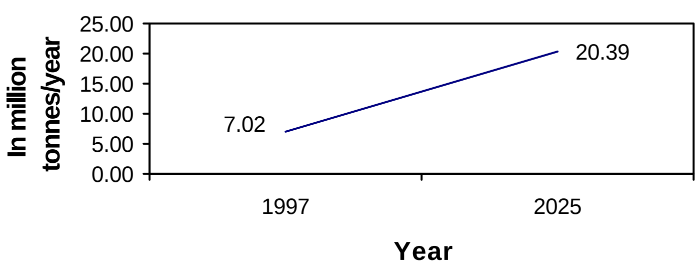
Fig 4: Cumulative land requirement for solid waste disposal (BAU)



Methane emissions. The landfill gas, which is about 50% to 60% methane, contributes significantly to global warming. It is estimated that, in 1997, about 7 million tonnes of methane was released into the atmosphere and this will increase to about 20 million tonnes by 2025 under the base case (figure 5).

The emissions of methane gas from landfills have been calculated using the Bingemer and Crutzen's [1987] approach, which assumes that 50% of the carbon emissions in the landfills is transformed into methane.

Fig 5: Methane emissions (BAU)



Land degradation

The steady growth of human as well as livestock population, the widespread incidence of poverty, and the current phase of economic and trade liberalisation, are exerting heavy pressures on India's limited land resources for competing uses in forestry, agriculture, pastures, human settlements and industries leading to very significant land degradation. According to the latest estimates (Sehgal and Abrol 1994), about 187.8 mha (57%

approximately) out of 328.73 mha of land area has been degraded in one way or the other. It appears therefore, that most of our land is either degraded, is undergoing degradation or runs the risk of being degraded. Among the different land categories, land under cultivation faces the biggest problem followed by grazing land and pastures, forests, barren lands, and uncultivable land in decreasing order.

Unstable use and inappropriate management practices in India have made the land suffer from varying degrees and types of degradation. Main reasons for the loss of vegetation are deforestation, cutting beyond the silviculturally permissible limit, unsustainable fuelwood and fodder extraction, shifting cultivation, encroachment into forest lands, forest fires and overgrazing. Other important factors responsible for the large-scale degradation are the extension of cultivation to land of low potential or in high risk of natural hazards, non-adoption of adequate soil conservation measures, improper crop rotation, indiscriminate use of agro-chemicals such as fertilisers and pesticides, improper planning and management of irrigation systems and extraction of ground water in excess of the recharge capacity.

Land degradation manifests itself chiefly in the form of water erosion, followed by wind erosion, biophysical, and chemical deterioration. Deforestation is both a type of degradation by itself, and a cause for other types of degradation, principally, water erosion. Till 1980, India's forest cover was being lost at the rate of 144,000 hectares per year (TERI 1998). Although it slowed down to 24 533 hectares per annum between 1980 and 1995, reversing the trend and halting the process of degradation continues to remain a major policy issue. Widespread deforestation in the catchment area of the Himalayas is leading to environmental backlash in the form of flooding and droughts, soil erosion, sedimentation and siltation in the flood plains of the Ganga and the Brahmaputra among other major rivers. Desertification, a potential and severe consequence of deforestation in arid, semi-arid, and dry sub-humid regions, can have untold ecological and social repercussions. Of the total area of around 328.7 million hectares, the extent of area under the threat of desertification in India is about 83.6 million hectares.

Even at the Earth Summit in Rio in 1992, issues related to deforestation were a major concern. The Agenda 21 declaration of the UNCED (United Nations Conference on Environment and Development) stated: 'Deforestation is a result of many causes; some natural, but mainly due to human development, such as inappropriate land tenure systems and incentives, expansion of agricultural areas, increasing forest product demand, and lack of information about and understanding of the value of forests' (UNCED 1992).

