



सत्यमेव जयते

# State Of Environment Report



*India*  
2009



जहाँ है हरियाली ।  
वहाँ है खुशहाली ॥

**Ministry of Environment & Forests  
Government of India**

# *State of Environment Report India-2009*

Environmental Information System (ENVIS)  
**Ministry of Environment & Forests**  
**Government of India**  
<http://www.moef.gov.in>, <http://envfor.nic.in>





जयराम रमेश  
JAIRAM RAMESH



राज्य मंत्री (स्वतंत्र प्रभार)  
पर्यावरण एवं वन  
भारत सरकार  
वई दिल्ली-110003  
MINISTER OF STATE (INDEPENDENT CHARGE)  
ENVIRONMENT & FORESTS  
GOVERNMENT OF INDIA  
NEW DELHI - 110 003

20<sup>th</sup> July 2009

## FOREWORD

It gives me great pleasure to introduce this year's edition of the 'State of Environment Report India 2009'. This year has been of particular significance and has seen the phenomenon of climate change come home to India. Not just in terms of effect but in terms of greater awareness and consciousness amongst our citizens. In numerous times in the past our country has been called upon repeatedly to balance economic growth with environmentally sustainable practices, to temper growth with environmental equity, sustainability and social justice. It is in this year that we have answered that call with conclusive steps forward.

It is also in this year that GDP has acquired the alternative and equally meaningful connotation of 'Green' Domestic Product. This exemplifies the need to infuse greater sensitivity towards the environment in our collective conscience. It is vital to maintain a healthy balance between rapid development while conserving our rich bio-diversity and natural resources.

The State of Environment Report works towards providing data on the country's environmental status that is comprehensive and available easily in one compendium. I congratulate all those who were involved in this assignment. I am glad that *Development Alternatives* have participated as equal partners in the production of this national report. I am confident that this report will serve as a useful tool and will find favour as being informative and user friendly by planners, policy makers, academicians, non-governmental organizations, civil society groups and all those interested in becoming more familiar with the state of our country's environment.

  
(Jairam Ramesh)



© Ministry of Environment and Forests, Government of India, 2009

Material from this publication may be used for educational purposes provided due credit is given.

Material from this publication can be used for commercial purposes only with the permission from the Ministry of Environment and Forests.

*Project Team*

George C Varughese  
Dr. KVijaya Lakshmi  
Anand Kumar  
Neelam Rana

*Prepared by*

**Development Alternatives**

B-32, TARA Crescent, Qutab Institutional Area, New Delhi - 110016  
Tel: 011- 2689 0380, 2613 4103  
Fax: 011-2613 0817

*Cover design, Layout & Photo credits*

Ministry of Environment and Forests  
Development Alternatives  
BrandStewards Pvt. Ltd.  
Motilal B. Soni





विजय शर्मा  
*Vijai Sharma*



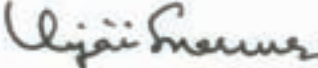
सचिव  
भारत सरकार  
पर्यावरण एवं वन मंत्रालय  
Secretary  
Government of India  
Ministry of Environment and Forests

## PREFACE

The State of Environment Report India 2009 presents an overview of the environmental scenario of our country. Its objective is to serve as a baseline document to help assist decision making and policy formulation.

The report has been prepared by Development Alternatives in active collaboration with the Ministry of Environment & Forests. A robust participatory process of consulting a range of stakeholders has been followed. The key environmental issues identified are: climate change, food security, water security, energy security and urban management. I am confident that the report will help all government agencies, NGOs and civil society in planning and policy formulation, and as a useful reference document.

I wish to thank Shri R.H. Khwaja, Dr. S.P. Sharma, Shri Nilkanth Ghosh and Shri Debabrata De, my colleagues in the Ministry, for their hard work in helping to prepare this Report. My appreciation is also due to the project team of Development Alternatives comprising of Shri Anand Kumar, Ms. Neelam Rana, Shri George C Varughese, and Dr. K. Vijaya Lakshmi.

  
(Vijai Sharma)



# CONTENTS

## Executive Summary

<b>I. Overview</b>	.....	<b>1-7</b>
General Profile	.....	2
<b>II. State and Trends of the Environment</b>	.....	<b>9-71</b>
Land	.....	10
Air	.....	20
Water	.....	40
Biodiversity	.....	50
<b>III. Key Environmental Issues</b>	.....	<b>73-157</b>
Climate Change	.....	74
Food Security	.....	90
Water Security	.....	102
Energy Security	.....	116
Managing Urbanization	.....	134
<b>IV. Policy and Institutional Options</b>	.....	<b>159-167</b>
<i>Annexures</i>		
<i>List of Abbreviations</i>	.....	<b>168</b>
<i>List of Tables</i>	.....	<b>169</b>
<i>List of Figures</i>	.....	<b>170</b>
<i>List of Boxes</i>	.....	<b>171</b>
<i>List of Consultation Workshop Participants</i>	.....	<b>172-179</b>





## Executive Summary

In the global context of State of the Environment (SoE) Reporting, India is probably unique. Over the last two decades, the Indian SoE reporting experience has ranged from grassroots initiatives like wall posters and citizens reports to media and academic documents and more formal government documents. While the quality of these outputs have been mixed, some of the processes adopted and products developed have been pioneering. Consequently, they have contributed to support policy and decision-making within the country and also for reporting to the global system.

With such a vast range of expertise and experience, Ministry of Environment and Forests, Government of India initiated the SoE reporting process with all State Governments and Union Territories (UTs) through a plan scheme in the Tenth Five Year Plan. The process was initiated in October 2002 and included streamlined data collection and collation systems, cross-sectoral consultative processes, a reporting systems using a range of static and interactive media, and linking SoE Reporting with logical follow-up decision and action.

The basic aim of the scheme is to bring out an overview of the environmental scenario of the States/UTs for mainstreaming environment in policy and decision-making. It is anticipated that through the SoE Reports, State Governments and UT Administrations would be able to integrate environmental dimensions in their socio-economic planning for sustainable development.

The present **National State of Environment (SoE) Report of India-2009** is one of the several reports emanating from the above process. Development Alternatives, the National Host Institute for SoE reporting process in India, has played a crucial role in preparing this report and also carrying out the participatory assessment processes for soliciting inputs from various stakeholders including line ministries, state and central governments, civil society organizations, academic institutions and business groups. The main objective of the SoE Report of India is to bring out an overview of the environmental scenario of India that serves as a baseline document and assists in logical and information-based decision-making. The SoE Report aims to provide policy guidelines and strategies for resource allocation for the coming decades, based on analysis of the state and trends of the environment and provide guidance for national environmental action planning.

The State of the Environment Report for India covers the state and trends of the environment (land, air, water, biodiversity) and five key issues - (1) Climate Change, (2) Food Security, (3)

Water Security, (4) Energy Security, and (5) Managing Urbanization. Land degradation is taking place through natural and man-made processes, resulting in the loss of invaluable nutrients and lower food grain production. Loss of biodiversity is of great concern since many plant and animal species are being threatened. Air quality in cities is deteriorating due to vehicular growth and a sharp increase in air pollution related diseases. The issue of availability of water, which is going to be one of the critical problems in the coming decades, needs to be addressed on priority basis. Generation of large quantity of hazardous waste from industries, along with the hospital waste has been affecting public health and environment. Climate change and energy security are major concerns which need to be addressed strategically. The SoE Report of India on environmental issues has been prepared, following the PSIR (Pressure-State-Impact-Response) framework.

The report provides an insight on various priority issues for India related to the current status of environment and natural resources, the pressures behind environmental changes and the impacts associated with these changes. The report also assesses the Government's current and proposed policy initiatives or programmes as a response to check and monitor further degradation of environment and also suggests policy options. The report is structured into five sections:

**Section – I** presents profile of India in brief with characteristics of bio-physical profile, socio-economic and cultural pattern, biodiversity, climate and economic base.

India is one of the oldest civilizations in the world, with kaleidoscopic variety and rich cultural heritage. Geographically, it accounts for a meagre 2.4 per cent of the world's total surface area of 135.79 million sq. km. Yet, India supports and sustains a whopping 16.7 per cent of the world population.

India covers an area of 32,87,263 sq. km., extending from the snow covered Himalayan peaks in the North to the tropical rain forests of the South. India's coast is 7,517 km (4,671 miles) long; of this distance, 5,423 km (3,370 miles) belongs to peninsular India, and 2,094 km (1,301 miles) to the Andaman & Nicobar and Lakshadweep Islands. The rivers of India can be classified into four groups viz., the Himalayan rivers, the Deccan rivers, the coastal rivers, and rivers of the inland drainage basin. The climate of India may be broadly described as tropical monsoonal type. Its climate is affected by two seasonal winds, the North-East monsoon and the South-West monsoon. The North-East monsoon, commonly known as the winter monsoon blows from land to sea, whereas the South-West monsoon, known as the

summer monsoon blows from sea to land after crossing the Indian Ocean, the Arabian Sea, and the Bay of Bengal. The South-West monsoon brings most of the rainfall during a year in the country. India, a mega diverse country with only 2.4 per cent of world's land area, accounts for 7-8 per cent of the recorded species of the world, including 45,500 species of plants and 91,000 species of animals. The Constitution of India, the longest and the most exhaustive constitution of any independent nation in the world, came into force on 26 January, 1950. India's diverse economy encompasses traditional village farming, modern agriculture, fisheries, handicrafts, a wide range of modern industries, and a multitude of services.

**Section – II** presents the state of environment & trends and integrated analyses of four major themes (Land, Air, Water and Biodiversity). The state and trends have been analyzed under the Pressure-State-Impact-Response (PSIR) framework.

### **Land**

India is the seventh largest country in the world, with a total land area of 3,287,263 sq. km. It measures 3,214 km. from North to South and 2,993 km. from East to West. It has a land frontier of 15,200 km. and a coastline of 7,517 km. Out of India's total geographical area of 328.73 Mha., 306 Mha. comprise the reporting area and 146.82 Mha. is degraded land. Land degradation occurring due to the natural and human induced causes, like wind erosion and water logging, is one of the priority concerns in India. The varying degrees and types of degradation stem mainly from unsustainable use and inappropriate land management practices. Loss of vegetation occurs as a result of deforestation, cutting beyond the silviculturally permissible limits, unsustainable fuel-wood and fodder extraction, shifting cultivation, encroachment into forest lands, forest fires and over-grazing, all of which subject the land to degradational forces. Other important factors responsible for large-scale degradation are; non-adoption of adequate soil conservation measures, improper crop rotation, indiscriminate use of agro-chemicals such as fertilizers and pesticides, improper planning and management of irrigation systems and extraction of groundwater in excess of the recharge capacity. The strategies identified to check land-degradation are as follows:

- Land degradation problem could be tackled to an extent by suitable policies that would internalize the issue into proper decision-making.
- At the macro level, the existing database on land use statistics cannot adequately facilitate the analysis of land degradation and its impact. Changes in the classification of land use statistics are needed in order to study its impact. Advanced technology like Remote Sensing could go a long way in generating vital information on different dimensions of land degradation.
- The information base on which farmers make decisions is incomplete in terms of internalizing rapid changes in soil and water quality variables; hence the need to move towards

more sustainable practices such as integrated pest management and land-conserving crop rotations. Research needs to be focused on measures such as integrated crop management. An integrated approach to the problem of degradation, linking agriculture and environment, is yet to be attempted even at the policy level.

### **Air**

Air pollution and the resultant impacts in India could be broadly attributed to the emissions from vehicular, industrial and domestic activities. Air quality has been, therefore, an issue of concern in the backdrop of various developmental activities. Some of the recommendations made to reduce air pollution are as follows:

- Take an integrated approach towards energy conservation and adoption of renewal energy technologies, including hydropower, by appropriately linking efforts to improve conversion, transmission, distribution, and end-use efficiency, and R&D in (and dissemination of) renewable energy technologies. Remove the statutory and regulatory barriers in setting up decentralized generation and distribution system for power and other secondary energy forms, based on local primary energy resources.
- Accelerate the national programmes for disseminating information on improved fuel wood stoves suited to local cooking practices and biomass resources.
- Strengthen the monitoring and enforcement of emission standards and prepare and implement action plans for both point and non-point sources.
- Promote reclamation of wastelands through energy plantations for rural energy, through multi-stakeholder partnerships involving the land owning agencies, local communities, and investors.
- Strengthen efforts for partial substitution of fossil fuels by bio-fuels, through promotion of bio-fuel plantation, promoting relevant research and development, and strengthening regulatory certification of new technologies.

### **Water**

From the East to the West and from the North to the South, water has defined life in the Indian subcontinent for thousands of years. On an average, the combination of rainfall, surface and groundwater resources have been sufficient in providing adequate water to the Indian population. Rise in demand and development pressures are changing the characteristics of water in India. Erosion in the watershed due to the fast growing development and poor land management practices is increasing siltation and changing stream hydraulics. Groundwater reserves are becoming more and more depleted as surface water sources have become too polluted for human use.

The Government of India has formulated the National Water Policy in 1987 to address issues regarding planning, development and allocating groundwater and surface water. It serves as a

guideline to help planners and managers in developing country's water resources to its maximum potential.

## **Biodiversity**

India is one of the 17 identified mega diverse countries of the world. Out of all the hot spots in the world, India has two, Eastern Himalaya and Western Ghats. India, with a varied terrain, topography, land use, geographic and climatic factors, can be divided into ten recognizable bio-geographic zones. These zones encompass a variety of ecosystems: mountains, plateaus, rivers, forests, deserts, wetlands, lakes, mangroves, coral reefs, coasts and islands.

Human activities, both directly and indirectly, responsible for current high rates of biodiversity loss are - habitat loss; fragmentation and degradation due to agricultural activities; extraction (including mining, fishing, logging and harvesting); and development (human settlements, industry and associated infrastructure). Habitat loss and fragmentation leads to the formation of isolated, small and scattered populations.

Strategies and actions required to protect the India's rich bio-wealth are as follows:

- Formulate conservation and prudent use strategies for each significant catalogued wetland, with participation from local communities, and other relevant stakeholders.
- Formulate and implement eco-tourism strategies for identified wetlands through multi-stakeholder partnerships involving public agencies, local communities, and investors.
- Integrate wetland conservation, including conservation of village ponds and tanks, into sectoral development plans for poverty alleviation and livelihood improvement, and link efforts for conservation and sustainable use of wetlands with the ongoing rural infrastructure development and employment generation programmes.

**Section – III** focuses on key environmental issues i.e. *Climate Change, Food Security, Water Security, Energy Security and Urbanization* that threaten to cripple the efforts towards holistic development of India. The issues are again analyzed under the Pressure-State-Impact-Response (PSIR) framework.

## **Climate Change**

India is a large developing country with nearly 700 million rural population directly depending on climate-sensitive sectors (agriculture, forests and fisheries) and natural resources (such as water, biodiversity, mangroves, coastal zones, grasslands) for their subsistence and livelihoods. Further, the adaptive capacity of dry land farmers, forest dwellers, fisher folk and nomadic shepherds is very low. Climate change may alter the distribution and quality of India's natural resources and adversely affect the livelihoods of its people. With an economy closely linked to its natural resource base and climatically sensitive sectors such as agriculture, water and forestry, India may face a major threat because of the projected change in climate. With climate change, there would be increasing scarcity of water, reduction in yields of

forest biomass, and increased risk to human health. The contribution of India to the cumulative global CO<sub>2</sub> emissions is only five per cent. Thus, historically and at present, India's share in the carbon stock in the atmosphere is relatively miniscule when compared to its distribution over the nation's population.

India released its National Action Plan on Climate Change (NAPCC) on 30<sup>th</sup> June, 2008 to outline its strategy to meet the Climate Change challenge. The National Action Plan advocates a strategy that promotes, firstly, the adaptation to Climate Change and secondly, further enhancement of the ecological sustainability of India's development path. India's National Action Plan stresses that maintaining a high growth rate is essential for increasing the living standards of the vast majority of people of India and reducing their vulnerability to the impacts of climate change. Accordingly, the Action Plan identifies measures that promote the objectives of sustainable development of India while also yielding to benefits for addressing climate change. Eight National Missions, which form the core of the National Action Plan, represent multi-pronged, long term and integrated strategies for achieving key goals in the context of climate change. The focus is on promoting understanding of Climate Change, adaptation and mitigation, energy efficiency and natural resource conservation.

## **Food Security**

Today, there are marketable surpluses of food grains in India; the prevalence of widespread hunger is not due to the non-availability of food in the market but due to lack of adequate purchasing power among the rural and urban poor. Inadequate purchasing power, in turn, is due to insufficient opportunities for gainful employment. The famines of jobs and of purchasing power are becoming the primary causes for the famines of food in the households of the poor. Poverty, increased food consumption, land degradation, climate change are some of the pressures of food insecurity.

Some of the measures to secure food security are as follows:

- The National Food Security Mission has been launched recently as a centrally sponsored scheme. The objective is to increase production and productivity of wheat, rice and pulses on a sustainable basis so as to ensure food security of the country.
- Boosting agricultural science and technology.
- Sustainable intensification and diversification of farming systems and value-addition.
- Promotion of organic farming – a solution to ensure economically sustainable agriculture.

## **Water Security**

Water security is emerging as an increasingly important and vital issue for India. Many Indian cities are beginning to experience moderate to severe water shortages, brought on by the simultaneous effects of agricultural growth, industrialization and urbanization. These shortages would be further aggravated

by receding of glaciers and dwindling fresh water resources. Population stress, irrigation requirements and industrialization are the major pressures for water insecurity.

The environmental challenges of water resource development and management in India are expected to manifest themselves more explicitly and rapidly in the coming years. These environmental challenges may be addressed through four broad approaches:

- Improving efficiencies and minimizing losses
- Recharging groundwater aquifers
- Abatement and treatment of water pollution
- Reuse and recycling of wastewater

### **Energy Security**

India is a developing country facing the critical challenge of meeting its rapidly increasing demand for energy. With over a billion people, India ranks sixth in the world in terms of energy demands. India's economy is projected to grow seven to eight per cent over the next two decades, spurring a substantial increase in demand for oil to fuel land, sea, and air transportation. While India has significant reserves of coal, it is relatively poor in oil and gas resources. India's oil reserves amount to 0.5 per cent of the global reserves.

In recent years, India's energy consumption has been increasing at one of the fastest rates in the world owing to population growth and economic development.

In the recent years, the Government of India has recognized the energy security concerns and more importance is being placed on energy independence. Some of the strategies for energy security are as follows:

- Power Generation Strategy will focus on low cost generation, optimization of capacity utilization, controlling the input cost, optimization of fuel mix, Technology upgradation and utilization of non-conventional energy sources.
- Transmission strategy will focus on development of National Grid including Inter-state connections, technology upgradation and optimization of transmission cost.
- Distribution strategy (to achieve distribution reforms) will focus on system upgradation, loss reduction, theft control, consumer service orientation, quality power supply commercialization, decentralized distributed generation and supply for rural areas.
- Conservation strategy (to optimize the utilization of electricity) will focus on demand side management, load management and technology upgradation to provide energy efficient equipment / gadgets.

### **Managing Urbanization**

Due to an uncontrolled urbanization in India, environmental degradation has been occurring very rapidly and causing shortages of housing, worsening of water quality, excessive air pollution, noise, dust and heat, and the problems of disposal of solid wastes and hazardous wastes. The situation in metropolises like Mumbai, Kolkata, Chennai, Delhi and Bangalore, is becoming worse year by year. Some of the strategies to manage urbanization are as follows:

- Redirection of migration flow is required. Since the mega cities have reached the saturation level for employment generation and to avoid over-crowding into the over congested slums of mega cities like Mumbai, Kolkata, Delhi and Chennai, there is a dire need to build a strong economic sector (Kundu and Basu, 1998) in the urban economy. Growth efforts and investments should be directed towards small cities which have been neglected so far so that functional base of urban economy is strengthened. Then, the redirection of migration to this desirable destination will be possible.
- Policy should also relate to proper urban planning where city-planning will consist of operational, developmental and restorative planning.

**Section – IV** provides the Policy and Institutional Options to cater the emerging environmental challenges. To address these challenges, it is essential to focus on diverse response options and instruments for possible solutions. Emphasis must be placed on increasing stakeholders responsibility and accountability and promoting more cooperative efforts for ensuring a healthy environment.

Spreading awareness and empowering people to take decisions, at the local level, is an effective way of dealing with the environmental problems of India. Their decisions will enable initiatives that will benefit them as well as the local environment. It has been seen that solutions always emerge whenever governments involve people, using a participatory approach to solve problems.

Community-based natural resource management initiatives, coupled with policy reforms, can prove to be an effective mechanism for improving access to, and improving productivity of, natural resources. The success of joint forest management and irrigation user groups in India, provide enough evidence that social capital and participatory processes are as crucial to environmental protection as financial resources and development programmes.

**Section – V** provides the list of annexures.

## CHAPTER - 2



# STATE & TRENDS OF THE ENVIRONMENT

# LAND

India is the seventh largest country in the world, with a total land area of 3,287,263 sq. km. (1,269,219 sq. miles). It measures 3,214 km (1,997 miles) from North to South and 2,993 km (1,860 miles) from East to West. It has a land frontier of 15,200 km (9,445 miles) and a coastline of 7,517 km (4,671 miles). Ever-growing population and urbanization is creeping into its forests and agricultural lands.