Biodiversity loss

India is one of twelve megadiversity countries of the world. The innumerable life forms harboured by the forests, deserts, mountains, other land, air and oceans provide food, fodder, fuel, medicine, textiles etc. Occupying only 2.4% of the world's land area, India's contribution to the world's biodiversity is approximately 8% of the total number of species (Khoshoo 1996), which is estimated to be 1.75 million (as per Global Biodiversity Assessment of UNEP of 1995). The potential of innumerable species across the country is yet unknown. It would therefore be prudent to not only conserve the species we already have information about, but also species we have not yet identified and described from an economic point of view. Taxus baccata, a tree found in the Sub-Himalayan regions, once believed to be of no value is now considered to be effective in the treatment of certain types of cancer. Among the 18 hot spots identified for biodiversity in the world, two are located in India – in the Eastern Himalayas and the Western Ghats.

Overexploitation of natural resources, habitat destruction and pollution are the major causes for the loss in rich biodiversity of the country. It is now estimated that of the 1,500 species of plants that are listed as threatened, 33 have gone extinct, 157 are endangered, 114 are vulnerable and 246 are rare (Nayar and Shastry 1988, 1989 and 1990). Nearly 23 animal species, including the Cheetah, are known to have become extinct and many more could have vanished (WCMC 1992, Khoshoo 1996). It is also estimated that among the animal species, 91 mammal species, 21 amphibian and reptile species, and 40 birds species are reported to be endangered (Mukherjee 1994).

While it is easy to delineate the proximate reasons of biodiversity loss, the underlying causes for these unsustainable patterns of resource degradation are multiple and complex and are closely linked with institutional, governance, economic, policy and technological failures. Markets also fail to capture the true value of biodiversity and thus incentives for its conservation are reduced.

Strategies and future directions

Strategies for improving air quality

Despite of the current initiatives taken by the government and the concerned agencies, air pollution remains a major concern in most of the urban centres of the country. Besides continuing and consolidating the ongoing schemes/ programmes, new initiatives and definite strategies need to be developed and implemented for the betterment of urban air quality.

Vehicles contribute significantly to the total air pollution load in most of the urban areas therefore the sector deserves a high primacy in decision making. Pollution loads from transportation sector can be controlled mainly by controlling the number of vehicles on road and controlling the per unit emissions. The measures outlined below are imperative as well.

- Stringent implementation of regulations and providing incentives that will help in a shift from a greater reliance on private vehicles, to public transport system. The public transport system needs to be augmented to support such shift.
- Significant efforts should be there towards traffic planning and management in order to reduce congestion and streamline the movement on roads. Construction of express highways linking major urban areas needs to be given due priority.
- Mass Rapid Transport Systems could be considered for the fast expanding and major urban areas in the country.
- Euro I norms have been in place with effect from 1 April 2000 and Euro II norms will be applicable all over India from 1 April 2005. In case of the NCR (National Capital Region), the Euro I and Euro II norms were brought forward on 1 June 1999 and 1 April 2000 respectively (CPCB 1999, SIAM 1999). Further tightening of the emission norms and their strict enforcement has to be ensured along with better fuel quality specifications.
- Use of alternative fuels such as CNG/ULSD (Ultra low sulphur diesel)/ LPG/Propane/ EV (electric vehicles) should be highly encouraged. The government needs to focus on studying the feasibility of different fuels, working on the mix of options for fuel use that meets stringent vehicular emissions criteria as specified by the regulatory bodies and the expansion of infrastructure to dispense these alternative fuels.
- Replacement of two-stroke engines.
- Strengthening of the I&M (inspection and maintenance) system, comprising inspection, maintenance, and certification of vehicles, is crucial for regulating pollution for the large number of vehicles in-use.

Additionally for the seventeen categories of large and medium scale industries and the large number of small-scale industries, the following may be viewed as necessary.

- Developing and promoting cleaner technologies with specific focus on waste minimisation and utilization technologies involving process changes, raw material substitution and improved housekeeping.

- Developing solutions appropriate for the level of operations in small-scale industries having neither the technological backing nor the financial resources for effective implementation. Thrust has to be on the development of appropriate pollution control devices applicable in the existing conditions, in small and medium enterprises.
- Having databases on available technologies, their performance, sources and investments required, etc. Such databases need to be created, updated regularly, and widely disseminated.
- Strengthening the emission standards for various categories of industries and motivating a shift from pollution control to pollution prevention strategies.
- Locating high pollution potential industries/projects after considering the carrying capacity and the local environmental conditions of the region.
- To reduce air pollution loads from the power sector, clean technology options e.g. clean coal technologies, need to be adopted at the process stage alongwith putting in place the end-of-the-pipe options. Important strategy will be to shift to cleaner gaseous fuels.
- Additionally electricity pricing is an important policy in the long run to encourage demand-side management options as using more efficient energy appliances to reduce power consumption.