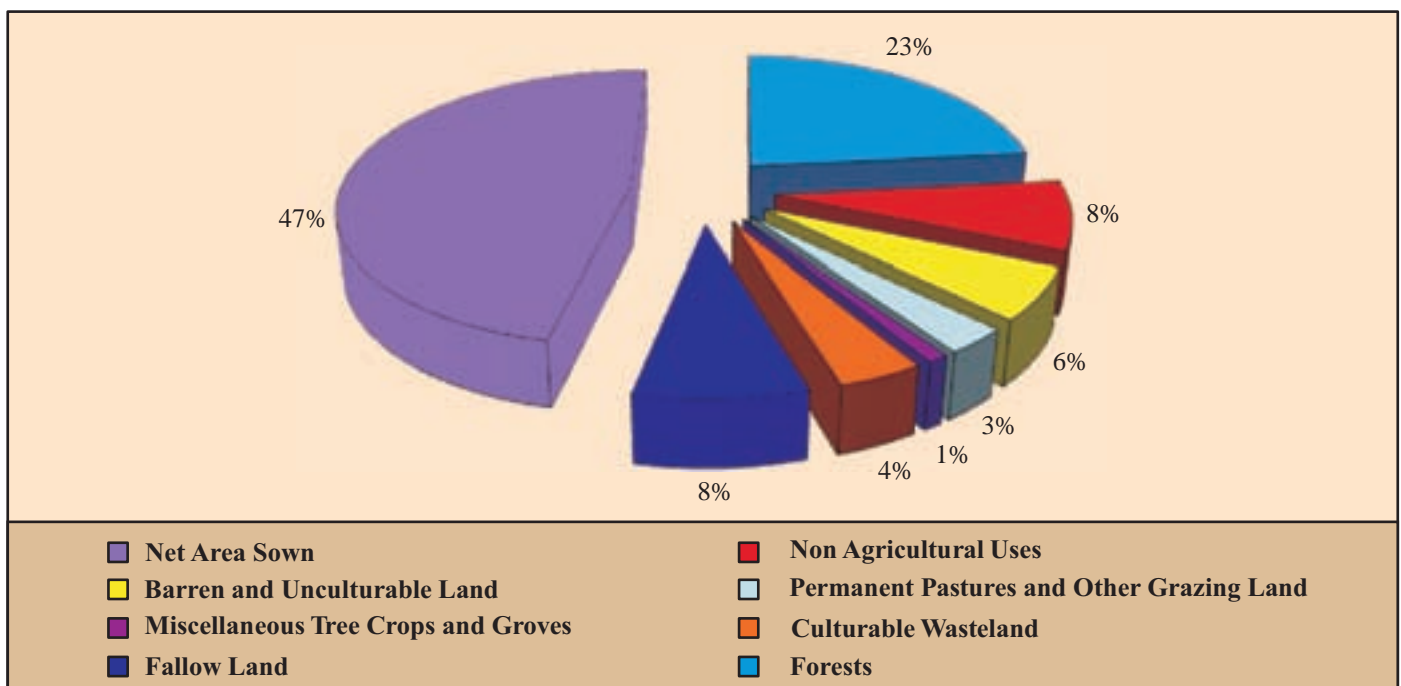
Although India occupies only 2.4 per cent of the world's total land area, it supports over 16.7 per cent of the entire global

population. Of the total geographical area of 328.73 Mha., 306 Mha. comprise the reporting area and 146.82 Mha. land is degraded land.

## LAND DEGRADATION STATUS

In India, an estimated 146.82 Mha. area suffers from various forms of land degradation due to water and wind erosion and other complex problems like alkalinity/salinity and soil acidity due to water logging (Figure 2.1.2).

Figure 2.1.1 : Land Use Classification in India (2005-2006)



Source: Agricultural Statistics at a Glance 2008, Ministry of Agriculture

**Table 2.1.1: Land Use Classification in India, (2005-2006)**

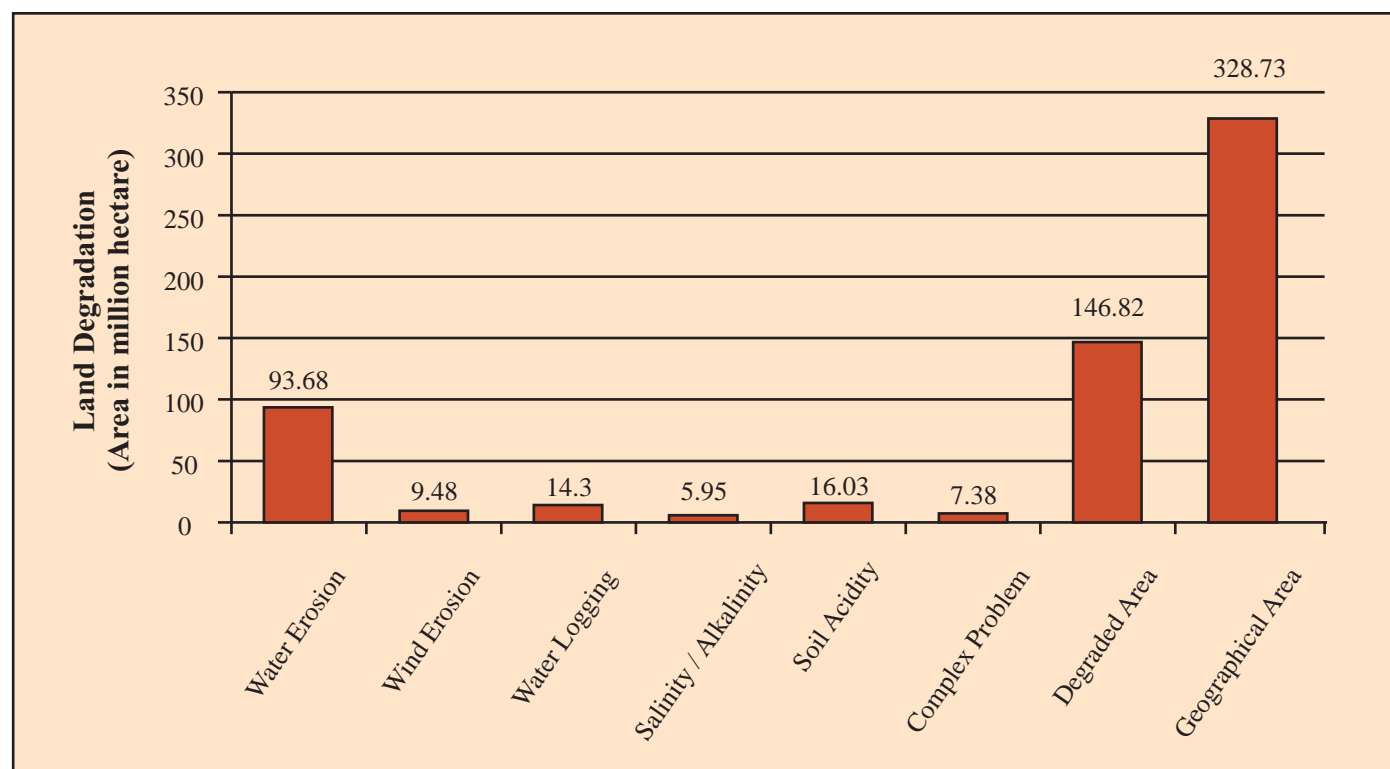
(Area in Mha)

Classification	2000-01	2001-02 (P)	2002-03 (P)	2003-04 (P)	2004-05 (P)	2005-06 (P)
1	2	3	4	5	6	7
I. Geographical Area	328.73	328.73	328.73	328.73	328.73	328.73
II. Reporting Area for Land Utilisation Statistics (1 to 5)	305.08	305.01	305.24	305.32	305.23	305.27
1. Forests	69.62	69.51	69.64	69.67	69.67	69.79
2. Not Available for Cultivation (a+b)	41.55	41.78	42.08	42.23	42.30	42.51
(a) Non Agricultural Uses	23.81	24.07	24.28	24.66	24.72	25.03
(b) Barren and Unculturable Land	17.74	17.71	17.80	17.57	17.58	17.48
3. Other Uncultivated Land excluding fallow Land(a+b+c)	27.71	27.37	27.41	26.98	27.00	26.92
(a) Permanent Pastures and Other Grazing Land	10.83	10.59	10.51	10.45	10.43	10.42
(b) Land Under Miscellaneous Tree Crops and Groves not Included in Net Area Sown	3.32	3.37	3.36	3.39	3.38	3.38
(c) Culturable Wasteland	13.56	13.41	13.54	13.14	13.19	13.12
4. Fallow Land (a+b)	25.03	24.94	33.46	25.48	24.94	24.17
(a) Fallow Land Other Than Current Fallows	10.19	10.30	11.76	11.20	10.72	10.50
(b) Current Fallows	14.84	14.64	21.70	14.28	14.22	13.67
5. Net Area Sown (6-7)	141.16	141.42	132.66	140.95	141.32	141.89
6. Gross Cropped Area	185.70	189.75	175.66	190.37	190.91	192.80
7. Area Sown More Than Once	44.54	48.33	43.00	49.42	49.59	50.90
8. Cropping Intensity*	131.60	134.20	132.40	135.10	135.10	135.90
III. Net Irrigated Area	54.84	56.30	53.88	56.00	58.54	60.20
IV. Gross Irrigated Area	75.82	78.07	72.89	77.11	79.51	82.63

*P* : Provisional  
 \* : Cropping Intensity is obtained by dividing the gross cropped area by the net area sown.  
 Note : The decline in net area sown in 2002-03 reflects the impact of the severe drought of 2002-03 on agriculture operations.

Source: Agricultural Statistics at a Glance 2008, Ministry of Agriculture

**Figure 2.1.2 : Extent of Various Kinds of Land Degradation in India**



Source: National Bureau of Soil Survey and Land Use Planning, 2005

The varying degrees and types of degradation, stem mainly from unstable use and inappropriate land management practices. Loss of vegetation occurs as a result of deforestation, cutting beyond the silviculturally permissible limits, unsustainable fuel-wood and fodder extraction, shifting cultivation, encroachment into forest lands, forest fires and over-grazing, all of which subject the land to degradational forces. Other important factors responsible for large-scale degradation are the extension of cultivation to lands of low potential or high natural hazards, non-adoption of adequate soil conservation measures, improper crop rotation, indiscriminate use of agro-chemicals such as fertilizers and pesticides, improper planning and management of irrigation systems and extraction of groundwater in excess of the recharge capacity. In addition, there are a few underlying or indirect pressures such as land shortage, short-term or insecure land tenancy, open access resource, economic status and poverty of the agriculture dependent people which are also instrumental, to a significant extent, for the degradation of land.

## DRIVERS OF CHANGE

### Agricultural Practices

Out of India's total geographical area (328.7 million hectares) 141.89 million hectares is the net sown area, while 192.80 million hectares is the gross cropped area. The net irrigated area is 60.20 million hectares and the cropping intensity is 135.90 per cent (Table 2.1.1).

A change in land use pattern implies variation in the proportion of area under different land uses at a point in two or more time periods. Over the past fifty years, while India's total population increased by about three times, the total area of land under cultivation increased by only 20.2 per cent (from 118.75 Mha. in 1951 to 141.89 Mha. in 2005-06). Most of this expansion has taken place at the expense of forest and grazing land. Despite fast expansion of the area under cultivation, less agricultural land is available on per capita basis.

Direct consequences of agricultural development on the environment arise from intensive farming activities, which contribute to soil erosion, land salination and loss of nutrients. The introduction of Green Revolution in the country has been accompanied by over-exploitation of land and water resources and excessive usage of fertilizers and pesticides. Shifting cultivation (or *Jhum* cultivation) has also been a major factor responsible for land degradation in hilly areas. Leaching due to extensive use of pesticides and fertilizers is a major source of contamination of water bodies.

The extent of agricultural intensification and extensification is characterized by an increase in cropping and irrigation intensity and the imbalanced use of chemical fertilizers, pesticides and insecticides. It has also led to land degradation, over-exploitation of underground water resources and increased use of chemical fertilizers, leading to eutrophication and water pollution in some regions.

Enhanced intensification and extensification also leads to

salination, alkalization and water logging in irrigated areas, along with eutrophication of water bodies and ill health of oceans, leading to loss of biodiversity. For achieving and maintaining food security and sustainable forestry, controlling of land/soil erosion is extremely vital.

It is essential to control soil erosion in order to attain and maintain food security, sustainable forestry and agricultural and rural development. Statistics reveal that only 23 per cent of the applied fertilizer is consumed by plants, the remaining 77 per cent is either leached out beyond the root zone or lost by volatilization.

### Shifting Cultivation

The current practice of shifting cultivation in the eastern and north-eastern regions of India is an extravagant and unscientific form of land use. According to a recent estimate, an area of 18765.86 sq. km. (0.59 percent of the total geographical area) is under shifting cultivation. The effects of shifting cultivation are devastating and far-reaching in degrading the environment and ecology of these regions. The earlier 15–20 years cycle of shifting cultivation on a particular land has reduced to two or three years now. This has resulted in large-scale deforestation, soil and nutrient loss, and invasion by weeds and other species. The indigenous biodiversity has been affected to a large extent. As per the statistics, Orissa accounts for the largest area under shifting cultivation in India.



*Forest fire caused by jhum burning*

### Excessive Chemical Usage

Per hectare consumption of fertilizers has increased from 69.8 kg in 1991-92 to 113.3 kg in 2006-07, at an average rate of 3.3 per cent. There is excessive use of urea and a bias against micronutrients. As against the desirable NPK proportion of 4:2:1, the average use of urea now is 6:2 and 4:1. The Steering Committee of the Planning Commission has observed that “because nitrogenous fertilizers are subsidised more than potassic and phosphatic fertilizers, the subsidy tends to benefit the crops and regions which require higher use of nitrogenous fertilizers as compared to crops and regions which require higher application of P and K.” The excessive use of urea has also affected the soil profile adversely (Table 2.1.2)

**Table 2.1.2: All India Consumption of Fertilizers in Terms of Nutrients (N, P & K)**

( 1000 tonnes)				
Year	N	P	K	Total
2000-01	10920.2	4214.6	1567.5	16702.3
2001-02	11310.2	4382.4	1667.1	17359.7
2002-03	10474.1	4018.8	1601.2	16094.1
2003-04	11077.0	4124.3	1597.9	16799.1
2004-05	11713.9	4623.8	2060.6	18398.3
2005-06	12723.3	5203.7	2413.3	20340.3
2006-07	13772.9	5543.3	2334.8	21651.0

Source: *Agriculture Statistics at a Glance, 2006-07, Ministry of Agriculture*

### Agricultural Waste Residue Burning

Burning of wheat and rice straw and other agricultural residue has also contributed to loss of soil fertility, apart from causing air pollution. Open field burning of straw after combine harvesting is a common practice in states like Punjab, Haryana and Uttar Pradesh in order to ensure early preparation of fields for the next crop. Punjab alone produces around 23 million tonnes of rice straw and 17 million tonnes of wheat straw, annually. This straw is rich in nitrogen, phosphorus and potassium. However, instead of recycling it back into the soil by mulching, it is burnt in the fields. This raises the temperature of the soil in the top three inches to such a high degree that the carbon: nitrogen equilibrium in soil changes rapidly. The carbon as CO<sub>2</sub> is lost to the atmosphere, while nitrogen is converted into a nitrate. This leads to a loss of about 0.824 million tonnes of NPK from the soil. This is about 50 per cent of the total fertilizer consumption in the state. Considering that 90 per cent of rice straw and 30 per cent of the wheat straw is available for recycling, it will be equivalent to recycling of 0.56 million tonnes of nutrients worth Rs. 4 billion. Moreover, agriculture experts also maintain that fire in the fields kills friendly fauna and bacteria.

### Soil Erosion

Soil is a unique non-renewable natural resource that supports life on planet Earth. It is estimated that one-sixth of the world's soil has already been degraded by water and wind erosion. In India, approximately 130 Mha. of land area (or 45 percent of the total geographical area) is affected by serious soil erosion through ravines and gullies, shifting cultivation, cultivated wastelands, sandy areas, deserts and water logging (Govt. of India, 1989). Excessive soil erosion with consequent high rate of sedimentation in the reservoirs and decreased fertility has created serious environmental problems with disastrous economic consequences.

In India, the Ganga, Brahmaputra and Kosi rivers carry huge amounts of eroded soil in the form of heavy silt, which deposits as sediments on the river bed. While soil erosion by rain and river in hilli areas causes landslides and floods, deforestation, overgrazing, traditional agricultural practices, mining and

incorrect siting of development projects in forested areas have resulted in exposing the green cover to severe soil erosion. Ravines and gullies account for 4 Mha. of land erosion. The area subjected to shifting cultivation reported 4.9 Mha. of eroded land.

In India, erosion rates range from 5 to 20 tonnes per hectare, sometimes going up to 100 tonnes per hectare. Nearly 93.68 million hectares are affected by water erosion and another 9.48 million hectares are affected by wind erosion annually in India. Thus, erosion leads to impoverished soil on one hand, and silting up of reservoirs and water tanks on the other.

Apart from checking soil erosion, the problem of conserving soil moisture is also of immense importance in the extensive regions of low and uncertain rainfall, forming parts of Punjab, Madhya Pradesh, Maharashtra, Andhra Pradesh and Karnataka. These tracts are characterized by scanty, ill-distributed and highly erosive rains, undulating topography, high wind velocity and generally shallow soils. The period of heavy downpour from August to October is also the period of severe erosion in these regions. About 76 per cent of Rajasthan's arid region is affected by wind erosion of different intensities, and 13 per cent by water erosion. In fact, 4 per cent of Rajasthan's arid area is affected by water logging and salinity or alkalinity.

In India, very little area is free from the hazard of soil erosion. It is estimated that out of 305.9 million hectares of reported area, 146 million hectares is in dire need of conservation measures.

### Change in Forest Cover

Forests are not just trees, but part of an ecosystem that underpins life, economies and societies. Forests provide a wide range of services which include prevention of soil erosion, floods, landslides, maintenance of soil fertility, and fixing carbon from the atmosphere as biomass and soil-organic carbon.

The total forest cover of the country, as per the 2005 assessment, is 677,088 sq. km. which constitutes 20.60 per cent of the geographic area of the country (Table 2.1.3 and Figure 2.1.4).



*Dry Deciduous Forests of the Melghat Tiger Reserve*

The total tree cover of the country has been estimated as 91,663 sq. km. or about 2.79 per cent of the country's geographical area (State of Forest Report, 2005).

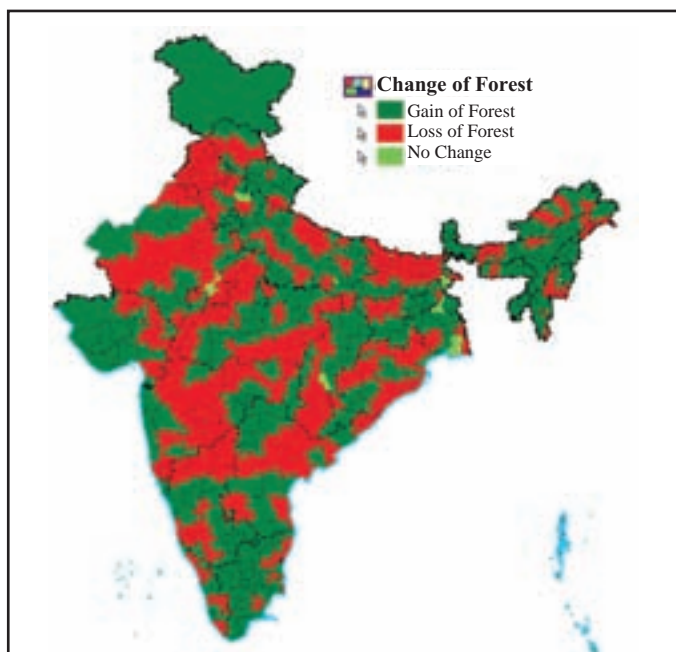
**Table 2.1.3: Status of Forest Cover in India, 2005**

Class	Area (sq. km.)	Percentage of Geographical Area
1	2	3
<b>Forest Cover</b>		
Very Dense Forest	54569	1.66
Moderately Dense Forest	332647	10.12
Open Forest	289872	8.82
<b>Total Forest Cover</b>	<b>677088</b>	<b>20.60</b>
<b>Non-Forest Cover</b>		
Scrub	38475	1.17
Non-Forest	2571700	78.23
<b>Total Geographical Area</b>	<b>3287263</b>	<b>100.00</b>

Source: *Compendium of Environment Statistics - India, 2007*

Between 2003 and 2005, the total forest cover had decreased slightly by 728 sq. km. The states, which have shown a decline in the forest covers, are Nagaland (296 sq. km), Manipur (173 sq. km), Madhya Pradesh (132 sq. km) and Chhattisgarh (129 sq. km). There has been a significant loss of forest cover in the Andaman and Nicobar Islands (178 sq. km) because of the Tsunami, whereas the states of Tamil Nadu (41 sq. km) and Tripura (32 sq. km) have shown a marginal increase in the forest cover, with Arunachal Pradesh (85 sq. km) showing significant increase in the total forest cover (Figure 2.1.3).