Besides strategies need to be developed to reduce the indoor air pollution by the use of improved smokeless stoves, better ventilation and increased access to clean fuels. Improved ventilation and improved biomass stoves are likely to be the most cost-effective options for short and mid term. But in the long term the option is to move up in the energy ladder from solid fuels to liquid and gaseous fuels for cooking. Kerosene, LPG, electricity, and solar energy are the potential and ideal options for long-term considerations.

Alternative scenario – air quality

Table 8 highlights the likely aggregate SPM emission projections under an alternative scenario marked with better fuels, efficient pollution control systems, greater transparency and with better institutions in place would assist in better performance as compared to the projected BAU scenario.

Table 8 Projected SPM emission from all sectors (million tonnes)
Business As Usual (BAU) vs Alternative scenario(Alt)

Year	*Domestic*	*Transport*	*Manufacturing*	*Power*	*Total*
1997	1	0.03	0.98	11.92	13.93
2025BAU	0.65	0.12	2.23	5.27	8.27
CAGR	-1.54%	5.12%	2.98%	-2.87%	-1.85%
2025Alt	0.435	0.057	1.931	0.211	2.634
CAGR	-2.93%	2.35%	2.45%	-13.42%	-5.77%

Strategies for water resource management and controlling water pollution

Water resource management

- The current approach to water-related matters restricts the issue only to political boundaries, involving number of agencies with overlapping responsibilities. This needs to shift to a river basin or sub-basin based approach for water management.
- The need is to develop surface irrigation sources and undertake measures for rainwater harvesting. Building appropriate water harvesting structures in the lower reaches to trap the run-off water is also desired to increase the overall resource availability.

- Efforts need to be intensified towards the conservation of water. Awareness generation towards recycling and reuse and developing cost-effective and efficient water appliances, would help in maintaining water as a valuable resource.
- Policy-level reforms need to be introduced in the current structure of subsidy and pricing of the rural electricity and agricultural water supply that encourages wasteful use of water.
- Promotion of traditional modes of irrigation and implementing the watershed approach will further enhance conservation and better management of water resources.
- Private sector participation at different stages of water supply, as well as better water pricing mechanisms ensure economic viability of operations. These would be beneficial in the efficient supply and usage of water in the domestic sector.
- To enhance the conservation and efficient utilisation of water in the industrial sector it is necessary to take a fresh look at the current shortcomings in the existing command and control regime, and motivate industries for voluntary initiatives like adopting tools for performance benchmarking, ISO 14000 standards and environmental rating.

Water pollution control

- To reduce the level of water pollution from the domestic sector it is essential to augment the existing waste water collection and treatment facilities and promote the implementation of decentralized waste water treatment plants. Possibilities of private sector participation, in different stages of wastewater collection and treatment, also need to be explored and implemented.
- Development and adoption of clean technologies especially for small-scale industries through appropriate economic instruments will help reduce the pollution loads from industrial sector.
- Innovative technological interventions are required for industries to undertake recycling and reuse of effluent water.
- Institutional mechanisms to address pollution in the agricultural sector need to be formulated.
- Use of bio-fertilizers needs to be encouraged and research activities in biotechnological pest control should be supported, to avoid pesticide-based pollution of water bodies.

Alternative scenario – water resources and pollution loads

Sectoral strategies for water with rational pricing structures, wiser resource utilization and better operational systems to collect wastewater and subsequent effective treatment thereafter, to check further resource degradation, would improve the existing scenario. The projected demand would go down by about 18% and with better tapping of the rain water resources, the gap between demand and supply would narrow, with a sustainable end insight. Table 9 projects the water demand levels and pollutant loads under the alternative scenario.

Table 9 Projected total water demand (billion cubic metres) and projected pollution levels (million tonnes of BoD) Business As Usual (BAU) vs Alternative scenario(Alt)

Year	*Irrigation*	*Domestic*	*Manufacturing*	*Power*	*Total*	*BOD load domestic*	*BOD load industrial*
1997 (BCM)	528.85	23.52	1.6	1.39	555.36	3.75	0.406
2025 BAU	789.50	39.76	4.79	3.75	837.80	6.58	0.007
CARG-BAU (%)	1.441	1.893	3.998	3.606	1.478	2.026	-13.670
2025 (BCM) Alt.	641.98	37.26	4.19	2.01	685.44	5.22	0.005
CARG-Alt. (%)	0.695	1.656	3.499	1.333	0.752	1.186	-14.481

Strategies for solid waste management

Managing municipal solid waste

Existing municipal solid waste management system needs to follow the following strategies for efficient management in the future.

- Targeting waste reduction- to reduce waste generation at source by introducing attractive tax incentives for market mechanisms that would minimise levels at source, making mandatory standards and regulation more effective, and promoting voluntary initiatives by business and consumers.
- Technological interventions in two particular functions need urgent consideration –in collection and in treatment and disposal of waste.
  1. *Collection of waste.* Increasing the coverage and efficiency of collection mechanism would help in better management and in reducing the formation of unhygienic and open dumpsites. Segregation of waste into biodegradable and non-biodegradable components is also required at source or at primary collection centers.
  2. *Treatment and disposal.* On the basis of availability of land and financial resources with the service provider, either of the methods — aerobic composting, anaerobic digestion or sanitary landfilling could be adopted for treatment and disposal of waste. However, since it appears that landfilling would continue to be the most widely adopted practice in India in the coming few years, in which case certain improvements need to be done to ensure sanitary landfilling and not mere dumping of waste.

- Institutional and regulatory reforms
  1. Strengthening urban local bodies to perform efficiently in managing the waste and ensuring strict enforcement of the recently introduced municipal solid waste (management and handling) rules.
  2. It is also imperative to harness and integrate the role of three emerging actors in this field — the private sector, NGOs, and ragpickers — into the overall institutional framework.

Managing the industrial waste

To ensure scientific management of hazardous waste generated in the country, the strategy should encompass all the aspects of waste management cycle starting from the generation of waste to its handling, segregation, transportation, treatment and disposal, in addition to a primary focus on waste minimisation/reduction.

- Efforts are required to quantify and characterise the volume of waste residues generated by industries and constantly upgrade this waste inventory so that appropriate management strategies could be incorporated in waste management plans.
- In light of the newly amended hazardous waste rules introduced in India in January 2000, it is important to focus capacity building and training of the officials of the SPCB (State Pollution Control Boards) and critical industrial sectors generating hazardous waste. The focus of this learning exposure should be to address responsibilities related to handling, storage, transportation, treatment and disposal of hazardous waste.
- It is required to set up standards not only for disposal of waste on land but also for cleanup of contaminated soils and groundwater,
- Apart from some dedicated facilities at large chemical plants, India lacks the infrastructure required for the proper treatment and disposal of hazardous waste. To set up such a facility at the state level, issues like the willingness to pay of the participating

industries, the type of ownership, financial mechanisms for such ventures and the extent of private sector participation need to be addressed/explored to ensure that they come into existence.

Alternative scenario for solid waste management

Arising from the implementation of the proposed strategies, it is estimated that there will be a reduction of around 28 square kilometres of land requirements for solid waste disposal and the methane emissions would also reduce by about 1.6 million tonnes per year under the alternative case scenario as compared to the baseline scenario. In this projected alternative scenario, it is being assumed that the collection efficiency would be increased to 90% by 2025 and simultaneously through an efficient recycling system, an average of about 13% to 15% of the municipal waste could be separated and sent to the recycling units, thereby reducing loads on the landfills.

Table 10 Projected cumulative land requirement and methane emissions

Business As Usual (BAU) vs Alternative scenario(Alt)

Year	*Land requirements (sq. km)*	*Methane emissions (mt/year)*
1997	9.52	7.02
2025 BAU	507.10	20.39
2025 Alt	479.71	18.74

Strategies for land degradation

In India, so far land management has been largely unsystematic, arbitrary and by no means, sustainable. In order to reduce the degree of land degradation and for the country to move on the path of sustainable development the following strategies could be considered.