**Figure 2.1.3 : Change in the Forest Cover of India**



Source: *State of Environment Atlas of India 2007, MoEF*

## Mining

India is rich in a variety of natural resources. Along with 56 per cent arable land, it has a significant number of sources of coal, iron ore, manganese, mica, bauxite, titanium ore, chromite, natural gas, diamonds, petroleum and limestone. India is self-sufficient in thorium, which is mined along the shores of Kerala, comprising 24 per cent of the world's known and economically available thorium.

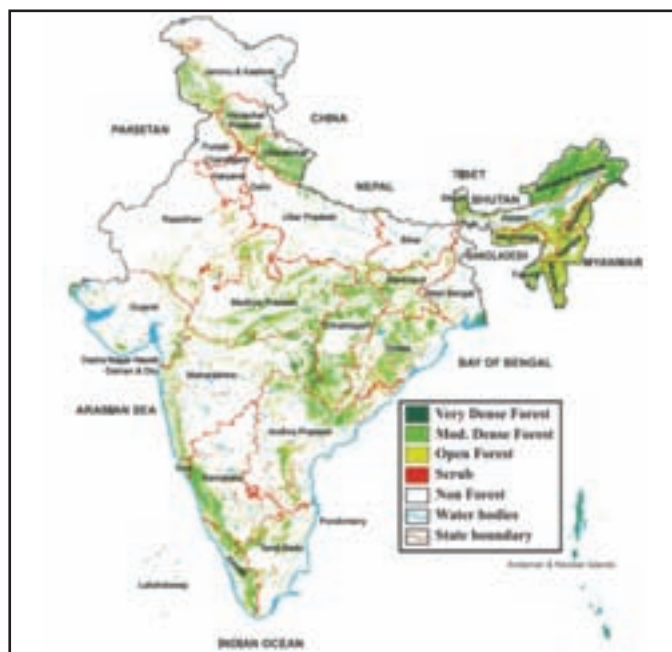
Land degradation is considered to be unavoidable by-product of mining and has reached alarming proportions, mainly due to over-exploitation and mismanagement of natural resources. Mining activity often leads to environmental problems like land degradation, particularly in opencast mining and land subsidence in underground mining. Open-cast mining in areas with forest cover causes deforestation.

Mining complexes, as estimated recently, occupy around 0.06 per cent of the total land area of the country.

## Flooding

The increasing frequency of floods in India is largely due to deforestation in the catchment areas, destruction of surface vegetation, change in land-use, increased urbanization and other developmental activities. The main reason, however, is the increased sedimentation and reduced capacity of drainage systems. Consequently, streams and rivers overflow their banks, flooding the downstream areas. These are of frequent occurrence in many parts of India, especially in hilly terrains, causing a disruption of normal life and considerable damage to the productive land system. The problem of human-induced water logging in India is more common in canal command areas (surface irrigation) because irrigation facilities are often introduced without adequate provision for drainage.

**Figure 2.1.4: Forest Cover Map of India**



Source: *Forest Survey of India, 2005*

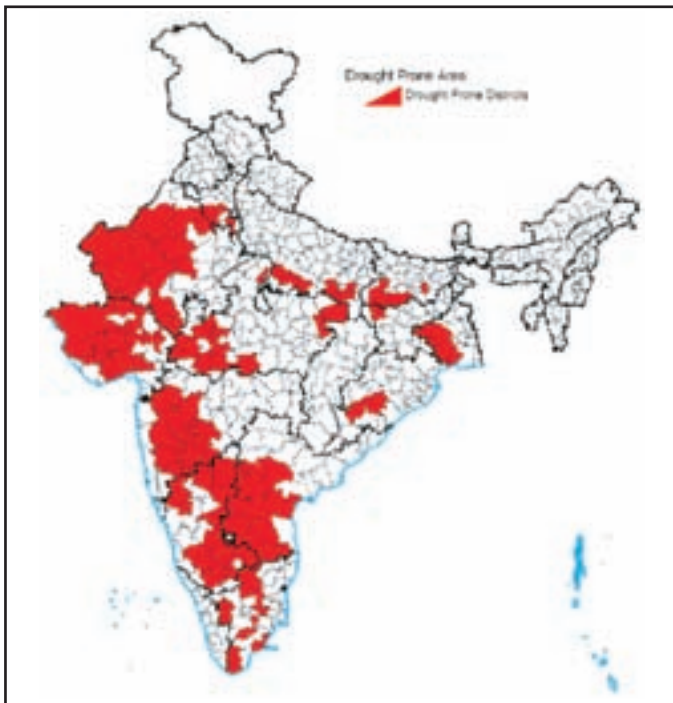
### Box 2.1.1: Drivers and Pressures Affecting Forest Ecosystems

Population pressure, poverty and weak institutional framework have often been viewed as the predominant underlying causes of forest depletion and degradation in developing countries. Excessive population and livestock pressure and the requirements of forest products for essential development generate pressure on forest resources like fuel-wood, fodder, timber, lumber, paper, which in turn triggers deforestation. Over-exploitation of the forest resources, as compared to its incremental and regenerative capacities, escalates the forest depletion and degradation process. India has witnessed a spurt of large projects from big dams and thermal power projects to huge mines and massive industrial complexes. About 92 per cent area in arid Rajasthan is affected by desertification (30 per cent slightly, 41 per cent moderately and 21 per cent severely). In the neighbouring arid Gujarat, about 93 per cent area is affected by desertification.

#### Desertification

In India, 228.3 Mha. of geographical area comprises arid (50.8 Mha.), semi-arid (123.4 Mha.) and dry sub-humid regions (54.1 Mha.). Western parts of Rajasthan and Kutch are chronically drought affected. As a matter of fact, droughts occur frequently in the areas affected by desertification (Figure 2.1.5).

Figure 2.1.5: Drought Prone Areas of India



Source: State of Environment Atlas of India 2007, MoEF

#### Pollution

Soil pollution from heavy metals due to improper disposal of industrial effluents, along with the excessive use of pesticides and mismanagement of domestic and municipal wastes, is becoming a major concern. Though no reliable estimates are available to depict the exact extent and degree of this type of land degradation, it is believed that the problem is extensive and its effects are significant. Some commercial fertilizers also contain appreciable quantities of heavy metals, which have undesirable effects on the environment. The indiscriminate use of agrochemicals, such as fertilizers and pesticides, is often responsible for land degradation. Soil texture, infiltration and permeability

characteristics are affected adversely to a considerable extent due to excessive grazing, fire and mismanagement of land under cultivation.

#### RESPONSE

1. Watershed management programmes have been taken up extensively in the recent past. The Soil and Water Conservation Division in the Ministry of Agriculture has been playing a key role in implementing Integrated Watershed Management Programmes. IWDP (Integrated Watershed Development Programme) was launched in the year 1989-90 to develop the wastelands on watershed basis, to strengthen the natural resource base and to promote the overall economic development of the resource-poor and disadvantaged sections of people inhabiting the programme areas.
2. The National Bureau of Soil Survey and Land Use Planning, the Central Soil and Water Conservation Research and Training Institute and the Indian Council of Agricultural Research (ICAR), have jointly initiated the preparation of maps of soil erosion affected areas in different states using the components of Universal Soil Loss Equation. Similar assessments need to be carried out for other degradation processes also. In addition, the All-India Soil and Land Use Survey, MoA, is engaged in generating spatial and non-spatial information on the soils of India and preparing



Wasteland reclamation through Dhaincha plantation

thematic maps like land capability classification, hydrological soil grouping, irrigability classification, etc. The state governments are also working on various aspects of soil conservation, following the guidelines of the Centre.

3. Joint Forest Management Programme: In India, Joint Forest Management (JFM) has emerged as an important intervention in management of forest resources. It recognizes the livelihood and sustenance needs of the people through the principle of 'care and share'. The concept of JFM has been interpreted in various ways but the basic element in this concept is to establish grassroots community based institutions for protection and management of forests. The programme aims at empowering local people for their active participation as partners in the management of forest resources and sharing the benefits derived from its protection and management. The JFM approach optimizes the returns, minimizes conflicts and links the forestry development works with the overall development of land based resources. It also aims at building technical and managerial capability at the grassroots level.
4. Soil conservation in arid, semi-arid and dry sub-humid areas was included as one of the themes in the 'International Convention on Combating Desertification' held in December 1996. India participated and ratified its commitments. The objective was to curtail wide scale deforestation and watershed degradation through appropriate corrective measures.



*Slope stabilization for soil conservation*

5. Drought Prone Areas Programme (DPAP): The Rural Works Programme (RWP) initiated in 1970-71 was re-designated as Drought Prone Areas Programme (DPAP) in 1973-74 to focus solely on problems of drought prone areas. At present, DPAP is under implementation in 972 Blocks of 185 Districts in 16 States (Table 2.1.4).

**Table 2.1.4: States under Drought Prone Area Programme**

Sl. No.	States	No. of Districts	No. of Blocks	Area in Sq. Km.
1	Andhra Pradesh	11	94	99,218
2	Bihar	6	30	9,533
3	Chhattisgarh	8	29	21,801
4	Gujarat	14	67	43,938
5	Himachal Pradesh	3	10	3,319
6	Jammu & Kashmir	2	22	14,705
7	Jharkhand	15	100	34,843
8	Karnataka	15	81	84,332
9	Madhya Pradesh	24	105	89,101
10	Maharashtra	25	149	1,94,473
11	Orissa	8	47	26,178
12	Rajasthan	11	32	31,969
13	Tamil Nadu	17	80	29,416
14	Uttar Pradesh	15	60	35,698
15	Uttarakhand	7	30	15,796
16	West Bengal	4	36	11,594
	<b>Total</b>	<b>185</b>	<b>972</b>	<b>7,45,914</b>

*Source: Annual Report 2007-2008, Ministry of Rural Development*

6. Desert Development Programme (DDP): The Desert Development Programme (DDP) was started both in hot desert areas of Rajasthan, Gujarat and Haryana and the cold deserts of Jammu & Kashmir and Himachal Pradesh in 1977-78. From 1995-96, the coverage has been extended to a few more districts in Andhra Pradesh and Karnataka. DDP was launched to tackle special problems of desert areas. The basic objective of this programme is to minimize the adverse effect of drought, and to control desertification through rejuvenation of the natural resource base of the identified desert areas. The programme also aims at promoting overall economic development and improving the socio-economic conditions of the resource - poor and disadvantaged sections of people inhabiting the programme areas. DDP is under implementation in 235 blocks of 40 districts in seven states having the coverage of about 45.7 Mha.
7. The National Land Use & Conservation Board's (NLCB) objective is to serve as a policy planning, coordinating and monitoring agency at the national level for issues concerning the health and scientific management of land resources of the country.
8. The Programme for Reclamation of Alkali Soil (RAS) was launched in the Seventh Five Year Plan for reclamation of soils, which are suffering from alkalinity. About 7 Mha. area in the country is affected by the salt problem, out of which about 3.58 Mha. area suffers from alkalinity. Such alkali soils are largely located in 11 states, namely- Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Madhya Pradesh,

Maharashtra, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh.

The main objectives of the programme are:-

- Reclamation of the lands affected by alkalinity and improving land productivity by growing salt tolerant crops and horticulture plantations;
- Increase the production of fuel- wood and fodder;
- Improve capacity of extension personnel and beneficiaries in various aspects of alkali land reclamation technology;
- Generate employment opportunities, thereby reducing rural-urban migration.

Since the inception of the programme, till its end in 2004-05, an area of 6.59 lakh ha. had been reclaimed under this programme.

9. Watershed Development Project in Shifting Cultivation Areas (WDPSCA) is basically a central assistance to states with an objective of overall development of jhum areas on watershed basis, reclaiming the land affected by shifting cultivation and socio-economic upgradation of jhumia families so as to encourage them for settled agriculture. The scheme is being implemented since 1994-95.

10. The Programme on Soil Conservation for Enhancing the Productivity of Degraded Lands in the Catchments of River Valley Project and Flood Prone River (RVP and FPR): Presently, this programme is being implemented in 53 catchments having a total catchment area of 110.11 Mha. falling in 27 states namely - Assam, Andhra Pradesh, Arunachal Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Mizoram, Meghalaya, Manipur, Nagaland, Orissa, Punjab,

Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, Uttaranchal and West Bengal.

The major objectives of the programme are:

- Prevention of land degradation by adoption of a multi-disciplinary integrated approach of soil conservation and watershed management in catchment areas;
- Improvement of land capability and moisture regime in the watersheds;
- Promotion of land use to match the land capability; and
- Prevention of soil loss from the catchments to reduce siltation of multipurpose reservoirs and enhance the *in-situ* moisture conservation and surface rainwater storage in the catchments to reduce flood peaks and the volume of run-off.

From the inception of the programme, till the end of the IX Plan (2005-06), an area of 62.58 lakh ha. had been treated.

11. Several initiatives for proper management of agricultural waste have also been taken up for promoting alternative uses of straw instead of burning it in the fields. The Department of Science, Technology & Environment, Government of Punjab constituted a task force in September, 2006 for formulation of a policy to mitigate the problem generated due to severity of burning of agricultural waste in the open fields after harvesting, and its consequent effects on soil, ambient air and health of living organisms. The task force has suggested promotion of agronomic practices and technological measures for better utilization of agricultural waste. These include use of *happy seeder*, developed by Punjab Agricultural University in collaboration with Australian Centre for International Agriculture Research (ACIAR) and use of paddy straw for power generation. The *happy seeder*,



Bihar : A Flood Prone State



*A view of Annamalai forest*

machine is compact and lightweight, and is tractor-mounted. It consists of two separate units, a straw management unit and a sowing unit. The *happy seeder* cuts, lifts and throws the standing stubble and loose straw and sows in one operational pass of the field while retaining the rice residue as surface mulch. It has thus the capability of managing the total loose straw and cutting rice residue in strips, which are thrown in front of each furrow opener.

Consequently, burning of paddy and wheat straw in the fields has been banned in the state of Punjab.

## **POLICY SUGGESTIONS**

- Land degradation problem can be tackled to an extent by suitable policies that would internalize degradation into proper decision-making, wherever possible. Inappropriate policy choices in the Indian context like free or highly subsidized pricing of electricity for tube well irrigation, heavily subsidized surface water for irrigation and subsidized chemical inputs have aggravated the problem. For example, overuse of poor quality tube well water has led to soil salinity. Economic instruments in the form of balanced incentives will be a cost-effective measure to encourage farmers to adopt soil conservation practices. For problems

regarding over-application of chemical inputs, in the long run, conjunctive use of chemical inputs with bio-inputs along with farm residue is the only answer.

- At the macro level, the existing database on land use statistics cannot adequately facilitate the analysis of land degradation and its impact. Modifications in the classification of land use statistics are needed in order to study its environmental impacts. Advanced technology like Remote Sensing can go a long way in helping generate better information on the different dimensions of land degradation.
- The information base on which farmers make decisions is incomplete with respect to internalizing rapid changes in soil and water quality variables, by moving towards more sustainable practices such as integrated pest management and land-conserving crop rotations. Research needs to be focused on measures such as integrated crop management. An integrated approach to the problem of degradation, linking agriculture and environment, is yet to be attempted even at the policy level.
- Farm research should address the issue of balancing the external inputs usage and the internal sources of nutrients. Thus from a policy perspective, there is a need for public and private initiative on several fronts - increased investment in

resource management, research and extension; research to develop suitable and more sustainable cropping patterns and rotations; correction of price distortions on key inputs, especially water and electricity; and special incentives to invest in bio-inputs and also inputs like gypsum, which helps in reclamation of salt-affected soil. Such policy interventions may be rewarding if they can counteract the environmentally perverse land use. However, costs of such interventions have to be considered against their potential benefits, before making definite policy prescriptions.

- Develop and implement viable models of public-private partnerships for setting up and operating secure landfills, incinerators, and other appropriate techniques for the treatment and disposal of toxic and hazardous waste, both industrial and biomedical, on payment by users, taking the concerns of local communities into account.
- Develop and implement strategies for cleaning up toxic and hazardous waste dump legacies, particularly in industrial areas, and abandoned mines, and work towards reclamation of such lands for future sustainable use.

## REFERENCES

- Annual Report 2007-08, Ministry of Rural Development
- Annual Report 2007-08, Ministry of Agriculture
- Badrinath K. V. S., Kiran Chand T. R. and Krishna Prasad V. (2006). Agriculture Crop Residue Burning in the Indo-Gangetic Plains - A study using IRS-P6 AWiFS satellite data. *Current Science*. Vol. 91(8), 1085-1089

- Benbi D. K., Nayyar V.K. and Brar J.S. (2006). The Green Revolution in Punjab: Impact on Soil Health. *Indian Journal of Fertilizers*. Vol 2(4), 57-66
- Compendium of Environment Statistics India 2007, Ministry of Statistics & Programme Implementation
- Economic Survey of India 2007-08, Ministry of Finance
- Dr Dewaram A. Nagdeve (2004). Environment and Health in India. *Population & Environment*. Vol 25 (5), 461-473
- Dr G. Mythili. Intensive Agriculture and its Impact on Land Degradation, Center of Excellence, Madras School of Economics
- National Environmental Policy 2006, Ministry of Environment and Forests
- 3<sup>rd</sup> National Report on Implementation of the United Nations Convention to Combat Desertification 2006, Ministry of Environment & Forests
- Sidhu B. S. and Beri V. (1989). Effects of Crop Residue Management on the Yields of Different Crops and on Soil Properties. *Biol. Wastes*. 27, 15-27
- Status of Environment Punjab 2007, Punjab State Council for Science & Technology
- State of Forest Report 2005, Forest Survey of India, Ministry of Environment & Forests
- Wasteland Atlas of India, 2005, Department of Land Resources, Ministry of Rural Development
- Ministry of Statistics & Programme Implementation, Government of India



Prevention of coastal erosion at Kanya Kumari

# AIR

In India, air pollution is proving to be an issue of concern. India's ongoing population explosion along with rapid urbanization and industrialization has placed significant pressure on its infrastructure and natural resources. While industrial development has contributed significantly to economic growth in India, it has done so at considerable cost to the environment. Air pollution and its resultant impacts can be attributed to emissions from vehicular, industrial and domestic activities. The air quality has been, therefore, an issue of social concern in the backdrop of various developmental activities.

There has been unbalanced industrial growth, unplanned urbanization and deforestation. According to reports, India's urban air quality ranks amongst the world's worst. Of the three million premature deaths in the world that occur each year due to outdoor and indoor air pollution, the highest numbers are assessed to occur in India. Some cities in India have witnessed decline in air pollution levels due to various measures taken by the Governments. In fact, according to a World Bank study, Delhi, Mumbai, Kolkata, Ahmedabad and Hyderabad have seen about 13,000 less premature deaths from air pollution related diseases.

## PRESSURES AFFECTING AIR QUALITY

### Population Growth

India has witnessed an explosive growth of population (0.3 billion in the year 1950 to 1.04 billion in the year 2002) accompanied by unplanned urbanization over the last five decades (Figure 2.2.1).

The total population of India is expected to exceed 1.6 billion by the year 2050 (Oldenburg 2005). The population growth has mainly centered on cities with large scale migration of rural population in search of livelihoods. In addition, high population growth rates especially in the Indo-Gangetic (IG) basin has resulted in unbalanced human concentration. The result is that IG basin is one of the most densely populated regions in the world.

This rapidly expanding population, especially in urban areas, is one of the main reasons for environmental concerns in the country. This problem can be narrowed down to many of the large cities in India. Between 1997 and 2020, the population of India's second largest city (Delhi) is expected to grow 1.9 times,

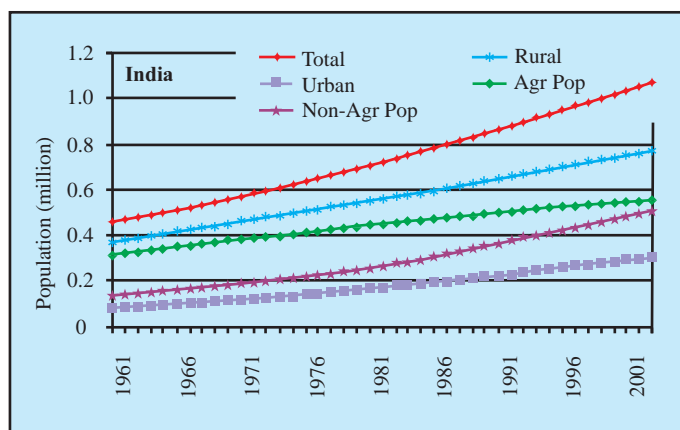


*Industrial emissions : A major cause of air pollution*

i.e. almost double (Bose 1997). The increase in population has been hinting towards an alarming situation. India sustains 16.7 per cent of the world's population on 2.4 per cent of its land area, exerting tremendous pressure on its natural resources. In fact, the growing air pollution menace is deadly for the urban poor in India, 50-60 per cent of whom live in slums.

Following the trends of urbanization and population growth in Indian cities, people buying more vehicles for personal use have perpetuated an increase in vehicles that contribute to vehicular emissions containing pollutants such as sulfur dioxide, nitrogen oxides, carbon monoxide, lead, ozone, benzene, and hydrocarbons (Goyal 2005).