- A well-defined, integrated land use policy should be developed and implemented at the earliest.
- As the two resources, land and water are absolutely inter-dependent, therefore land management in conjunction with water management, should be the core of any agenda for national development. The approach should be developed to manage the land on a natural watershed basis, as it presents an ideal unit for the most effective management, and the rational utilisation of land and water resources, for optimum production with minimum hazard to the resources.
- IPNS integrated plant nutrient system (IPNS) has to be adopted to improve fertiliser use efficiency and reduce the potential danger of pollution from higher nutrient use in agriculture. A systematic monitoring mechanism needs to be developed, to assess the balance between input and withdrawal of nutrients, to guard against possible nutrient depletion (Sarkar et al. 1991).
- Domestic and municipal wastes, sludges, pesticides, industrial wastes, etc. need to be used with utmost caution, to avoid the possibility of soil pollution by heavy metals and other toxic substances, which are often present in them.
- An increase in industrialisation, urbanisation, mining and infrastructure development is taking away considerable areas of land from agriculture, forestry, grassland, pasture, etc. resulting in environmental disturbances. An AEQM (area-wide environment quality management) approach needs to be adopted to harmonise such development activities and make them compatible with surrounding land use and guard against any form of land degradation,

- Education, training, research, and technology development enable to analysing and adapting conditions and principles, for sustainable land use as well as resource conservation technologies and practices. Research institutes and NGO's need to develop ways of working closely with land users and communities.

Strategies for Biodiversity

- The existing laws related to biodiversity shall be examined in order to bring them in tune with the provisions of the convention to reflect the current understanding of biodiversity conservation.
- There is a need for the existence of a biodiversity cell in all development departments impinging on land and water. Efforts should also be made to integrate conservation with development.
- Policies need to be formulated for the protection of wetlands, grasslands, sacred groves, marine flora and fauna and other areas of significance from the point of view of biodiversity.
- There should be a continuous monitoring of biodiversity, used to review the results of policies and programmes. Documentation of biodiversity is an important issue, which requires attention.
- Incentives and disincentives for improper use of biodiversity should be introduced.
- Allocation of financial resources for biodiversity conservation should also be increased.
- There is need to focus on improved forest management through plantation forestry and joint forest management programme with community and private sector participation. There is also a vast scope for expanding agroforestry and farm forestry on agricultural lands by planting trees along farm boundaries in a manner that does not affect crop production adversely. It is also important to have technological advancement to increase forest productivity.
- It is important to generate maps of the protected areas of the country showing their contiguity with the existing reserved and protected forests.
- Involvement of local communities who influence conservation, management, and utilisation of biodiversity should be enhanced along with involvement of private sector.

Policies toward successful environmental management

Over and above the sectoral strategies, the immense challenges of environmental problems also require a variety of other actions, at different levels that will enable sustainable management of both the natural and environmental resources.

- Trade and environment
- Environmental governance
- Economic policy instruments for conserving environment
- Enhancing corporate environmental responsibility**.**

Trade and environment

The linkages between trade and environment are very significant. The 1992 Rio Earth Summit endorsed the view of an open multilateral trading system aiming at an efficient allocation and utilisation of the resources. The global rules of trade between nations are governed by the WTO (World Trade Organization) whose main function is to ensure that trade flows as smoothly, predictably and freely as possible. The WTO, the youngest international organization established on 1st January 1995, is the successor to the GATT (General Agreement on Tariffs and Trade). Of the 142 countries represented at the WTO, developing or least-developed countries have a representation of over 75% and enjoy some

special provisions. These relate to longer time periods for implementing agreements and commitments, as well as provisions that require all WTO members to safeguard the trade interests of developing countries, and support developing countries in building infrastructure for WTO work, handle disputes, and implement technical standards. However, developing countries are very much concerned about various issues related to the WTO. These include intellectual property rights, agriculture, technology, environment, and labour issues. It is argued that developed countries use environmental resulations as non-tariff barriers against developing country exports entering their markets.
The CTE (Committee on Trade and Environment) in the WTO is responsible for addressing various issues related to trade and the environment.

Trade and environment policies can affect each other in terms of

- product effects, related to the commercial exchange of goods and services,
- scale effects, related to expansion of markets and economic activity and
- structural effects related to the distribution and intensity of production and consumption.