**Figure 2.2.1: Total Rural, Urban, Agricultural Population Growth (Agr Pop) and Non-Agricultural Population (Non-Agr Pop) for India, Since 1961**



Source: Census, 2001

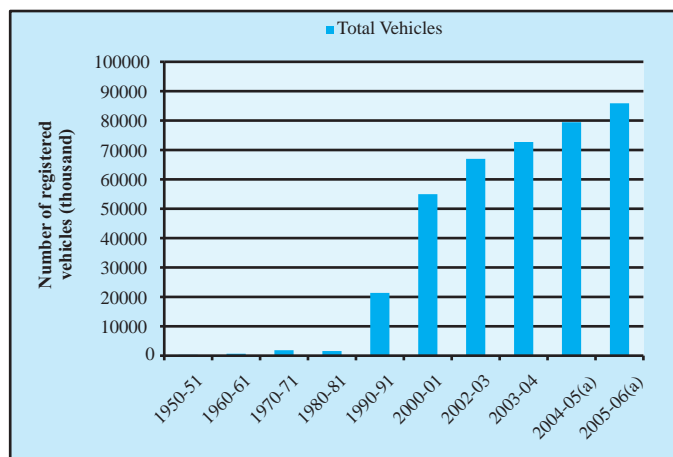
### Vehicular Emission Load

As a result of urbanization in India, pressure on urban transport is likely to increase substantially in this new millennium. Total vehicle population of India is more than 85 million (about 1 per cent share of the world) (Figure 2.2.2). The increase in vehicles, as well as the presence of other motorized forms of transportation (taxis, autos, trains, buses, etc.), will contribute to the already existent large amount of vehicular emissions. The worst thing about vehicular pollution is that it cannot be avoided as the vehicular emissions are emitted at near-ground level.

Following the trend of Delhi's urbanization and the lack of appropriate mass transport system, people buying more vehicles for personal use have perpetuated an increase in vehicles. The amount of registered vehicles in Delhi has increased fifty-one times over a thirty year period. Unbelievably, as much as 17 per cent of the cars in India run in Delhi alone. It has more cars than the total numbers of cars in the individual states of Maharashtra, Tamil Nadu, Gujarat and West Bengal. The vehicle stock in Delhi is expected to almost quadruple by the year 2020.

However, there are several ways by which government, industry, and the public can significantly contribute to the twin goals of reducing our dependence on motor vehicles and consequently

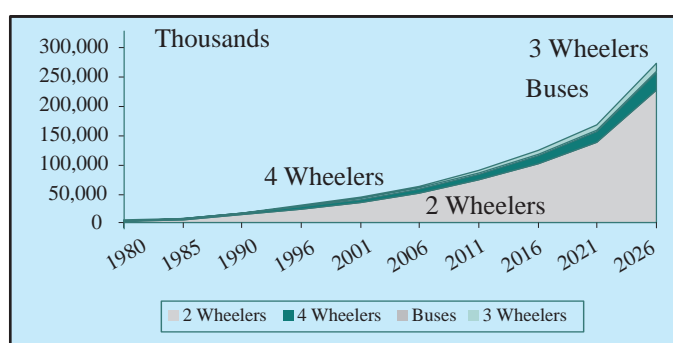
**Figure 2.2.2 : Total Registered Motor Vehicles in India**



Note : (a) provisional

Source: Economic Survey of India, 2007-2008, Ministry of Finance

**Figure 2.2.3: Vehicular Growth in India**



Source: Transportation economics and environmental issues that influence product strategy, TERI 2003

reducing harmful emissions. A vigilant, informed, and active citizenry will help ensure that air pollution concerns are factored into the way we plan our cities, towns, and transportation systems.

### Industrial Sector Growth

Growth of India's economy is led by a robust performance of the industrial sector (Table 2.2.1 & 2.2.2). The development of a diversified industrial structure, based on a combination of large and small-scale industries, along with growing population has contributed to the growing incidence of air pollution. Impressive growth in manufacturing (7.4 per cent average over the past 10 years) is a reflection of growth trends in the fields of electronics and information technology, textiles, pharmaceuticals, basic chemicals etc. These industries, belong to the 'red category' of major polluting processes designated by the Central Pollution Control Board (CPCB), and have significant environmental consequences in terms of air emissions. The economic boom has also led to an increase in investments and activities in the construction, mining, and iron and steel sectors. This in turn, is causing a significant increase in brick making units, sponge iron plants and steel re-rolling mills that involve highly polluting processes.

Air borne emissions emitted from various industries are a cause of major concern. These emissions are of two forms, viz. solid particles (SPM) and gaseous emissions (SO<sub>2</sub>, NO<sub>2</sub>, CO, etc.). Heavy polluting industries were identified which are included under the 17 categories of highly polluting industries for the purpose of monitoring and regulating pollution from them. The Ministry of Environment and Forests has developed standards for regulating emissions for various industries including thermal power stations, iron and steel plants, cement plants, fertilizer plants, oil refineries, pulp and paper, petrochemicals, sugar, distilleries and tanneries.

**Table 2.2.1 : Annual Growth Rates (Per Cent) For Industries**

Period	Mining	Manufacturing	Electricity	General
(weights)	(10.47)	(79.36)	(10.17)	(100.00)
1995-96	9.7	14.1	8.1	13.0
2000-01	2.8	5.3	4.0	5.0
2001-02	1.2	2.9	3.1	2.7
2002-03	5.8	6.0	3.2	5.7
2003-04	5.2	7.4	5.1	7.0
2004-05	4.4	9.2	5.2	8.4
2005-06	1.0	9.1	5.2	8.2
2006-07	5.4	12.5	7.2	11.6
2007-08				
(Apr-Nov)	4.9 (4.2 <sup>b</sup> )	9.8 (11.8 <sup>b</sup> )	7.0 (7.3 <sup>b</sup> )	9.2 (10.9 <sup>b</sup> )

(a): based on Index of industrial production.  
Base 1993-94=100; figure for April-Nov 2006-07

Source: *Economical Survey of India, 2007-2008, Ministry of Finance*

The industrial units in India are largely located in the states of Gujarat, Maharashtra, Uttar Pradesh, Bihar, West Bengal and Madhya Pradesh. The highest concentration of sulphur dioxide and oxides of nitrogen is, therefore, often found in cities located in these states. Some other industrial states in Delhi, Punjab, Rajasthan and Andhra Pradesh are also becoming critical.

### Power Sector

The power sector is a major consumer of coal, using about 78 per cent of the country's coal production. Coal-fired thermal units

account for around 62.2 per cent of total power generation in the country. Coal is a major energy source catering to India's growing energy needs. It meets about 51 per cent of the country's commercial energy needs, and about 70 per cent of the electricity produced in India comes from coal. Thus, coal continues to be the mainstay for the Indian power sector.

India's heavy reliance on coal explains the country's relatively high carbon intensity level. Coal production through opencast mining, its supply to and consumption in power stations, and industrial boilers leads to particulate and gaseous pollution. Radioactive emissions from nuclear power plants are of grave concern as they can cause serious impact both in terms of spatial and inter-generational effects.

**Table 2.2.2: Sectoral Growth Rates**

(at Factor Cost, 1999-2000 prices)

Year	Agriculture	Industry	Services	Total
2002-03	-7.2	7.1	7.4	3.8
2003-04	10.0	7.4	8.5	8.5
2004-05	0.0	9.8	9.6	7.5
2005-06 (QE)	6.0	9.6	9.8	9.0
2006-07 (RE)	2.7	10.9	11.0	9.4
<b>Average: Tenth Plan</b>	2.1	8.9	9.3	7.6

Note: QE – Quick Estimates ; RE – Revised Estimates

Source: *Annual Report, 2007-2008, Planning Commission*

In 2006-07, India had encountered 495.54 million tonne/year of total absolute emissions of CO<sub>2</sub> from the power sector (Table 2.2.3). However, the contribution of India to the cumulative global CO<sub>2</sub> emissions is only 5 per cent. Thus historically, and at present, India's share in the carbon stock in the atmosphere is relatively very small when compared to its population. With high capital costs associated with replacing existing coal-fired plants and the long time required to introduce advanced coal technologies, many of India's highly polluting coal-fired power plants are expected to remain in operation for the next couple of decades, thereby keeping India's carbon emissions on the rise.

**Table 2.2.3: Total Absolute Emissions of CO<sub>2</sub> (Million Tonnes/Year) From the Power Sector by Region for 2000-01 to 2006-07**

Region	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
1	2	3	4	5	6	7	8
North	97.87	102.74	106.81	110.00	112.21	120.10	129.55
East	58.03	61.43	66.59	75.51	83.96	92.52	93.36
South	89.02	92.18	105.24	108.12	105.60	101.76	109.25
West	135.19	141.60	148.56	144.13	157.78	153.93	157.72
North-East	2.21	2.16	2.29	2.46	2.47	2.53	2.65
<b>India</b>	<b>382.31</b>	<b>4000.11</b>	<b>429.48</b>	<b>440.22</b>	<b>462.02</b>	<b>470.85</b>	<b>495.54</b>

Source: *Compendium of Environment Statistics - India, 2007*

## Agricultural Waste Burning

Almost all the leading newspapers of northern India published reports on the incident of a thick cloud of smog that enveloped many parts of Punjab and Haryana on 15 October, 2005. People experienced reduced visibility, besides irritation in the eyes and throat. This smog was attributed to the large scale burning of rice straw by farmers.

Punjab alone produces around 23 million tonnes of rice straw and 17 million tonnes of wheat straw annually. More than 80 per cent of paddy straw (18.4 million tonnes) and almost 50 per cent wheat straw (8.5 million tonnes) produced in the state is being burnt in fields every year.

Apart from affecting the soil fertility, this also causes air pollution due to emission of large amounts of suspended particulate matter, besides gases like CH<sub>4</sub>, CO, NO<sub>2</sub>, SO<sub>2</sub>, etc., leading to various health hazards like respiratory, skin and eye diseases. Intensive agriculture is also a contributor to greenhouse gases (GHG) like carbon dioxide, methane and nitrous oxide, causing climate change. At an all India level, emissions from the agriculture sector are reported to be 28 per cent of the aggregate national emissions. These include emissions from enteric fermentation in livestock, manure management, rice cultivation and burning of agricultural crop residues.

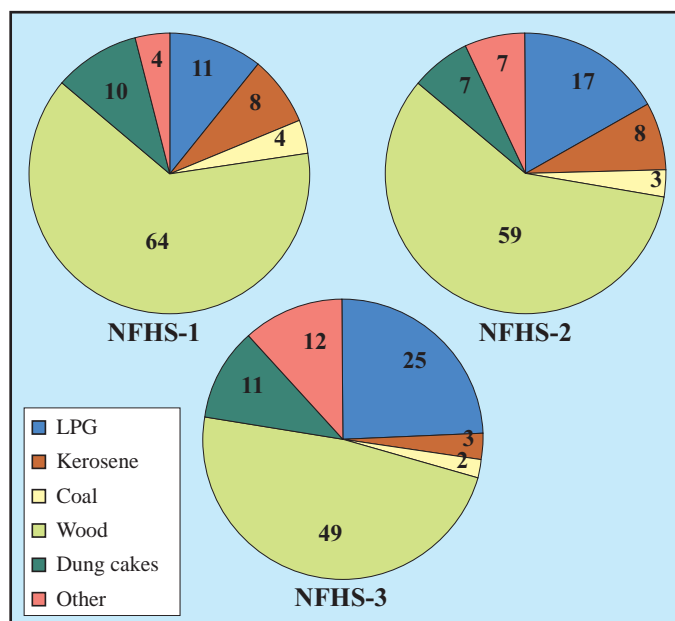
The National Remote Sensing Agency (NRSA), Hyderabad (Badrinath *et al.*, 2006) conducted a study to calculate the total emissions produced from straw-burning during the harvesting season in Punjab. The calculated total emissions suggested that wheat crop residue burning contributed to about 113 Gg (Giga gram: 10 billion gram or 10 million kg) of CO, 8.6 Gg of NO<sub>x</sub>, 1.33 Gg of CH<sub>4</sub>, 13 Gg PM<sub>10</sub> (smoke) and 12 Gg of PM<sub>2.5</sub> during May 2005.

The extent of paddy crop residue burning in Punjab only during October 2005 had been estimated to be in an area of 12,685 sq. km., which is much higher than the wheat crop residue burning that occurs during the month of May each year. Emissions from burning paddy fields were estimated to be 261 Gg of CO, 19.8 Gg of NO<sub>x</sub>, 3 Gg of CH<sub>4</sub>, 30 Gg of PM<sub>10</sub> and 28.3 Gg of PM<sub>2.5</sub> during October 2005.

## Domestic Sector - Indoor Air Pollution

A considerable amount of air pollution results from burning of fossil fuels. The household sector is the second largest consumer of energy in India after the industrial sector. National Family Health Survey-3 (NFHS-3) found that 71 per cent of India's households use solid fuels for cooking and that 91 per cent of rural households also do the same. According to National Family Health Survey-3, more than 60 per cent of Indian households depend on traditional sources of energy like fuel-wood, dung and crop residue for meeting their cooking and heating needs (Figure 2.2.4). Burning of traditional fuels introduces large quantities of CO<sub>2</sub> in the atmosphere, when the combustion is complete, but if there is an incomplete combustion followed by oxidation, then CO is produced, in addition to hydrocarbons.

Figure 2.2.4: Proportion of Households by Type of Fuel Usage



Source: National Family Health Survey-3, 2005-2006

## STATEWISE AIR QUALITY TRENDS

CPCB has identified a list of polluted cities in which the prescribed National Ambient Air Quality Standards (NAAQS) are violated. Action plans are being formulated and 88 of them are being implemented to control air pollution in non-attainment cities by respective states.

### Ambient Air Quality Trends

Central Pollution Control Board is executing a nation-wide programme of ambient air quality monitoring known as National Air Quality Monitoring Programme (NAMP). The network consists of 342 monitoring stations covering 127 cities/towns in 26 States and 4 Union Territories of the country.

The country-wide ambient air quality monitoring carried out by CPCB at 201 monitoring stations revealed that National Ambient Air Quality Standards (NAAQS) for Respirable Suspended Particulate Matter (RSPM), the main air pollutant of public health concern, were violated at most of the monitoring stations (MoEF, 2005). The estimated annual economic cost of damage to public health from increased air pollution, based on RSPM measurements for 50 cities with the total population of 110 million, reached USD 3 billion (Rs. 15,000 crores) in 2004.

Air quality data and trends highlight an emerging phenomenon of conflicting trends for different categories of cities, similar to that experienced by many other countries, thereby reflecting the complex forces behind the impact of growth on environmental action and outcome.

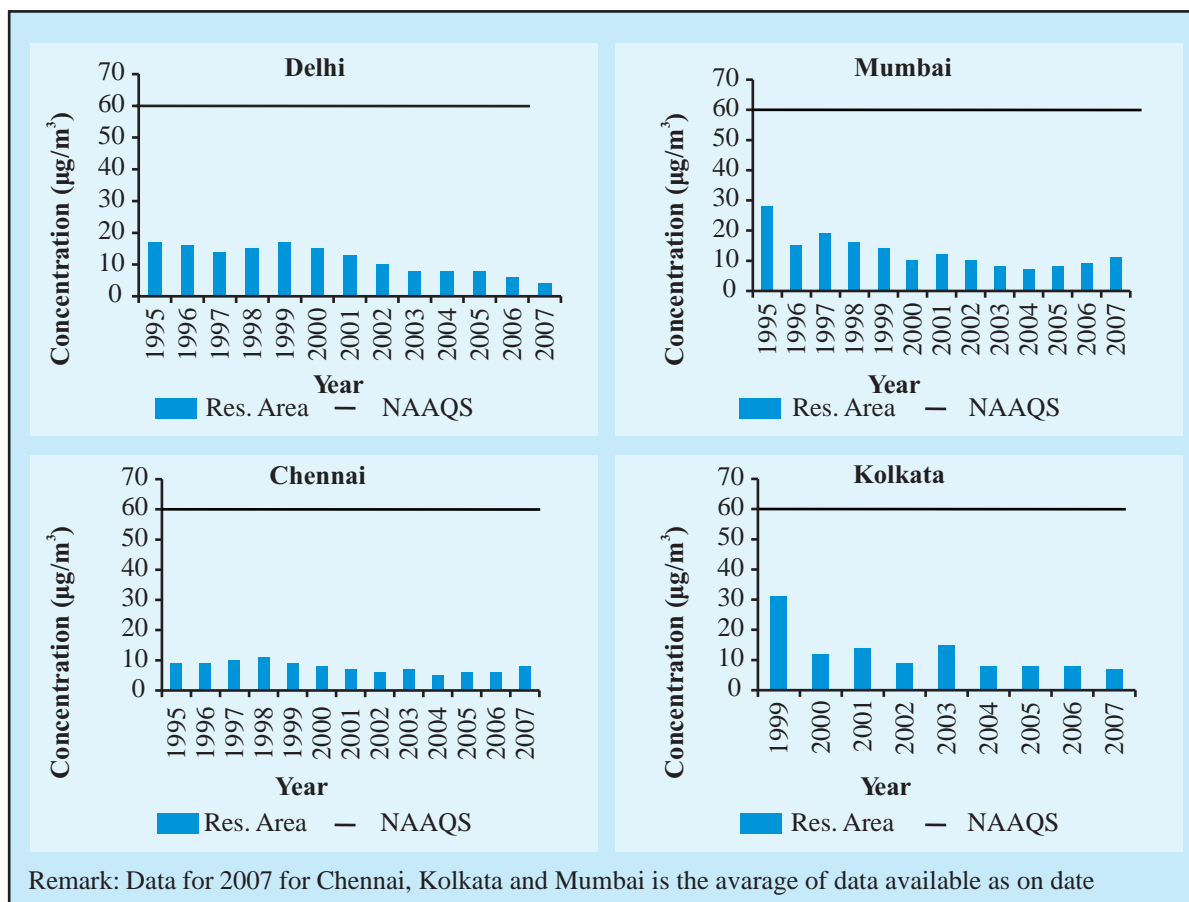
### Sulphur Dioxide (SO<sub>2</sub>)

Annual average concentration of SO<sub>2</sub> levels are within the prescribed National Ambient Air Quality Standards (NAAQS) at

almost all the locations as per the reports of the Central / State Pollution Control Board. A decreasing trend has been observed in SO<sub>2</sub> levels in many cities like Delhi and Mumbai, during the

last few years. This trend may be due to various measures taken, such as reduction of sulphur in diesel etc. and use of LPG instead of coal as a domestic fuel (Figure 2.2.5).

**Figure 2.2.5: Trends in Annual Average Concentration of SO<sub>2</sub> in Residential Areas of Delhi, Mumbai, Chennai and Kolkata**



Source: Central Pollution Control Board, 2008

**Table 2.2.4 : Top Ten Locations with respect to SO<sub>2</sub> Emissions During 2007 in Residential Areas**

Sl. No.	Residential Area		
	Location	State	Annual Average conc.(µg/m <sup>3</sup> )
1	Nashik Municipal Council Building, Nashik	Maharashtra	49
2	Ahirpara, Khurja	Uttar Pradesh	43
3	Gram Panchayat Ghugus, Chandrapur	Maharashtra	39
4	RTO Colony Tank, Nashik	Maharashtra	36
5	Nagar Parishad, Chandrapur	Maharashtra	34
6	Fisheries College, Tuticorin	Tamil Nadu	29
7	AVM Jewellery Building, Tuticorin	Tamil Nadu	28
8	Clock Tower, Dehradun	Uttranchal	27
9	Elbert Ekka Chowk, Ranchi	Jharkhand	22
10	Vishak Hostel, Bhilai	Chhattisgarh	21

Note: Annual average national standard is 60 µg/m<sup>3</sup>

Source: Central Pollution Control Board, 2008

**Table 2.2.5: Top Ten Locations with respect to SO<sub>2</sub> Emissions During 2007 in Industrial Areas**

Sl. No.	Industrial Area		
	Location	State	Annual Average Conc. (µg/m <sup>3</sup> )
1	CGCRI, Khurja	Uttar Pradesh	47
2	VIP Industrial Area, Nashik	Maharashtra	44
3	MIDC, Chandrapur	Maharashtra	41
4	Bistupur Vehicle Testing Center, Jamshedpur	Jharkhand	39
5	Golmuri Vehicle Testing Center, Jamshedpur	Jharkhand	37
6	Dombivali MIDC Phase-II	Maharashtra	32
7	Ambernath Municipal Council Office	Maharashtra	29
8	Chemical Div. Labour Club, Nagda	Madhya Pradesh	28
9	Raunag Auto Limited, Gajraula	Uttar Pradesh	28
10	Raja Agencies, Tuticorin	Tamil Nadu	28

Note: Annual average national standard is 80 µg/m<sup>3</sup>

Source: Central Pollution Control Board, 2008

The highest concentration amongst all residential areas was observed at the monitoring station located in Nashik Municipal Corporation Building, Nashik and the highest concentration from the industrial areas was observed at the monitoring station located at CGCRI, Khurja, U.P. during 2007, although SO<sub>2</sub> levels at none of the monitoring stations exceeded the NAAQS (Table 2.2.4 & 2.2.5).

### Nitrogen Dioxide (NO<sub>2</sub>)

During the last few years, a decreasing trend has been observed in nitrogen dioxide levels due to various measures taken for vehicular pollution control such as stricter vehicular emission norms. Vehicles are one of the major sources of NO<sub>2</sub> in the country. However, Delhi observed an increasing trend in the past few years, especially after the introduction of CNG. This alternative fuel is known to emit, comparatively, more NO<sub>2</sub> than diesel and petrol (Figure 2.2.6).

During 2007, the highest concentration of NO<sub>2</sub> among all residential areas was observed at Town Hall, Delhi and from the industrial areas, at Bandhaghat, Howrah. Nonetheless, NO<sub>2</sub> levels at 81 per cent of the monitoring stations in industrial areas and 70 per cent of the monitoring stations in residential areas were found to be lower than the NAAQS (Table 2.2.6 & 2.2.7).

### Particulate Matter

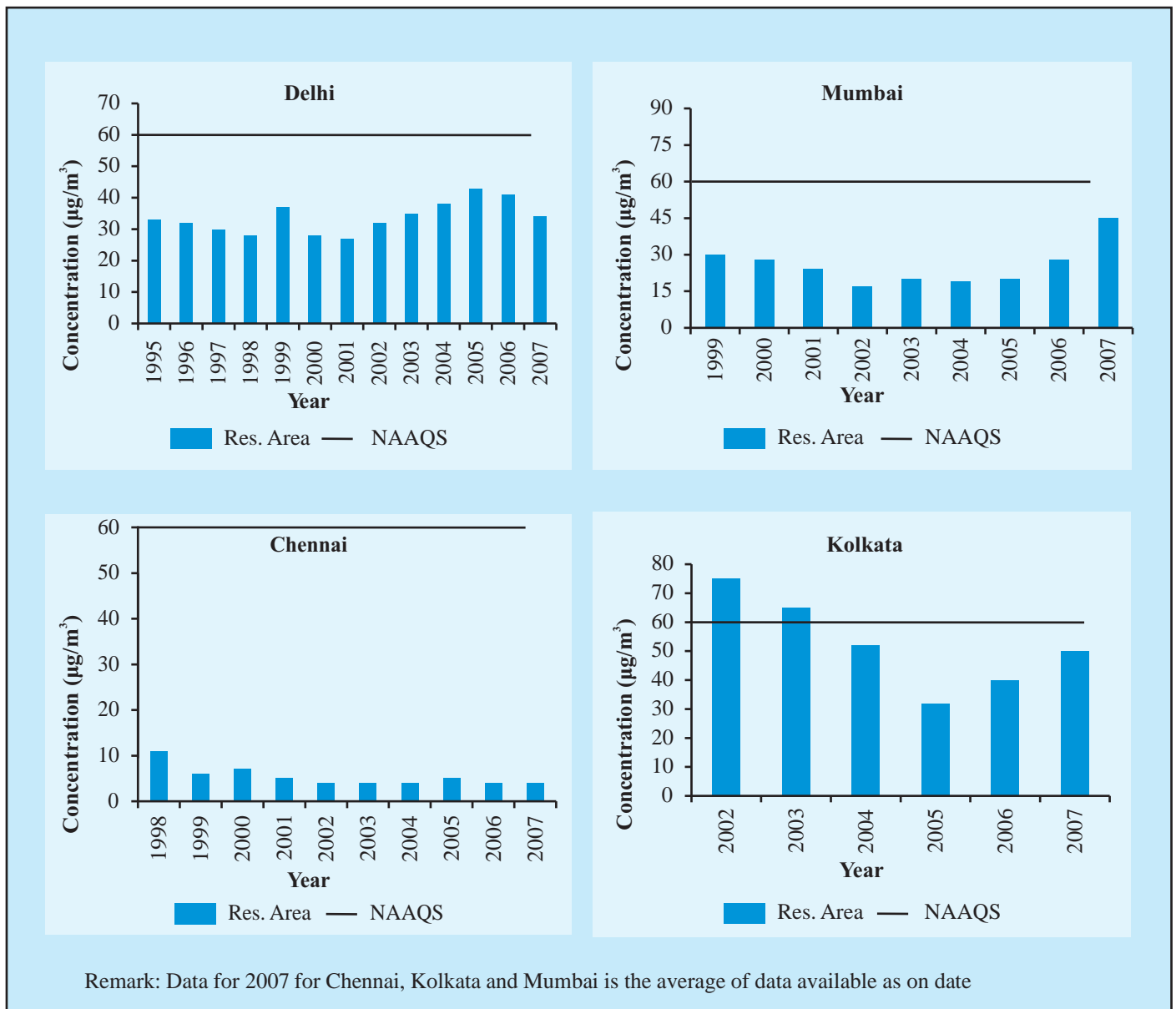
Annual average concentrations of Respirable Suspended Particulate Matter (RSPM) and Suspended Particulate Matter

(SPM) exceeded the NAAQS in most of the cities. In cities like Delhi, this is due to engine gensets, small scale industries, biomass incineration, boilers and emission from power plants, re-suspension of traffic dust and commercial and domestic use of fuels (Figure 2.2.7). A decreasing trend in RSPM however, has been observed in cities like Solapur and Lucknow during the last few years. The probable reason could be corrective measures, like reduction of sulphur in diesel, use of premix 2-T oil dispenser and stringent standard for particulate matter in diesel vehicles. Lower levels of RSPM and SPM are also found to be governed by factors like presence of excellent ventilation effects owing to sea and land breeze, in coastal cities and wet deposition in the month of monsoon.

The highest concentration from residential areas was observed at a monitoring station located at M/s Modi Oil & General Mills, Gobindgarh and in case of industrial areas at Sub-divisional Office, Satna. RSPM level at 51 per cent of the monitoring stations in residential areas and 14 per cent of the monitoring stations in industrial areas, was critical (Table 2.2.8 & 2.2.9).

As far as SPM is concerned, highest concentrations were observed at Town Hall, Delhi and Regional Office, Udaipur from the residential and industrial areas, respectively. The percentage violation of NAAQS (24 hourly avg.) was less than two per cent at 68 monitoring stations of industrial and 30 monitoring stations of residential areas. In the remaining stations, it was two per cent or more (Table 2.2.10 & 2.2.11).

**Figure 2.2.6: Trends in Annual Average Concentration of NO<sub>2</sub> in Residential Areas of Delhi, Mumbai, Chennai and Kolkata**



Source: Central Pollution Control Board, 2008

It is well-known that particulate matter less than 2.5 micron (PM<sub>2.5</sub>) is the most harmful particle as it reaches the alveolar region (i.e. blood and gas exchange region) of the respiratory tract, causing various respiratory and cardiovascular ailments. It has also been established that fine particles are more prone to get enriched with toxic and carcinogenic substances than the coarse particles.

Recognizing its importance, CPCB has initiated the monitoring of PM<sub>2.5</sub> in some major cities.

Particulate matter with size less than 2.5 micrometre (PM<sub>2.5</sub>) was measured at BSZ Marg (ITO), New Delhi using continuous analyzers (Figure 2.2.8). The annual average concentration of PM<sub>2.5</sub> was found to be 102 µg/m<sup>3</sup> during 2007. The monthly average concentration of PM<sub>2.5</sub> varied from 34 µg/m<sup>3</sup> to

198 µg/m<sup>3</sup>, change in climatic conditions being a decisive factor. Presence of lesser volume of troposphere in the winter season, aided easy mixing resulting in higher concentrations. Similarly, lower concentrations were observed in monsoon months as particulate matter is washed out due to wet deposition.

## NOISE POLLUTION

Of late, noise has been recognized as a pollutant which until recently was considered only a nuisance. The Central Pollution Control Board (CPCB) notified the ambient noise standards, in 1987 under section 20 of the Air (Prevention and Control of Pollution) Act, 1981. The noise standards specify 55 dB (A) and 45 dB (A) as limits for day and night time, respectively, for residential areas; 75 dB (A) and 70 dB (A) in the day and night

**Table 2.2.6: Top Ten Locations with respect to NO<sub>2</sub> During 2007 in Residential Areas**

Residential Area			
Sl. No.	Location	State	Annual Average conc. (µg/m <sup>3</sup> )
1	Town Hall, Delhi	Delhi	82*
2	Maulali, Kolkata	West Bengal	76*
3	Ghuseri Naskarpara, Howrah	West Bengal	68*
4	Gandhi Maidan, Patna	Bihar	67*
5	Salt Lake, Kolkata	West Bengal	66*
6	Sarojini Nagar, Delhi	Delhi	65*
7	Minto Park, Kolkata	West Bengal	65*
8	Bator, Howrah	West Bengal	57
9	Lal Bazaar, Kolkata	West Bengal	54
10	Regional Office, Dhanbad	Jharkhand	52

\*- Locations where annual mean concentration of NO<sub>2</sub> exceeded the NAAQS of 60 µg/m<sup>3</sup> for Residential areas

Source: Central Pollution Control Board, 2008

**Table 2.2.7: Top Ten Locations with respect to NO<sub>2</sub> During 2007 in Industrial Areas**

Industrial Area			
Sl. No.	Location	State	Annual Average conc. (µg/m <sup>3</sup> )
1	Bandhaghat, Howrah	West Bengal	91*
2	Behala Chowrasta, Kolkata	West Bengal	73
3	Howrah Municipal Corporation, Howrah	West Bengal	73
4	Mayapuri Industrial Area, Delhi	Delhi	70
5	Dew India Ltd, Durgapur	West Bengal	65
6	Dunlop Bridge, Kolkata	West Bengal	62
7	Cossipore, Kolkata	West Bengal	60
8	Kwality Hotel, Durgapur	West Bengal	59
9	Asansol Municipal Corporation, Asansol	West Bengal	57
10	Bistupur Vehicle Testing Center, Jamshedpur	Jharkhand	53

\*- Locations where annual mean concentration of NO<sub>2</sub> exceeded the NAAQS of 80 µg/m<sup>3</sup> for Industrial areas

Source: Central Pollution Control Board, 2008

time for industrial areas and 50 dB (A) and 40 dB (A) in the day and night time for silence zones.

For residential areas, average noise level exceeds the day as well as night time limit for major cities. The situation is worse in silence zone areas.

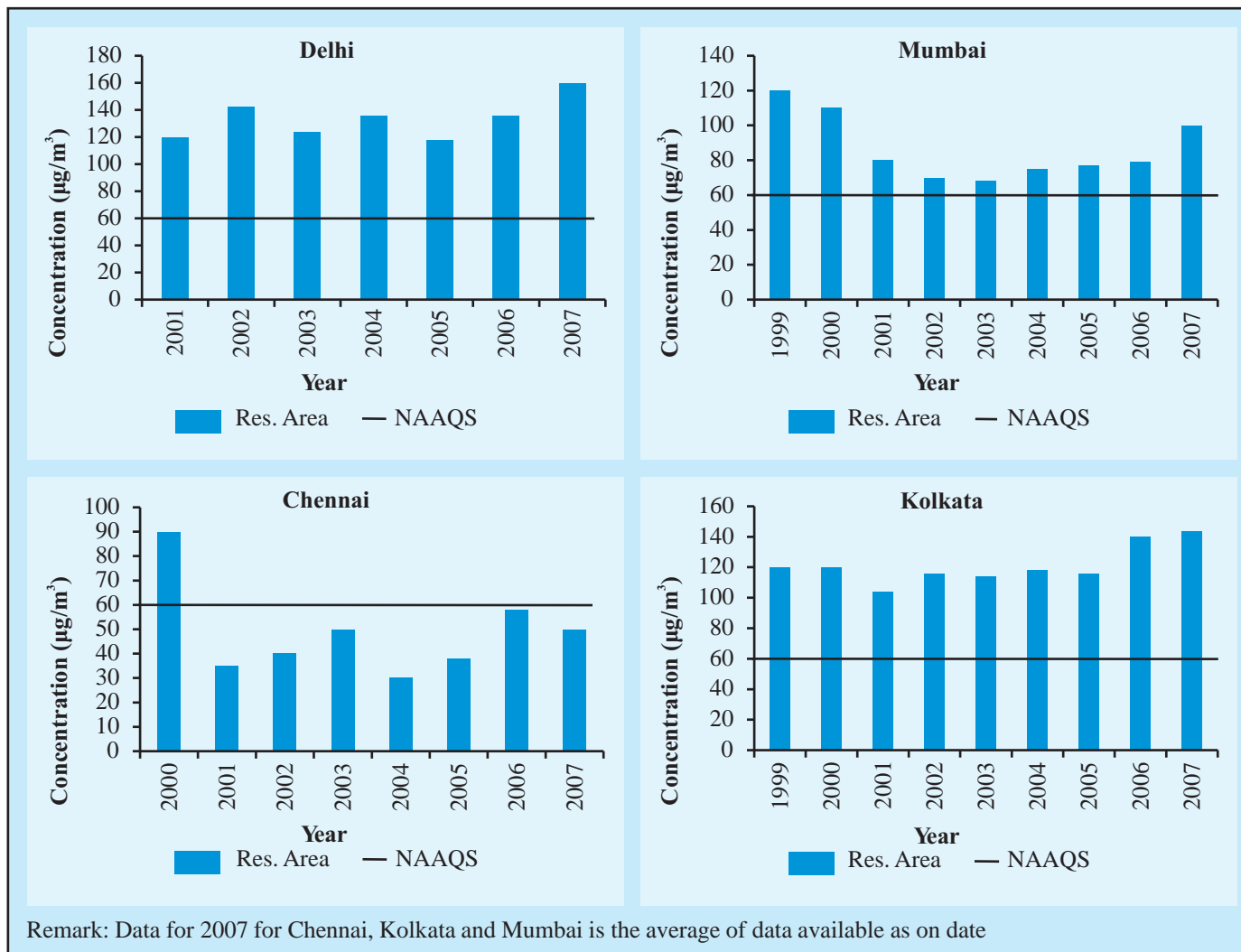
There are significant health impacts of noise pollution as depicted in table 2.2.13.

## IMPACT

### Health Problems

Air quality is deteriorating especially in metropolitan cities, mainly due to vehicular emissions. There is evidence that the health of over 900 million urban people around the world is deteriorating daily because of high levels of ambient air pollutants. The toxicology of air pollution is very complex as

**Figure 2.2.7: Trends in Annual Average Concentration of RSPM in Residential Areas of Delhi, Mumbai, Chennai and Kolkata**



Source : Central Pollution Control Board, 2008

**Table 2.2.8: Top Ten Locations with respect to RSPM During 2007 in Residential Areas**

Sl. No.	Residential Area		
	Location	State	Annual Average Conc. (µg/m³)
1	M/s Modi Oil & General Mills, Gobindgarh	Punjab	252*
2	PPCB Office Building, Ludhiana	Punjab	231*
3	Ahirpara, Khurja	Uttar Pradesh	201*
4	Deputy Ka Padao, Kanpur	Uttar Pradesh	198*
5	Town Hall, Delhi	Delhi	198*
6	Kidwai Nagar, Kanpur	Uttar Pradesh	197*
7	A S School, Khanna	Punjab	196*
8	Aminabad, Lucknow	Uttar Pradesh	193*
9	Aliganj, Lucknow	Uttar Pradesh	190*
10	Sharda Nagar, Kanpur	Uttar Pradesh	185*

\*- Locations where annual mean concentration of RSPM exceeded the NAAQS of 60µg/m³ for Residential areas

Source: Central Pollution Control Board, 2008

**Table 2.2.9 : Top Ten Locations with respect to RSPM During 2007 in Industrial Areas**

Industrial Area			
Sl. No.	Location	State	Annual Average Conc.( $\mu\text{g}/\text{m}^3$ )
1	Sub-divisional Office, Satna	Madhya Pradesh	288*
2	Rita Sewing Machine, Ludhiana	Punjab	261*
3	Sahibabad Industrial Area, Ghaziabad	Uttar Pradesh	250*
4	Mayapuri Industrial Area, Delhi	Delhi	233*
5	Markfed Vanaspati, Khanna	Punjab	233*
6	M/s Raj Steel Rolling Mills, Gobindgarh	Punjab	228*
7	Bulandshahar Road Industrial Area, Ghaziabad	Uttar Pradesh	210*
8	CGCRI, Khurja	Uttar Pradesh	209*
9	Center for Development of Glass Industry, Firozabad	Uttar Pradesh	205*
10	VKIA, Jaipur	Rajasthan	202*

\*- Locations where annual mean concentration of RSPM exceeded the NAAQS of  $120 \mu\text{g}/\text{m}^3$  for Industrial areas

Source: Central Pollution Control Board, 2008

**Table 2.2.10: Top Ten Locations with respect to SPM During 2007 in Residential Areas**

Residential Area			
Sl. No.	Location	State	Annual Average Conc.( $\mu\text{g}/\text{m}^3$ )
1	Town Hall, Delhi	Delhi	476*
2	Regional Office, Noida	Uttar Pradesh	447*
3	Kidwai Nagar, Kanpur	Uttar Pradesh	442*
4	Deputy Ka Padoo, Kanpur	Uttar Pradesh	440*
5	Ahirpara, Khurja	Uttar Pradesh	432*
6	Shivpur/Sigra, Varanasi	Uttar Pradesh	422*
7	Sharda Nagar, Kanpur	Uttar Pradesh	421*
8	A-1 Platters, Amritsar	Punjab	411*
9	Aminabad, Lucknow	Uttar Pradesh	402*
10	Jail Chauraha, Jhansi	Uttar Pradesh	402*

\*- Locations where annual mean concentration of SPM exceeded the NAAQS of  $140 \mu\text{g}/\text{m}^3$  for Residential areas

Source: Central Pollution Control Board, 2008

there are different types of pollutants affecting the individual differently.

The pollutants in air, namely -  $\text{SO}_2$ ,  $\text{NO}_x$  and Suspended Particulate Matter (SPM) - damage the human respiratory and cardio-respiratory systems in various ways. The elderly, children, smokers and those with chronic respiratory diseases are the most vulnerable. It has been reported that high levels of pollution affect mental and emotional health too. Elevated levels

of lead in children result in impaired neurological development, leading to lowered intelligence quotient, poor school performance and behavioural difficulties.

A study conducted by All India Institute of Medical Sciences and Central Pollution Control Board in Delhi showed that exposure to higher levels of particulate matter contributed to respiratory morbidity. It indicated that the most common symptoms relating to air pollution were irritation of eyes (44 per cent), cough (28.8

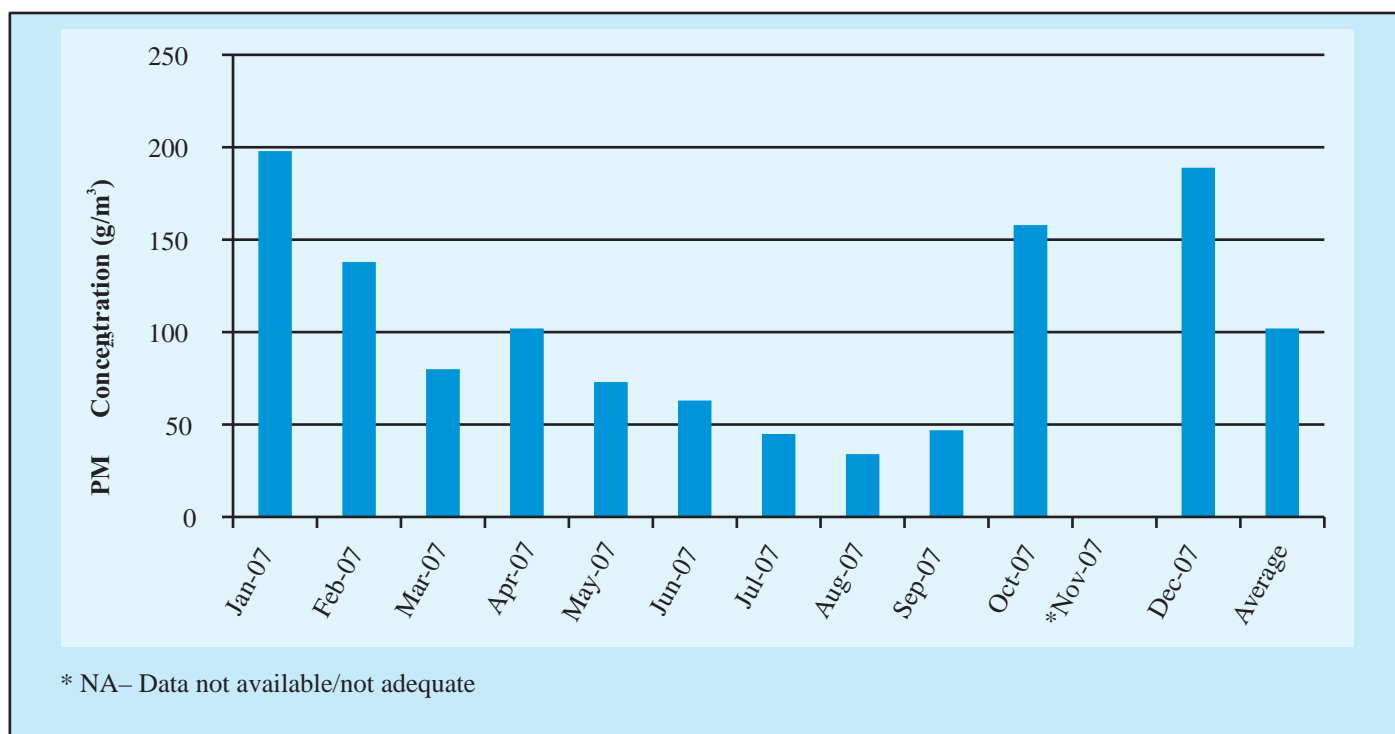
**Table 2.2.11: Top Ten Locations with respect to SPM During 2007 in Industrial Areas**

Sl. No.	Industrial Area		
	Location	State	Annual Average Conc. ( $\mu\text{g}/\text{m}^3$ )
1	Regional Office, Udaipur	Rajasthan	250*
2	Center for Development of Glass Industry, Firozabad	Uttar Pradesh	486*
3	CGCRI, Khurja	Uttar Pradesh	485*
4	Fazalganj, Kanpur	Uttar Pradesh	484*
5	Sahibabad Industrial Area, Ghaziabad	Uttar Pradesh	475*
6	Mayapuri Industrial Area, Delhi	Delhi	461*
7	Jajmau, Kanpur	Uttar Pradesh	444*
8	Shahdara, Delhi	Delhi	440*
9	M/s GEE PEE Electroplating and Engineering Works, Noida	Uttar Pradesh	437*
10	Sub-divisional Office, Satna	Madhya Pradesh	433*

\*- Locations where annual mean concentration of SPM exceeded the NAAQS of  $360 \mu\text{g}/\text{m}^3$  for Industrial areas

Source: Central Pollution Control Board, 2008

**Figure 2.2.8: Concentration of  $\text{PM}_{2.5}$  ( $\text{g}/\text{m}^3$ ) at Bahadur Shah Zafar Marg (ITO), Delhi During 2007**



Source: Central Pollution Control Board, 2008

per cent), pharyngitis (16.8 per cent), dyspnea (16 per cent) and nausea (10 per cent). In Mumbai, the prevalence of both symptoms and signs of such diseases is around 22.2 per cent.