An inadequate knowledge on the linkages between trade and the environment and the inapt policy approaches, may lead to tensions between trading nations under the banner of 'green protectionism'. Disparate lines of thinking already divide the developed and the developing countries, on such linkages. Developed countries are of the view that maintaining less stringent environmental compliance standards is equivalent to some sort of subsidy on products and hence needs to be counterbalanced by duties, taxes etc. On the other hand, developing countries argue in favour of less stringent environmental standards as compared to the standards prevalent in developed countries and instead have those in tune with the standards prevalent in countries at a similar stage of developed.

The general fear among emerging economies including India is that many of their export commodities may face non tariff barriers to international markets in the form of stringent environmental standards and other requirements like eco-labels on manufactured products; harmonisation of the environmental standards, requirements for packaging, and border tax adjustment for environmental levies and charges. Meeting such standards with the available financial and technological resources is a daunting task. Further the migration of inferior technologies and polluting industries, may pose health hazards to natives in developing countries.

India is heavily dependent on the world's three major markets, viz the USA, the EU and Japan for both exports and imports. Exporters face access problems in these major markets due to stringent environmental standards, packaging and regulations like use of certain chemicals and pesticides, increased safeguard measures and eco-labelling requirements. For instance, about 75% of the Indian exports to Germany are subject to various environmental measures. The environmentally sensitive sectors of concern to India include leather, marine and textiles. Importantly, these sectors are found to be India's vibrant export oriented sectors with a share of about 43% of total exports in 1996-97. Other sectors likely to be affected include chemicals, tea and agricultural products.

Leather industry India is expected to play a dominant role in the leather industry with the largest holding of livestock. With over 75% of the total production by SMEs (small and medium enterprises), the Indian industry faces major challenges due to the new environmental requirements and the use of certain chemical dyes. Germany has already banned all imported leather products containing PCP (Pentachlorophenol), which is suspected carcinogen. Similarly some of the EU countries have imposed strictness on importers to return/ recycle the packaging material and also desire eco-labels-on all leather products. Challenges are therefore posed for the Indian leather industry because of the lack of financial resources, readily available eco-friendly production technologies and economical substitutes for PCP and benzidine dyes.

Textiles and textile garments Textile exports earn substantial net foreign exchange for India, as the import content of this industry is very little. A major part of these exports come from SMEs which amount to about 63% of the total exports from the textile sector. 40% of the exports are directed to the European Union. However, internationally demand is now increasing for eco-friendly textiles resulting in structures on the type of chemicals and dyes used in India. In 1993, Germany's textile industry introduced the eco-labels —Markenzeichen Schastoffgeprufth Textilien and Markenzeichen Unweltschonende Textilien, setting norms for the content of pollutants in the product and for the production processes, respectively. Pressures are therefore building up on the Indian textile industry to supply guaranteed pesticide free cotton, use substitutes for the hazardous chemicals, and engage in better practices for packaging.

Marine products Marine products are considered to be the most environmentally sensitive in the international markets. The nature of exported products has itself changed, from dried items in the 1960s, to processed and canned items till 1980s, and frozen items from the mid-1980s. Issues of concern for developing countries include — over the use of chemicals in aquacultural practices; pesticides and antibiotics and food safety standards requiring stringent quality control during handling, processing and storage of marine products. International standards like HACCP by USFDA, ISO 9000 and EC directive (EC 91/943) demand very high hygenic standards in production and processing facilities.

India has always been committed towards environmental protection and sustainable development. In fact, the very ethos of India's culture and history have been to respect and worship nature. The multilateral trading system being designed to deal with trade issues exclusively, the nation should strongly check attempts to legitimize any trade restricting measure, based on environmental issues. India is against the introduction of non-trade related issues into the WTO framework. The nation is more concerned about implementation issues and how to deal with already mandated negotiations. In fact the steps taken in the direction of trade liberalization should ensure rewards in the form of larger markets and greater trade-flows for all, rather than encouraging efforts in protectionism. Meanwhile, the country should also gear up to attain higher environmental standards and adopt practices like eco-labelling, better packaging and eliminating subsidies that have detrimental effects on the environment. This helps in attaining greater process efficiencies and in meeting international challenges and market requirements, in a competent manner.