Among the six major communicable diseases, maximum cases (2,58,07,722) were reported for Acute Respiratory Infection while maximum number of people (7,073) died due to Pulmonary Tuberculosis in India, during the year 2006 (Figure 2.2.9).

### Climate Change

India is a fast growing economy and has many future developmental targets, several of which are directly or indirectly linked to energy and therefore increased green house gas emissions.

Though the contribution of India to the cumulative global  $\text{CO}_2$  emissions is only 5 per cent but impacts could be severe at local level. India has nearly 700 million rural population directly

**Table 2.2.12: Average Noise Levels (dB[A]) in Various Metropolitan Cities**

Sl. No.	Metropolitan Cities	Day/ Night	Industrial Area	Commercial Area	Residential Area	Silence Area
1	Kolkata	Day	78	82	79	79
		Night	67	75	65	65
2	Mumbai	Day	76	75	70	66
		Night	65	66	62	52
3	Chennai	Day	71	78	66	63
		Night	66	71	48	49
4	Bangalore	Day	78	76	67	67
		Night	53	57	50	--

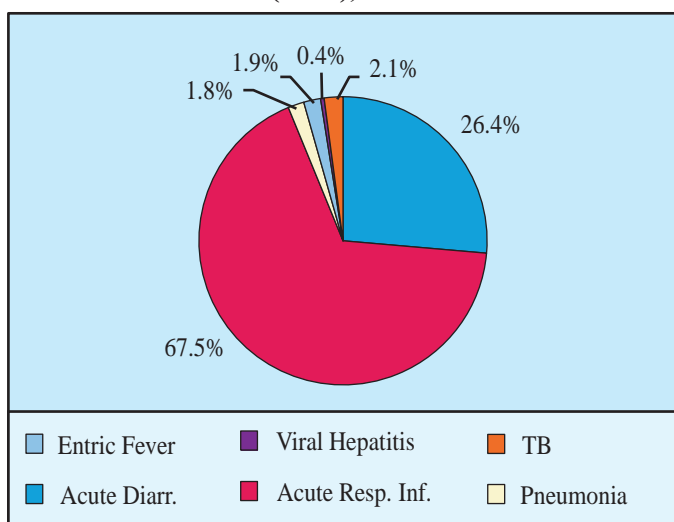
Source: Compendium of Environment Statistics India, 2007

**Table 2.2.13: Effects of Noise Pollution on Human Health**

A. Noise Hazards	
<b>Stage: I</b> Threat to Survival (a) Communication interference (b) Permanent hearing loss	<b>Stage: II</b> Causing injury (a) Neural-humoral stress response (b) Temporary hearing loss (c) Permanent hearing loss
B. Noise Nuisances	
<b>Stage III</b> Curbing Efficient Performance (a) Mental Stress (b) Task Interference (c) Sleep Interference	<b>Stage IV</b> Diluting Comfort and Enjoyment (a) Invasion of privacy (b) Disruption of Social Interaction (c) Hearing Loss

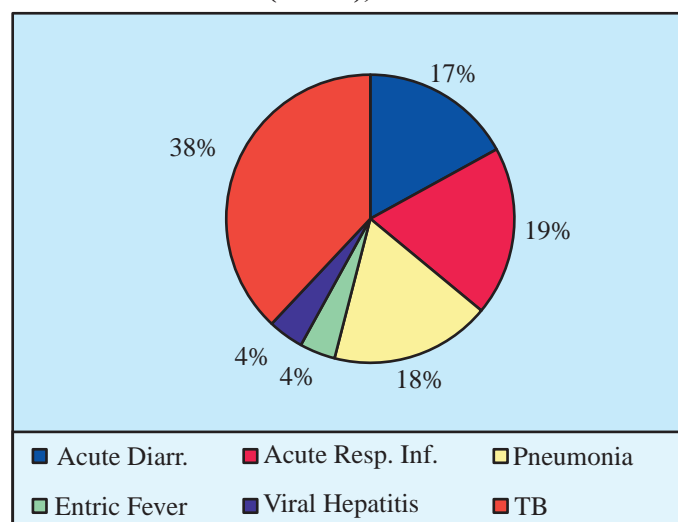
Source: West Bengal Pollution Control Board, 2008

**Figure 2.2.9: Six Major Communicable Diseases (cases), 2006**



Source: Monthly Health Condition from Directorate of Health Services of States/UTs

**Figure 2.2.10: Six Major Communicable Diseases (deaths), 2006**



Source: Monthly Health Condition from Directorate of Health Services of States/UTs

**Table 2.2.14: Prevalence of Tuberculosis by Type of Housing and Fuels/Cooking Arrangements**

Sl.No.	Cooking fuel	Number of persons per 100,000 suffering from		
		Tuberculosis <sup>2</sup>	Medically treated tuberculosis	Number of usual residents
1	Electricity or gas <sup>1</sup>	220	217	124,028
2	Kerosene	564	550	13,511
3	Coal/lignite/charcoal	472	436	12,001
4	Wood	463	430	257,123
5	Straw/shrubs/grass	1,012	924	28,038
6	Agriculture crop residues	703	703	20,872
7	Dung cakes	440	416	65,681
8	Other	755	755	640
	Total	445	418	522,027

Note: Total include usual residents with missing information on cooking fuel, place for cooking, and type of fire/stove among households using solid fuels who are not shown separately.

<sup>1</sup>Includes natural gas, and biogas.

<sup>2</sup>Includes coal, lignite, charcoal, wood, straw/shrubs/grass, agriculture crop waste and dung cakes.

Source: NFHS-3, 2005-2006

depending on climate sensitive sectors (agriculture, forests and fisheries) and natural resources for their subsistence and livelihoods. Further, the adaptive capacity of dry land farmers, forest dwellers, fisher folk and nomadic shepherds is very low.

Climate change is likely to impact all the natural ecosystems as well as socio-economic systems as shown by the National Communications Report of India to the UNFCCC.

#### Acid Rain

Acid rain is the direct consequence of air pollution caused by gaseous emissions (carbon monoxide, sulphur dioxide, nitrogen oxides) from industrial sources, burning of fuels (thermal plants, chimneys of brick-kilns or sugar mills.) and vehicular emissions. The most important effects of acid rain are damage to freshwater aquatic life, vegetation and damage to buildings and material.

In India, the main threat of an acid rain disaster springs from our heavy dependence on coal as a major energy source. Even though Indian coal is relatively low in sulphur content, what threatens to cause acid rain in India is the concentrated quantity of consumption, which is expected to reach very high levels in some parts of the country by 2020. As energy requirements in India are growing rapidly in tune with the growing economy, coal dependence in the country is expected to grow threefold over the current level of consumption, making the clouds of acid rain heavier over many highly sensitive areas in the country like the northeast region, parts of Bihar, Orissa, West Bengal and coastal areas in the south. Already, the soils of these areas have a low pH value, which acid rain will aggravate further making them infertile and unsuitable for agriculture.

The prospect of increasing consumption of coal in Asia makes the acid rain threat even more real than ever. Possible options for mitigation are: radical improvements in energy efficiency, a switchover to low sulphur fuels like natural gas, greater use of

renewables, major cut-down and removal of sulphur from crude oil distillates like diesel, fuel oil, etc., and finally, the widespread use of state-of-the-art pollution control devices in all polluting sectors of the economy.

## IMPACTS OF INDOOR AIR POLLUTION

Use of solid fuel (wood, animal dung, crop residue/grasses, coal, and charcoal) exposes people to high levels of toxic air pollutants, which result in serious health consequences. National Family Health Survey-3 (NFHS) found that 71 per cent of India's urban households and 91 per cent of rural households use solid fuels for cooking purposes.

There is a great deal of variation in the prevalence of TB according to the type of cooking fuel the household uses. It ranges from a low of 217 per 100,000 residents, (among households using electricity, liquid petroleum gas, natural gas, or biogas), to a high of 924 per 100,000 (among households using straw, shrubs, or grass for cooking). High TB prevalence is also seen amongst households using agricultural crop residue (703/100,000) or other fuels not specified in the table (755/100,000)(Table 2.2.14).

Studies have found that besides TB, acute respiratory infections, chronic obstructive pulmonary disease, asthma, lung cancer, ischaemic heart disease and blindness can also be attributed to indoor air pollution.

## RESPONSE

### 1. Air (Prevention and Control of Pollution) Act, 1981

- Government of India enacted the Air (Prevention and Control

of Pollution) Act, 1981 to arrest the deterioration in the air quality. The Act prescribes various functions for the Central Pollution Control Board (CPCB) at the apex level and State Pollution Control Boards at the state level. The main functions of the Central Pollution Control Board are as follows:

- To advise the Central Government on any matter concerning the improvement of the quality of the air and prevention, control and abatement of air pollution.
- To plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution.
- To provide technical assistance and guidance to the State Pollution Control Board.
- To carry out and sponsor investigations and research related to prevention, control and abatement of air pollution.
- To collect, compile and publish technical and statistical data related to air pollution; and
- To lay down standards for the quality of air.

**The main functions of the State Pollution Control Boards are as follows:**

- To plan a comprehensive programme for prevention, control and abatement of air pollution and to secure the execution thereof.
- To advise the State Government on any matter concerning prevention, control and abatement of air pollution.
- To collect and disseminate information related to air pollution.
- To collaborate with the Central Pollution Control Board in

programmes related to prevention, control and abatement of air pollution; and

- To inspect air pollution control areas, assess quality of air and to take steps for prevention, control and abatement of air pollution in such areas.

## 2. National Air Quality Monitoring Programme

- Central Pollution Control Board is executing a nation-wide National Air Quality Monitoring Programme (NAMP). The network consists of 342 operating stations covering 127 cities/towns in 26 States and 4 Union Territories of the country.
- The objectives of the NAMP are to determine the status and trends of ambient air quality; to ascertain whether the prescribed ambient air quality standards are violated; to assess health hazards and damage to materials; to continue the ongoing process of producing periodic evaluation of air pollution situation in urban and industrial areas of the country; to obtain the knowledge and understanding necessary for developing preventive and corrective measures and to understand the natural cleansing processes undergoing in the environment through pollution dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated.
- Under the NAMP, four air-pollutants viz., SO<sub>2</sub>, Oxides of Nitrogen as NO<sub>2</sub>, SPM and RSPM (PM<sub>10</sub>), have been identified for regular monitoring at all the locations.
- Keeping in view the monitored data available on air quality, the Hon'ble Supreme Court, in its various judgments, has



*More vehicles means more air pollution*

**Table 2.2.15: Gasoline Lead Phase Out Programme**

Phase	Date of Introduction	Lead Content	Areas Covered
Phase-I	June 1994	Low lead (0.15 g/l)	Delhi, Mumbai, Kolkata, Chennai
Phase-II	1.4.1995	Unleaded (0.013 g/l)+ low leaded	Delhi, Mumbai, Kolkata, Chennai
Phase-III	1.1.1997	Low leaded	Entire Country
Phase-IV	1.9.1998	Only unleaded	National Capital Territory (NCT)
Phase-V	31.12.1998	Unleaded+Low leaded	Capitals of States & UTs
Phase-VI	1.9.1998	Unleaded	National Capital Region (NCR)
Phase-VII	1.2.2000	Unleaded	Entire Country

Source: Central Pollution Control Board, 2008

**Table 2.2.16: Diesel Sulphur Reduction Programme**

Phase	Date of Introduction	Sulphur Content (%)	Areas Covered
Phase-I	April 1996	0.50	Four Metros & Taj
Phase-II	August 1997	0.25	Delhi & Taj
Phase-III	April 1998	0.25	Metro Cities
Phase-IV	January 2000	0.25	Entire Country
Phase-V	April 2000	0.05	NCR-private vehicles
	January 2000	0.05	Mumbai-all vehicles
	March 2001	0.05	NCT-all vehicles
	June 2001	0.05	NCT-all vehicles
	July 2001	0.05	Chennai & Kolkata
Phase-VI	October 2001	0.05	All retail outlets of four metros
Phase-VII	2003	0.05	Ahmedabad, Surat, Agra, Pune & Kanpur
Phase-VIII	2005	0.05	Entire Country
Phase-IX	2005	0.035	10 Metro Cities & Agra
Phase-X	2010	0.035	Entire Country
Phase-XI	2010	0.005	10 Metro Cities

Source: Central Pollution Control Board, 2008

**Table 2.2.17: Gasoline Benzene Reduction Programme**

Date of Introduction	Benzene Content	Areas Covered
Before 1996	No specification	Entire Country
April 1996	5% benzene	Entire Country
April 2000	3% benzene	Metro Cities
November 2000	1% benzene	NCT & Mumbai
2005	1% benzene	All Metro Cities

Source: Central Pollution Control Board, 2008

**Table 2.2.18: Vehicular Pollution Control Measures & Impact on Air Quality in Delhi**

	1994	1996	1998	2000	2001(Jan-June)
Emission Norms of Vehicles	<ul style="list-style-type: none"> <li>Relaxed norms</li> </ul>	<ul style="list-style-type: none"> <li>Emission norms made stringent as compared to 1991</li> </ul>	<ul style="list-style-type: none"> <li>Emission norms made for cat. convertor fitted vehicles made stringent</li> <li>Hot-start replaced by cold-start tests which gives less emissions</li> </ul>	<ul style="list-style-type: none"> <li>Euro-I equivalent norms for all types of vehicles, expert passenger vehicles which are Euro-II equivalent</li> </ul>	<ul style="list-style-type: none"> <li>CNG/LPG Norms finalized</li> </ul>
Fuel Quality Improvement	<ul style="list-style-type: none"> <li>Diesel sulphur 1%</li> <li>Gasoline Lead 0.56 g/l</li> <li>Benzene no limit</li> </ul>	<ul style="list-style-type: none"> <li>Fuel quality specifications notified under EPA for the first time Pb (g/l)=0.15 Diesel S=0.5%</li> </ul>	<ul style="list-style-type: none"> <li>Diesel sulphur reduced to 0.25%</li> <li>Gasoline Benzene reduced to 3%</li> <li>Gasoline Lead phased</li> </ul>	<ul style="list-style-type: none"> <li>Diesel sulphur to reduce 0.05% in selected outlets</li> <li>Gasoline Benzene reduced to 1%</li> <li>Gasoline sulphur with 0.05% max. sulphur in all outlets</li> <li>Low smoke 2-T oil introduced</li> </ul>	<ul style="list-style-type: none"> <li>Diesel with 0.05% sulphur throughout retail outlets in NCT</li> </ul>
Other Measures	-	<ul style="list-style-type: none"> <li>Govt. vehicles to run on CNG/ Catalytic Converter</li> </ul>	<ul style="list-style-type: none"> <li>15 years old commercial vehicles banned</li> <li>Pre-mix 2-T oil in retail outlets</li> </ul>	<ul style="list-style-type: none"> <li>Buses more than 8 years old phased out</li> <li>Replacement of Pre-1990 autos/taxis with vehicles on clean fuels</li> <li>Conversion of Post-1990 autos to CNG initiated</li> <li>Fuel testing lab established</li> </ul>	<ul style="list-style-type: none"> <li>All Auto/taxis and buses to run on CNG</li> <li>At present 1600 buses, 11000 taxis and cars, 25000 autos on CNG</li> </ul>
CO( $\mu\text{g}/\text{m}^3$ )	3343	5587	5450	4686	3069
SO <sub>2</sub> ( $\mu\text{g}/\text{m}^3$ )	42	35	25	18	16
NO <sub>2</sub> ( $\mu\text{g}/\text{m}^3$ )	66	75	63	59	-
Pb( $\mu\text{g}/\text{m}^3$ )	408	312	136	101	-
RSPM( $\mu\text{g}/\text{m}^3$ )	-	-	200	191	163
Vehicle No. (Lakh)	23.72	27.96	31.67	34.0	-
% of Calm Wind	-	-	41.69	43.0	-

Source: Central Pollution Control Board, 2008

**Table 2.2.19: Ambient Air Quality of Delhi - Comparison of Pre-CNG (2000) with 2008\***

Parameter	Prescribed Annual Standard (Residential)	2000	2008*	Percentage Increase/ Decrease
No. of Vehicles (Approx. in Lakhs)		35	55	57
SO <sub>2</sub>	60	18	5	(-72)
NO <sub>2</sub>	60	36	48	33
SPM	140	405	413	2
RSPM	60	159	192	21
CO	2000	4686	2348	(-50)
<p>All values are in µg/m<sup>3</sup></p> <p>*Data of November and December is taken from the year 2007 for averaging the year 2008</p> <p><b>Observations:</b></p> <p># Increase in number of vehicles (57 per cent), NO<sub>2</sub> (33 per cent), SPM (2 per cent) &amp; RSPM (21 per cent)</p> <p># Decrease in SO<sub>2</sub> (72 per cent) &amp; CO (50 per cent)</p>				

Source: Central Pollution Control Board, 2008

identified sixteen cities namely; Hyderabad, Patna, Ahmedabad, Faridabad, Jharia, Bangalore, Pune, Mumbai, Sholapur, Jodhpur, Chennai, Agra, Kanpur, Lucknow, Varanasi and Kolkata as equal to or more polluted than Delhi. Action plans for improvement of air quality in these cities have been drawn.

- The CPCB has evolved a format for preparation of action plans, which has been circulated to all State Pollution Control Boards/Committees. The action plans emphasize on identification of sources of air pollution, assessment of pollution load and adoption of abatement measures for identified sources. Setting up of an inter-departmental task force for implementation of city specific action plans has also been suggested.

### 3. Vehicular Pollution Control Measures

#### I. Vehicular Emission Norms

In order to control vehicular pollution, a road map has been adopted as per the schedule proposed in the Auto Fuel Policy (2002), which includes use of cleaner fuels, automobile technologies and enforcement measures for in-use vehicles through improved Pollution Under Control (PUC) certification system. As per the Policy, Bharat Stage-II norms for new vehicles have been introduced throughout the country from April 1, 2005.

EURO-III equivalent emission norms for all new vehicles, except 2-3 wheelers, have been introduced in 11 major cities from April 1, 2005. To meet Bharat Stage-II, EURO-III and EURO-IV emission norms, matching quality of petrol and diesel is being made available.

The vehicle emission norms in India are detailed below.

- a) During 1990-91, for the first time in India, notified mass emission norms for vehicles at the manufacturing stage as well as for in-use vehicles were implemented. These norms were notified under the EPA, the Motor Vehicle Rules and the Air Act.
- b) The emission norms introduced in 1996 have been crucial in controlling vehicular pollution because of stringency in the norms along with specifications on fuel quality. For the first time, crankcase and evaporative emission norms were introduced.
- c) From April 1995, in the four metros - Delhi, Mumbai, Kolkata and Chennai, passenger cars were allowed to register themselves only if they were fitted with a catalytic converter. Emission norms for such vehicles were stricter by 50 per cent compared to the 1996 norms.
- d) The testing method for passenger car norms was changed from hot start to cold start. This was a more stringent requirement compared to the earlier one.

- e) Year 2000 experienced stricter norms which were already notified in 1997 under the Motor Vehicle Rules. Automobile manufacturers had to undergo major modifications to meet these standards.
  - f) As per the Hon'ble Supreme Court's directions, only private vehicles conforming to at least EURO-I norms are to be registered. Consequently, in Mumbai, EURO- II norms for private vehicles (4 wheelers) was made applicable from 2001. In Kolkata, India-2000 norms (EURO-I) were implemented from November 1999.
  - g) From October 1, 1999 emission norms for agricultural tractors were introduced throughout the country. Bharat Stage-II and Bharat Stage-III emission norms for tractors were scheduled to be implemented from 2003 and 2005 respectively.
  - h) The Bharat Stage-II norms for new 4-wheeler, private non-commercial vehicles were introduced in Mumbai from January 2001 and in Kolkata and Chennai from July 2001 to October 24, 2001.
  - i) Only those taxis were registered in Delhi, which conformed to Bharat Stage-II norms.
  - j) Bharat State-II norms for Diesel 4-wheeler transport vehicles were introduced in NCT from 24th October, 2001, and in Greater Mumbai, Kolkata and Chennai from October 31, 2001.
  - k) An expert committee on the Auto Oil Policy was constituted during September 2001. The interim report of the committee was submitted to the government on January 1, 2000, recommending Bharat Stage-III emission norms for all categories of 4-wheelers in seven mega cities from 2005 and for the rest of the country by 2010. The final report of the committee was submitted in September 2002 and includes the road map for control of vehicular pollution till 2010.
- b) Delhi and Kolkata have introduced the Metro Rail system. The Government of Maharashtra has also developed a master plan for the Mumbai Metro with implementation in three phases over nine corridors. Other states like Karnataka is in the initial phase of implementing Mass Rapid Transit System (MRTS).
  - c) To provide better public transport and to ease congestion, proposals for Bus Rapid Transit System (BRTS) have been approved for Ahmedabad, Bhopal, Indore, Jaipur, Pune, Rajkot, Vijayawada and Visakhapatnam under JNNURM, covering a total length of more than 310 kms.

#### **V. Reduction of Emissions by Using Lubricants**

- a) Specifications of 2T oil for two stroke engine with respect to smoke emissions were notified under the EPA in September 1998, for implementation from April 1, 1999 throughout the country.
- b) Pre-mix 2T oil dispenser has been installed at all petrol filling stations in Delhi so that excessive oil is not being used by the vehicle owners. Sale of loose 2T oil was banned from December 1998 in Delhi and Kolkata.

#### **VI. Technology**

- a) Fitting catalytic converter for new petrol passenger cars was made compulsory from April 1, 1995 in four metros and 45 cities from September 1, 1998.
- b) Two wheeler scooters with four stroke engine were introduced in the market from October 1998.
- c) Registration of only rear engine auto rickshaws was allowed from May 1996 onwards.

#### **VII. Alternate Fuels**

- a) CNG vehicles were introduced in Mumbai and Delhi. At present more than 80,000 CNG vehicles (19000 cars, 49810 autos, 4935 RTVs & 8874 buses) are plying in Delhi and about 23,000 in Mumbai. All city buses were converted to the CNG mode in Delhi.
- b) There are more than 111 CNG filling stations installed in Delhi with an average consumption of 674 tonnes per day of CNG.
- c) Emission norms for CNG & LPG driven vehicles have been notified.
- d) Petrol vehicles are running on ethanol blended (5 per cent) petrol in states of Maharashtra, Andhra Pradesh, Goa, Gujarat, Haryana, Karnataka, Tamil Nadu, Uttar Pradesh, Daman & Diu and Union Territories of Dadar & Nagar Haveli, Chandigarh and Pondicherry.
- e) Planning Commission, Government of India, has announced a National Mission on bio-diesel. Specifications for this have been drafted by the Bureau of Indian Standards (BIS).

#### **VIII. Control of Pollution from In-use Vehicles**

Idling emission norms have been notified for in-use vehicles. Pollution Under Control (PUC) certificates are

### **II. Fuel Quality Specifications**

For the first time, diesel and gasoline fuel quality with respect to environment related parameters was notified under the EPA in April 1996.

All these measures were introduced in phases (Table 2.2.15, 2.2.16 and 2.2.17).

### **III. Traffic Management**

- a) Restrictions have been imposed on goods vehicles during day time from August 1999 in Delhi.
- b) Left lane of the roads have been made exclusive for buses and other HMV (Heavy Motor Vehicles) in Delhi.
- c) Time clocks have been installed at important traffic signals to enable the drivers to switch off their vehicles depending on the time left in the clocks.
- d) More fly-overs and subways have been constructed and T-Junctions have been closed for better traffic flow.

### **IV. Public Transport Systems**

- a) Number of buses have been increased in major cities to encourage the use of public transportation and reduce private vehicle use.

issued for adherence to idling emission norms every 3-6 months. The number of computerized PUC centres in Delhi alone is around 353.

#### IX. Mass Awareness Programmes

- Messages/articles related to vehicular emissions are disseminated through newsletters, pamphlets, newspapers, magazines, television, radio, internet, workshops and summer exhibitions.
- Display of ambient air quality data through display systems in major cities through newspapers, daily news and internet.
- NGOs working on vehicular pollution control are being encouraged for mass awareness campaigns.

#### 4. Industrial Pollution Control

The measures taken for controlling air pollution from industries are as follows:

- Emission standards have been notified under the Environment (Protection) Act, 1986 to check pollution.
- Industries have been directed to install the necessary pollution control equipments in a time bound manner and legal action has been initiated against the defaulting units.
- 24 critically polluted areas have been identified. In all, Action Plan has been formulated for restoration of environmental quality in these areas.
- Environmental guidelines have evolved for siting of industries.
- Environmental clearance is made compulsory for 29 categories of development projects involving public hearing/NGO participation as an important component of the EIA process.
- Environmental audit in the form of environmental statement has been made mandatory for all polluting industries.
- Preparation of Zoning Atlas for setting up industries based on environmental considerations, in various districts of the country, has been taken up.
- Power plants (coal based) located beyond 1000 kms from the pit-head are required to use low ash content coal (not exceeding 34 per cent) with effect from June 1, 2002. Power plants located in the sensitive areas are also required to use low ash coal, irrespective of their distance from the pit-head.

#### POLICY SUGGESTIONS

- Take an integrated approach towards energy conservation and adoption of renewal energy technologies, including hydropower, by appropriately linking efforts to improve conversion, transmission, distribution, and end-use efficiency, and R&D in dissemination of renewable energy technologies. Remove policies, legal, and regulatory barriers in setting up of decentralized generation and



Noise monitoring at Kota

distribution systems for power and other secondary energy forms, based on local primary energy resources.

- Accelerate the national programmes of dissemination of solar cookers and improved fuel wood stoves suited to local cooking practices and biomass resources.
- Strengthen the monitoring and enforcement of emission standards and prepare and implement action plans for both point and non-point sources, relying on a judicious combination of flats and incentive based instruments.
- Formulate a national strategy for urban transport to ensure adequate investment, public and private, in low pollution mass transport systems.
- Promote reclamation of wastelands by energy plantations for rural energy, through multi-stakeholder partnership involving the land-owning agencies, local communities and investors.
- Strengthen efforts for partial substitution of fossil fuels by bio-fuels, through promotion of bio-fuel plantation, promoting relevant research and development, and strengthening regulatory certification of the new technologies.

#### REFERENCES

- Annual Report 2006-07, Central Pollution Control Board
- Annual Report 2006-07, Ministry of Environment & Forests
- Badrinath K. V. S., Kiran Chand T. R. and Krishna Prasad V. (2006). Agriculture Crop Residue Burning in the Indo-Gangetic Plains - A study using IRS-P6 AWiFS satellite data. *Current Science*. Vol. 91(8), 1085-1089
- Bose, Ranjan K., and V. Srinivasachary. (1997). Policies to Reduce Energy Use and Environmental Emissions in the Transport Sector-a Case of Delhi City. *Energy Policy*. Vol. 25, 1137-1150
- Compendium of Environment Statistics India 2007, Ministry of Statistics & Programme Implementation
- ENVIS Centre, Indian Institute of Tropical Meteorology
- Goyal, S. K., S. V. Ghatge, P. Nema, and S. M. Tamhane. Understanding Urban Vehicular Pollution Problem Vis-a-Vis Ambient Air Quality - Case Study of a Megacity ( Delhi,

- India. Environmental Monitoring and Assessment 119 (2005): 557-569. 12 Nov. 2006
- Luthra A. (1999). Vehicular Emissions in India: Retrospect and Prospects. *Environment and People*. Vol. 16(4)
  - Nagdeve D. (2004). Air Pollution in Mega Cities of India, International Institute for Population Sciences
  - National Environment Policy 2006, Ministry of Environment & Forests
  - National Family Health Survey-3 (2005-06), Ministry of Health & Family Welfare
  - National Health Profile 2006, Ministry of Health & Family Welfare
  - National Ambient Air Quality Status 2007, Central Pollution Control Board
  - Oldenburg P. "India" .Microsoft Encarta Encyclopedia. 2005
  - Pradeep Kumar Dadhich. Potential for CCS in India: Opportunities and Barriers Opportunities and Barriers. Expert Group Meeting on Carbon Dioxide Capture and Storage and Sustainable Development. United Nations Department of Economic and Social Affairs, 2007
  - Sagar A., Bhattacharya M. & Joon Vinod (2007). A Comparative Study of Air Pollution - Related Morbidity Among Exposed Population of Delhi. *Indian Journal of Community Medicine*. Vol. 32(4)
  - Status of Environment Punjab 2007, Punjab State Council for Science & Technology
  - India Strengthening Institutions for Sustainable Growth (Country Environmental Analysis), South Asia Environment and Social Development Unit South Asia Region. World Bank, April 2007
  - Society of Indian Automobile Manufacturers. Fuel and Vehicular Technology. 2006



*Stone crushing unit needs dust control systems to minimize air pollution*



# WATER

From the East to the West and from the North to the South, water has defined life in the Indian subcontinent for thousands of years. On an average, the combination of rainfall, surface and groundwater resources have been sufficient for providing adequate water to the Indian population.

Rise in demand and development pressures are changing the scenario of water availability in India. Erosion in the watersheds due to rapid development and poor land management practices is increasing siltation and changing stream hydraulics. Groundwater reserves are becoming more and more depleted even as surface water sources become too polluted for human use. Biodiversity in the country's once extensive wetlands and coastal mangroves is fast declining. To add to this, current socio-economic activities and economic incentives are encouraging the unsustainable consumption of this resource.

The realization that India's water resources need to be more

carefully managed, is leading to the adoption of sustainable water management practices. By managing its water more judiciously, India can avert the crisis that looms large over the future.

## NATIONAL WATER RESOURCES AT A GLANCE

### Surface Water

India is blessed with many rivers. Twelve major river systems drain the subcontinent along with a number of smaller rivers and streams and form a total catchment area of approximately 252.8 Mha. Of the major rivers, the Ganga-Brahmaputra-Meghna system is the biggest, with a combined catchment area of about 110 Mha, which is more than 43 per cent of the catchment area of all the major rivers in the country. Other major rivers with a

Table 2.3.1: Water Availability in India

Sl. No.	Items	Quantity (Cubic Km)
1	Annual Precipitation (including snowfall)	4000
2	Average Annual Availability	1869
3	Per Capita Water Availability (2001) in cubic metres	1820
4	Estimated Utilizable Water Resources	1122
	(i) Surface Water Resources	690 Cu.Km.
	(ii) Ground Water Resources	431 Cu. Km.

Source: Ministry of Water Resources, 2006

**Table 2.3.2: Water Availability- Basinwise**

Sl. No.	Name of the River Basin	Average Annual Availability (cubic km/year)
1	Indus (up to Border)	73.31
2	a) Ganga	525.02
	b) Brahmaputra, Barak & Others	585.6
3	Godavari	110.54
4	Krishna	78.12
5	Cauvery	21.36
6	Pennar	6.32
7	East Flowing Rivers Between Mahanadi & Pennar	22.52
8	East Flowing Rivers Between Pennar and Kanyakumari	16.46
9	Mahanadi	66.88
10	Brahmani & Baitarni	28.48
11	Subernarekha	12.37
12	Sabarmati	3.81
13	Mahi	11.02
14	West Flowing Rivers of Kutch, Sabarmati including Luni	15.1
15	Narmada	45.64
16	Tapi	14.88
17	West Flowing Rivers from Tapi to Tadri	87.41
18	West Flowing Rivers from Tadri to Kanyakumari	113.53
19	Area of Inland drainage in Rajasthan desert	Negligible
20	Minor River Basins Draining into Bangladesh & Burma	31
Total		1869.35

Source: Ministry of Water Resources, 2006

catchment area of more than 10 Mha. are Indus (32.1 Mha.), Godavari (31.3 Mha.), Krishna, (25.9 Mha.) and Mahanadi (14.2 Mha.).

Over 70 per cent of India's rivers drain in the Bay of Bengal, mostly as a part of the Ganga-Brahmaputra system. The Arabian Sea, on the western side of the country, receives 20 per cent of the total drainage from the Indus system as well as from a number of smaller rivers down the western coast. The remaining ten per cent drain into the interior basins and few natural lakes scattered across the country.

### Groundwater

Groundwater represents one of the most important water sources in India. Total replenishable groundwater potential of the country has been estimated by the Ministry of Water Resources as 431 Km<sup>3</sup> per year (Table 2.3.1). Excluding the water reserved for drinking, industrial and other purposes (other than irrigation), which is about 16 per cent of the total potential, the potential available for irrigation is 360 Km<sup>3</sup> per year. The figure for net draft of groundwater considering the present utilization indicates that a substantial portion of the total potential (about 68 per cent) still remains untapped.

## WATER DEMAND

Access to adequate water is one of the leading factors limiting development in India. Agricultural, industrial and domestic uses are competing more and more for a limited supply. The agricultural sector continues to dominate water use owing to its continued importance to the Indian economy, while industrial demands are increasing as the sector continues to grow. Domestic needs claim only a small portion of the annual water withdrawals as access to adequate water and sanitation supplies remains low throughout the country. Greater access and an improvement in the socio-economic situation is likely to result in a higher demand for water in the coming years, in rural India.

### Agriculture Demand

Agriculture remains central to the Indian economy and therefore, receives the greatest share of the annual water allocation. According to the World Resources Institute (2000), 92 per cent of India's utilizable water is devoted to this sector, mostly in the form of irrigation.

The necessity of irrigation in agricultural production is greater due to the unpredictable nature of the monsoon. In regions completely dependent on rain-fed agriculture, a weak monsoon season can result in drought like conditions leading to reduced

yields or even total crop failure. The normal monsoon too allows the farmers to produce only one crop a year with a low yield. Indeed, the productivity of irrigated agriculture per unit of land has been estimated as seven times more than that of the rain-fed agriculture (*World Bank, 1999*).

The growth in the irrigated area, along with improvements in the farming technologies and plant genetics, has been responsible for the incredible growth in crop production over this period. The increase in production also has contributed greatly to the national economy and to India's food security. However, irrigation expansion has also placed greater demands on surface and groundwater resources. Groundwater alone accounts for 39 per cent of the water used in agriculture and the surface water use often comes at the expense of other sectors such as the industrial and the domestic supply.

On the other end, flood conditions could prove to be equally devastating for the agricultural sector and require careful planning in terms of drainage and construction of flood control structures. Development projects such as dam and canal construction were devised to help mitigate the effect of monsoon on rivers and seasonal streams. For the most part, they have been successful in reducing the impact of flooding in some areas, their effectiveness being limited in exceptional rainfall situations.

### **Industrial Demand**

In the past several decades, industrial production has increased in India owing to an increasingly open economy and greater emphasis on industrial development and international trade. Water consumption for this sector has consequently risen and will continue growing at a rate of 4.2 per cent per year (*World Bank, 1999*). According to the World Bank, demand of water for industrial, energy production and other uses will rise from 67 billion m<sup>3</sup> to 228 billion m<sup>3</sup> by 2025.

Hydroelectric generation already accounts for a large percentage of water demand. The potential in India has been estimated to be 84,000 MW, of which only 22,000 MW is currently being

harnessed (*MOWR, 2001*). The large untapped potential, particularly in the northern regions of India, and the growing demands for electricity from a larger population and industrial sector, will ensure that the development of this activity continues in the coming years.

### **Domestic Demand**

Demand from the domestic sector has remained low and accounts for only five per cent of the annual freshwater withdrawals in India (*World Resources Institute, 2000*). Domestic water use will increase as the population continues to grow and access to water is improved. Recent data from the World Bank indicates that the demand over the next twenty years will double from 25 billion m<sup>3</sup> to 52 billion m<sup>3</sup>.

Only 85 per cent of the urban and 79 per cent of the rural population has access to safe drinking water and fewer still have access to adequate sanitation facilities (*World Resources Institute, 2000*) despite Central Government's commitment to provide the same in the National Water Policy (1987). Most urban areas are serviced by a municipal water distribution system. Usually, the municipal water supply originates from local reservoirs or canals, but in some cases water may be imported through inter-basin transfer. Although major cities in India enjoy access to central water supply systems, these schemes often do not adequately cover the entire urban population and are notoriously inefficient and unreliable. In rural areas, access to water is even more precarious. Over 80 per cent of the rural domestic water comes from groundwater sources since it is more reliable in terms of water quantity and quality. Still, in areas where water is scarce, rural women travel long distances to wells or streams to fetch water for their daily needs.

## **WATER POLLUTION**

Water pollution is a serious problem in India as almost 70 per cent of its surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic,



*A High Altitude Lake in Kanchanjunga National Park*

organic and inorganic pollutants (*MOWR 2000*). In many cases, these sources have been rendered unsafe for human consumption as well as for other activities such as irrigation and industrial needs. This illustrates that degraded water quality can contribute to water scarcity as it limits its availability for both human use and the ecosystem.

In 1995, the Central Pollution Control Board identified severely polluted stretches on 18 major rivers in India (*World Bank 1999*). Not surprisingly, the majority of these stretches were found in and around large urban areas. The high incidence of severe contamination near urban areas indicates that the industrial and domestic sector's contribution to water pollution is much higher

than their relative importance, implied in the Indian economy. Despite this, agricultural activities still dominate in terms of overall impact on water quality.

Besides rapidly depleting groundwater table, the country faces another major problem on the water front - groundwater contamination - a problem which has affected as many as 19 states, including Delhi. The geogenic contaminants, including salinity, iron, fluoride and arsenic have affected groundwater in over 200 districts spread across 19 states (Table 2.3.3 and Table 2.3.4). Studies have shown that long-term intake of fluoride can cause tooth decay and crippled bones. Arsenic can cause skin cancer and skin pigmentation.