Environmental governance

To mainstream the environment, it is necessary to use the natural resources rationally. This would require improving the environmental governance, by integrating green considerations into the development process and reducing the government's monopoly over the control of natural resources, to ensure better public participation. Also, systems of governance need to be decentralised and the states and local bodies be given greater authority and responsibility, with measures that assure accountability, transparency, and efficiency. This would require mainstreaming of the environment in the process of policy making and ensuring greater community participation.

The current structure of property rights leads to conditions of open access, whereby a resource is subject to exploitation and depletion or to capture by a powerful elite. Redefining property rights, strengthening the legal framework and restructuring the bureaucracy to achieve more effective governance, is therefore desired. Besides decentralisation, empowering communities with decision-making tools and allowing them full control of their own resource base is needed, to ensure a sustainable use of natural resources and the conservation of biodiversity.

Economic policy instruments for conserving the environment

The planning strategy has had important implications for the quality, and sustainability of the environmental and the natural resource base, as these constitute important inputs into production or function as a recipient of wastes. Therefore, policy prescriptions that promote an environment friendly economic growth as discussed below need to be looked into.

Greening the budgets Addressing measures in the budget for environmental management is an effective way to deal with environmental concerns. Since the government's annual budget and its estimates of proposed expenditure are important statements of environment policy, the budget can discourage environmentally detrimental activities or encourage environmentally beneficial activities. A green budget would require a balanced approach using different instruments like subsidies, grants and revenue generating instruments.

Natural resource accounting Increasing pressure of human activity has led to exceeding the natural thresholds of regeneration capacity, thus leading to a decrease in the environmental quality and unsustainable growth patterns which ultimately increase the burden for future generations. Tracking down the degradation of environment quality and reflecting it in projected economic growth, is essential to reflect the true environmentally-adjusted growth rate of country. Such an accounting framework would thus assist in identifying strategies of sustainable development that balance the satisfaction of human needs, with the long-term maintenance of environmental functions.

Market-based instruments for green choices Market-based instruments can be defined as 'regulations that encourage behaviour through market signals rather than through explicit directions'. Policy makers can use a variety of market-based instruments to encourage green choices by consumers and producers like

- reducing environmentally harmful subsidies on electricity and water supply.
- introducing pollution charges like fees or taxes on the amount of pollution that a firm or source generates, and
- markets can be set up or encouraged to emerge so that the costs of pollution are minimised, and resources are allocated across different sectors.

Enhancing corporate environmental responsibility

With growing public awareness and activism, regulatory pressures, resource shortages, increase in international pressures and opportunities, and a surge in expectations for greater transparency and accountability, the industry has to realise that greater environmental responsibility does not necessarily imply, lower profits. Tools such as EIA (Environmental Impact Assessment), LCA (Life Cycle Assessment), performance evaluation and monitoring systems, systems for institutionalising environmental management, environmental accounting techniques, and reporting and disclosure systems need to be developed, possibly through industry associations. Such measures aim to bring about a shift toward better operating systems, specifically the technologies in use. For a developing country like India, the next 10–15 years offer an unparalleled opportunity to change the technology base to a cleaner and more resource-efficient one.

Conclusions

Sustainable development has posed a challenge to identify meaningful strategies and workable action-plans, the world over. While efforts till date have succeeded in improving income levels, much remains to be done to substantially improve the quality of life, for the majority of our population. Clearly, the environmental challenges imposed by the economics of growth are going to multiply in magnitude and complexity—more people are going to share dwindling quantities of water, more vehicles are going to emit pollutants, and there is going to be less land available for competing uses.

This exercise to *assess the futurity* of present decisions and to look forward to the long term consequences of present actions, has helped to identify the option-generating and option-foreclosing actions that we must undertake now. For sustainable human development to occur, considerable changes are required in the industrial and agricultural patterns, utility services, consumer attitudes, and lifestyles of people, keeping in view our social and developmental priorities. Better environmental governance, by clarifying property rights and strengthening the legal framework, will promote better environmental management. The corporate sector's potential to undertake the stewardship of the environment to match its role in the economy needs to be explored. Market-based instruments could help reduce the cost of environmental protection, stimulate environmentally friendly technological change and also become drivers for changes in market based mechanisms. Improved technologies can reduce the pressure on resources while keeping the economy going.

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