**Table 2.3.3: State-wise Details of Distribution of Fluoride in Groundwater above Permissible Limit**

Sl. No.	State	Fluoride	
		No. of districts affected	Districts (in parts)
1	Andhra Pradesh	19	Adilabad, Anantpur, Chittoor, Guntur, Hyderabad, Karimnagar, Khammam, Krishna, Kurnool, Mehaboobnagar, Medak, Nalgonda, Nellore, Prakasham, Rangareddy, Vishakhapatnam, Vizianagaram, Warangal, West Godavari
2	Assam	4	Goalpara, Kamrup, Karbi, Anglong, Naugaoan
3	Bihar	9	Aurangabad, Banka, Buxar, Jamui, Kaimur, Munger, Nawada, Rohtas, Supaul
4	Chhattisgarh	12	Bastar, Bilaspur, Dantewara, Janjgir-Champa, Jashpur, Kanker, Korba, Koriya, Mahasamund, Raipur, Rajnandgoan, Suguja
5	Delhi	6	East Delhi, New Delhi, Northwest Delhi, South Delhi, Southwest Delhi, West Delhi
6	Gujarat	18	Ahmedabad, Amreli, Anand, Banaskantha, Bharuch, Bhavnagar, Dahod, Junagarh, Kachchh, Mahesana, Narmada, Panchmahals, Patan, Rajkot, Sabarkantha, Surat, Surendranagar, Vadodara
7	Haryana	14	Bhiwani, Faridabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Kurkshetra, Mahendragarh, Panipat, Rewari, Rohtak, Sirsa, Sonapat
8	Jammu & Kashmir	2	Rajauri, Udhampur
9	Jharkhand	6	Bokaro, Giridih, Godda, Gumla, Palamau, Ranchi
10	Karnataka	20	Bagalkot, Bangalore, Bellary, Belgaum, Bidar, Bijapur, Chamarajnar, Chikmagalur, Chitradurga, Devangere, Dharwar, Gadag, Gulbarga, Haveri, Kolar, Koppala, Mandya, Mysore, Raichur, Tumkur
11	Kerala	1	Palakkad
12	Madhya Pradesh	19	Bhind, Chhatarpur, Chhindwara, Datia, Dewas, Dhar, Guna, Gwalior, Harda, Jabalpur, Jhabua, Khargone, Mandsaur, Rajgarh, Satna, Seoni, Shajapur, Sheopur, Sidhi
13	Maharashtra	8	Amrawati, Chandrapur, Dhule, Gadchiroli, Gondia, Jalna, Nagpur, Nanded
14	Orissa	11	Angul, Balasore, Bargarh, Bhadrak, Boudh, Cuttack, Deogarh, Dhenkanal, Jajpur, Keonjhar, Suvarnapur
15	Punjab	11	Amritsar, Bhatinda, Faridkot, Fatehgarh Saheb, Firozpur, Gurdaspur, Mansa, Moga, Muktsar, Patiala, Sangrur
16	Rajasthan	30	Ajmer, Alwar, Banswara, Barmer, Bharatpur, Bhilwara, Bikaner, Bundi, Chhittorgarh, Churu, Dausa, Dholpur, Dungarpur, Ganaganagar, Hanumangarh, Jaipur, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Karauli, Kota, Nagaur, Pali, Rajasamand, SawaiModhopur, Sikar, Sirohi, Tonk, Udaipur
17	Tamil Nadu	16	Coimbatore, Dharmapuri, Dindigul, Erode, Karur, Krishnagiri, Namakkal, Perambalur, Pudukotai, Ramnathpuram, Salem, Shivaganga, Theni, Thiruvannamalai, Vellore, Virudunagar
18	Uttar Pradesh	10	Agra, Aligarh, Etah, Firozabad, Jaunpur, Kannauj, Mahamayanagar, Mainpuri, Mathura, Maunathbhanjan
19	West Bengal	8	Bankura, Bardhaman, Birbhum, Dakshin, Dinajpur, Malda, Nadia, Purulia, Uttar Dinajpur

Source: Ministry of Water Resources, 2008

**Table 2.3.4: Occurrence of High Arsenic in Groundwater of some States of India**

State	District	Blocks where high Arsenic is observed wells of CGWB
Assam	Dhemaji	Dhemaji, Bodordloni, Sisiborgaon
Bihar	Bhojpur	Barhara, Shahpur, Koilwar, Arrah, Bihiya, Udawant Nagar
	Bhagalpur	Jagdishpur, Sultanganj, Nathnagar
	Begusarai	Matihani, Begusarai, Barauni, Balia, Sabehpur Kamal, Bachwara
	Buxar	Brahmpur, Semary, Chakki, Buxar
	Darbhanga	Biraul
	Khagaria	Khagaria, Mansi, Godri, Parbatta
	Kishanganj	Kishanganj, Bahadurganj
	Katihar	Manasahi, Kursela, Sameli, Barari, Manihari, Amdabad
	Lakhiserai	Piparia, Lakhiserai
	Munger	Jamalpur, Dharhara, Bariarpur, Munger
	Patna	Maner, Danapur, Bakhtiarpur, Barh
	Purnea	Purnea East, Kasba
	Saran	Dighwara, Chapra, Revelganj, Sonpur
	Samastipur	Mohinuddin Nagar, Mohanpur, Patori, Vidhyapati Nagar
Vaishali	Raghopur, Hajipur, Bidupur, Desri, Sahdei Bujurg	
Chhattisgarh	Rajnandgaon	Chouki
West Bengal	Bardhaman	Purbasthali I & II, Katwa I & II, and Kala II
	Haora	Uluberia II and Shampur II
	Hugli	Balagarh
	Malda	English Bazar, Manikchak, Kaliachak I, II & III, Ratua I and II
	Murshidabad	Raninagar I & II, Domkal, Nowda, Jalangi, Hariharpara, Suti I & II, Bhagwangola I & II, Beldanga I & II, Berhampur, Raghunathganj I & II, Farakka, Lalgola, Murjigang, Samsheganj
	Nadia	Karimpur I & II, Tehatta I & II, Kaliganj, Nawadwip, Haringhata, Chakda, Santipur, Naksipara, Hanskhali, Krishnagarh, Chapra, Ranaghat I & II, Krishnanagar I & II.
	North 24 Parganas	Habra I & II, Barasat I & II, Rajarhat, Deganga, Beduria, Gaighata, Amdanga, Bagda Boangoan, Haroa, Hasnabad, Basirhat I & II, Swarupnagar, Barackpur I & II Sandeshkhali II
	South 24 Parganas	Baruipur, Sonarpur, Bhangar I & II, Joynagar I, Bishnupur I & II, Mograhat II, Budge Budge II
Uttar Pradesh	Agra	Agra, Etmadpur, Fatehabad, Khairagarh
	Aligarh	Jawan Sikandarpur
	Ballia	Belhari, Baria, Muralichapra, Reoati, Siar
	Balrampur	Gaindas Bujurg, Gainsari, Harraiyyabazar, Pachparwa, Sridatganj, Tulsipur
	Gonda	Bhelsar, Colonelganj, Haldarmau, Katrabazar, Nawabganj, Pandari, Kripal, Tarabgani, Wazirganj
	Gorakhpur	Gorakhpur
	Lakhimpur Kheri	Daurahra, Ishanagar, Nighasan, Pallia, Ramia Vihar
	Mathura	Mathura
Moradabad	Moradabad	

Source: Ministry of Water Resources, 2008

## PRESSURES

### Agriculture

The rapid increase in agro-chemical use in the past five decades, has contributed significantly to the pollution of both surface and groundwater resources. Pesticide consumption rose from less than one million tonne (technical grade) in 1948 to a maximum of 75 million tonnes in 1990 (CSE 1999). Per hectare

consumption of fertilizers has increased from 69.8 kg in 1991-92 to 113.3 kg in 2006-07 at an average rate of 3.3 per cent.

Fertilizers and pesticides enter the water supply through run-offs and leaching into the groundwater table and pose a hazard to human, animal and plant population. Some of these chemicals include several substances considered extremely hazardous by WHO and are banned or under strict control in developed countries. Studies on the Ganga River indicate the presence of



*Groundwater overdraft is a serious concern*

chemicals such as HCH, DDT, endosulfan, methyl malathion, malathion, dimethoate, and ethion in levels greater than those recommended by the international standards (*World Bank 1999*). Some of these substances have been known to bio-accumulate in certain organisms, leading to an increased risk of contamination when used for human consumption and a persistence of the chemicals in the environment over long periods of time.

Water enriched with nutrients leads to eutrophication. Decaying organic matter releases odourous gases and partially decomposed matter accumulates on the river or lakebed, thereby limiting water's suitability for human consumption and other uses. High levels of fertilizer use has been associated with increased incidence of eutrophication in rivers and lakes in several of India's most important water bodies, such as the Hussein Sagar in Hyderabad and Nainital in Uttar Pradesh (*MOWR 2000*)

### **Industries**

Although the industrial sector only accounts for three per cent of the annual water withdrawals in India, its contribution to water pollution, particularly in urban areas, is considerable. Wastewater generation from this sector has been estimated to be 55,000 million m<sup>3</sup> per day, of which 68.5 million m<sup>3</sup> are dumped directly into local rivers and streams without prior treatment (*MOWR 2000*). The government has called for the establishment of Common Effluent Treatment Plants (CETP) in industrial areas but their implementation has been slow, and most industries either are not connected to CETPs or only partially treat their wastewater before disposal. The Central and State Pollution Control Boards have identified 1,532 'grossly polluting' industries in India, although almost non of the industries comply with the emission standards (*World Bank 1999*).

Wastewater from industrial activities is often contaminated with highly toxic organic and inorganic substances, some of which are persistent pollutants and remain in the environment for many years. For instance, over 50 per cent of the urban organic load in some cities originates from industrial effluents. Further, heavy metal contamination from thermal power, tannery and mining activities has occurred in several locations (*World Bank 1999*). Water contamination from industrial areas is compounded usually due to the high concentration of industries over a small area. Increasing industrial development, coupled with inadequate zoning and emissions regulations, will only aggravate the problem in the coming years.

### Domestic Usage

All of India's fourteen major river systems are heavily polluted, mostly from the 50 million cubic meters of untreated sewage discharged into them each year (*APCSS 1999*). The domestic sector is responsible for the majority of wastewater generation in India. Combined, the 22 largest cities in the country produce over 7,267 million litres of domestic wastewater per day, of which slightly over 80 per cent is collected for treatment (*CSE 1999*).

Inadequate treatment of human and animal wastes also contributes to high incidence of water-related diseases in the country. Till date, only 19.2 per cent of the rural and 70 per cent of the urban inhabitants have access to adequate sanitation facilities (*WRI 2000*). Therefore, water contaminated by human waste is often discharged directly into watercourses or seeps into the groundwater table from faulty septic tanks or pit latrines. The level of faecal coliform bacteria in most rivers often exceeds WHO standards and is responsible for causing a number of gastro-intestinal ailments among the population.

Improper disposal of solid waste also leads to surface and groundwater pollution. Runoff from garbage dumps and city streets carries litter, deposited particulate matter and chemicals to nearby streams and canals. Leaching from landfills and garbage pits transports toxic substances and heavy metals to the water table. Annual production of solid waste in India has been estimated to be 2,000 million tonnes (*MOWR 2000*). This figure will undoubtedly continue to increase with the growing population and the higher consumption of disposable goods resulting from improvement in the socio-economic conditions of the rural and urban residents.

## STATE & TRENDS

The water quality data on rivers, lakes, ponds, tanks and groundwater locations being monitored under the network, is evaluated against the water quality criteria, and the monitoring locations, on exceeding one or more parameters are identified as polluted, and require action for restoration of water quality. The locations on rivers, lakes, ponds, tanks and groundwater which have not met the criteria are summarized below.

- High Biochemical Oxygen Demand (BOD), one of the most important indicators of pollution, was observed in

Amlakhadi at Ankleshwar (714 mg/l) followed by Ghaggar at Moonak, Punjab (626 mg/l); Khari at Lali village, Ahmedabad (320 mg/l); Musi at Hyderabad (225 mg/l); Sabarmati at Ahmedabad (207 mg/l); Kalinadi at Kannauj, Uttar Pradesh (136 mg/l); Khan at Kabitkhedi, Indore, Madhya Pradesh (120 mg/l); Damanganga D/s Daman at Kachigaon (112 mg/l); Kalinadi at D/s of Muzzafarnagar, Uttar Pradesh (110 mg/l); Saroonagar, Ranga Reddy Dist. Andhra Pradesh (71 mg/l); Gandigudem at Medak Dist. (60 mg/l); Hindon at Saharanpur (60 mg/l); Yamuna at Sonapat (59 mg/l); Krishna D/s of Islampur (40mg/l); Satluj D/s Hussainwala Ferozpur, Punjab (40 mg/l); Bhima at Pune (36 mg/l); Elangabeel System point, Assam (64 mg/l); Bharalu at Guwahati, Assam (43 mg/l); Sukhna at Parwanoo Dist., Solan (36 mg/l); Chandola Lake at Ahmedabad (36 mg/l); Hussain Sagar Lake, Budamaru, Andhra Pradesh (33 mg/l); Dhadar at Kothada (32 mg/l); Bhaleshwar Khadi at N.H. No. 8 (27 mg/l); Gomti at Sitapur (25 mg/l); Chambal at Dholpur (25 mg/l); Yamuna between Delhi and Etawah (10-59 mg/l) and Tapi at Uphad, Maharashtra (25 mg/l). Due to a high BOD, dissolved oxygen in these stretches was observed to be either nil or very low most of the time.

- Total number of observations having BOD less than 3 mg/l; 3 to 6 mg/l and above 6 mg/l was 64 per cent, 18 per cent and 18 per cent, respectively. The total number of observations having total Coliform number less than 500 MPN/100 ml was 45 per cent; between 500-5000 MPN/100 ml was 31 per cent and exceeding 5000 MPN/100 ml was 24 per cent MPN/100 ml. Similarly, the number of observations having Faecal Coliform bacterial count less than 500 MPN/100 ml was 53 per cent; between 500-5000 MPN/100 ml was 26 per cent and 21 per cent observations were exceeding 5000 MPN/100 ml.
- Faecal Coliform, another important indicator of pollution in India was found the highest in the Yamuna river in Agra, Nizamuddin, Mazawali and Okhla ( $5.2 \times 10^6$  to  $3.7 \times 10^6$ ) followed by Hindon after confluence with Krishna ( $1.1 \times 10^6$  to  $4.6 \times 10^5$ ); Ganga at Dakshineshwar and Uluberia ( $1.1 \times 10^6$  to  $2.8 \times 10^5$ ); Damodar at Haldia ( $1.4 \times 10^6$ ); Khari at Lali Village, Ahmedabad ( $7.5 \times 10^5$ ); Sabarmati at Ahmedabad ( $1.1 \times 10^6$  to  $4.6 \times 10^5$ ); Bharalu at Guwahati, Assam ( $2.4 \times 10^5$ ); Ganga at Varanasi ( $1.1 \times 10^5$ ); Satluj at Ludhiana ( $1.1 \times 10^5$ ); Tapi at Ukai ( $1.5 \times 10^5$ ); Kalinadi at Muzaffarnagar ( $3.1 \times 10^5$ ); Damanganga at Silvasa ( $1.2 \times 10^6$ ); and Brahmaputra at Dhenukapahar and Pandu ( $2.4 \times 10^5$ ).

## IMPACT

Due to various factors, available water is deteriorating in quality. Tests indicate that the biological contamination of surface water sources, much of it due to untreated or partially treated sewage, exceeds permissible limits at many locations. Similarly, overexploitation of groundwater, besides other human activities

has led to contamination of groundwater in many parts of the country. While salinity (dissolved salts in water) and iron make the taste of water and vegetables cooked in it unappealing, long-term usage of water with fluoride and arsenic can lead to several health hazards.

Around 85 per cent of the rural population of the country uses groundwater for drinking and domestic purposes. High concentrations of fluoride and arsenic in groundwater beyond the permissible limits of 1.5 mg/l and 0.05 mg/l, respectively poses health hazard. In all, 19 states in India have been identified as 'endemic' areas for fluorosis, with an estimated 44 million people impacted, and another 66 million at risk. The scenario is the worst in the hard rock terrain viz., granites.

Arsenic is a known carcinogen and is highly toxic. It is perhaps the only human carcinogen for which there is adequate evidence of carcinogenic risk by both inhalation and ingestion (Centeno et al. 2002; Chen & Ahsan 2004). The occurrence of Arsenic in groundwater was first reported in 1980 in West Bengal in India. Apart from West Bengal, arsenic contamination in groundwater has been found in the states of Bihar, Chhattisgarh, Uttar Pradesh and Assam. Arsenic in groundwater has been reported in 15 districts in Bihar, 9 districts in Uttar Pradesh, 8 districts in West Bengal and one district each in Chhattisgarh and Assam.

## RESPONSE

The management of India's water resources falls under the jurisdiction of a number of government agencies, although the primary responsibility for the development of water resources belong to the individual states. The Central Government oversees the implementation of national policy on resource development and exploitation, as well as manages inter-state and international rivers and river valleys. It also provides technical advice to individual states on development, flood control, coastal erosion, dam safety, navigation and hydropower when required.

### National Water Quality Monitoring Programme (NWMP)

CPCB in collaboration with State pollution control boards established a nationwide network for water quality monitoring comprising 1,019 stations in 27 States and 6 Union Territories. The monitoring is undertaken on a monthly or quarterly basis for surface water and on a half yearly basis for groundwater. The monitoring network covers 200 Rivers, 60 Lakes, 5 Tanks, 3 Ponds, 3 Creeks, 13 Canals, 17 Drains and 321 Wells.

The water quality monitoring results obtained between 1995 to 2006 indicate that organic and bacterial contamination continue to be critical in water bodies. This is mainly due to discharge of domestic wastewater mostly in untreated form from the urban centres of the country. The municipal corporations at large are not able to treat the wastewater, increasing municipal sewage load flowing into water bodies without treatment. Secondly, the receiving water bodies also do not have adequate water for dilution, because of which the oxygen demand and bacterial

pollution is depicting an increasing trend and leading to water borne diseases. The water quality monitoring results were analyzed with respect to the indicator of organic matter (Biochemical oxygen demand) and indicator of pathogenic bacteria (total coliform and faecal coliform).

The result of such analysis shows that there is gradual degradation in water quality.

### National Water Policy

A comprehensive policy on water is necessary on the face of a growing number of social, economic and environmental issues surrounding water resources in India. In 1987, the National Water Resources Council adopted the National Water Policy (NWP) and submitted the document to Parliament for implementation. The NWP is the primary document stating the position of the Government of India (GOI) on water resource issues, ranging from drought and flood management to drinking water provisions.

In essence, the policy serves as a guideline to help planners and managers develop the country's water resources to its maximum potential. But the adoption of the policy is also a step-forward for the government in terms of promoting the sustainable management of the country's water resources.

The policy addresses many issues regarding planning, development and allocation of water, including groundwater and surface water sources. Among the points addressed in the policy are:

- Development of standardized national information system containing data on water availability and use is essential for appropriate planning;
- Resource planning should be conducted using a catchment or a watershed as the basic unit;
- Water development projects should be multi-purpose and should address various priorities such as drinking water provision and flood-mitigation;
- Environmental impact of new projects should be assessed and minimized wherever possible;



*A view of Dal Lake in Kashmir*

- Socially disadvantaged groups such as Scheduled Castes and Tribes and other minority groups are to be included in the planning process as much as possible, and farmers must become increasingly involved in the irrigation management policies;
- Groundwater development should be based on the basis of the potential and recharge capabilities of the aquifer;
- Water allocation should be based on the following priorities: drinking water, irrigation, hydro-power, navigation, industrial and other uses;
- Irrigation planning should attempt to maximize benefits to farmers and integrate soil and water conservation practices;
- Water rates should reflect the true cost of water use and encourage economic use of the resource;
- Promotion of conservation through education, regulation and incentives be encouraged;
- Development of a master plan for flood control and management should be undertaken and include soil conservation, forestry management, zoning and forecasting considerations;
- Drought-prone areas should be given priority in water development projects and programmes such as soil moisture conservation and water harvesting practices should be encouraged;
- Additional research in a number of areas such as hydro-meteorology, groundwater hydrology and recharge, water harvesting, crops and cropping systems, sedimentation and reservoirs, river morphology and hydraulics, recycling and re-use, and sea water resources should be pursued.

The National Water Resources Council is the body responsible for reviewing the progress made by the government in implementing the policy. The Council is composed of Secretaries from various Ministries associated with water resources and the Chief Secretaries of States/Union Territories. Through the National Water Board, the Council is able to make recommendations regarding the financing and development of new projects and provide suggestions on further action to be taken.

### Acts And Regulations

Water in India is governed under three different Acts: the Environmental Protection Act (1986), the River Boards Act (1956) and the Inter-State Water Disputes Act (1956). Other Acts and Regulations affect water resources in different ways by addressing its importance for agriculture, biodiversity and conservation and drinking water. These three Acts, however, have the broadest scope in terms of how they affect all aspects of water management.



*A common effluent treatment plant at Chennai*

## River Boards Act

The regulation and development of inter-state rivers and river valleys was to be entrusted to various River Boards when this Act was adopted in 1956. The River Boards were designed to advise the central government on development opportunities, co-ordinate activities and resolve disputes. Under their mandate, the Boards were required to provide advice to the government on the following topics:

- Conservation with a view to control and optimise use of water resources;
- Promotion and operation of schemes related to irrigation, water supply and drainage;
- Promotion and operation of schemes related to hydro-power and flood control;
- Promotion and control of navigation;
- Promotion of afforestation and control of soil erosion;
- Prevention of pollution; and
- Other duties as deemed necessary.

The Indian government has been unable to constitute a River Board since the Act was enacted, almost fifty years ago. However, there is a realisation of the fact that the Act should be revised and amendments are currently under way to strengthen its powers.

## Inter-State Water Disputes (ISWD) Act, 1956

Since the majority of the rivers in India are shared between neighbouring States, the ISWD Act was enacted in 1956 to adjudicate any dispute regarding the distribution or control of rivers or river valleys. The Act gives the Government the power to constitute Tribunals to serve as intermediaries in the disputes. Till date, five Inter-State Water Tribunals have been established:

- Godavari Water Disputes Tribunal (April 1969)
- Krishna Water Disputes Tribunal (April 1969)
- Narmada Water Disputes Tribunal (October 1969)
- Ravi and Beas Water Disputes Tribunal (April 1986)
- Cauvery Water Disputes Tribunal (June 1990)

The first three Tribunals have been concluded, but a final decision is still pending on the last two matters.

## International Treaties

A number of international disputes regarding the allocation and management of water of several large transboundary rivers have arisen between India and its neighbours. Fortunately, these differences have been settled through diplomatic channels with the signing of treaties and agreements. The three principal treaties are:

- The Indus Water Treaty - India and Pakistan (1960)

- The Indo Nepal Treaty on the Integrated Development of Mahakali River (1996)
- The Ganga Water Sharing Treaty with Bangladesh: Sharing of Lean Season Flow of Ganga at Farakka Barrage in India (1996)

All three disputes arose from disagreements on the allocation of water resources between India and the other countries. In case of both Indus and Mahakali Rivers, the equitable distribution of irrigation water was under contention. The Farakka Barrage dispute originated when the water level entering Bangladesh from India was reduced to almost nothing during the lean season (January to May) due to the construction of the Farakka Barrage on the Indian side of the border. In 1996, an agreement was reached between the governments of India and Bangladesh to share the flow during the lean season in the ratio of 60 per cent (Bangladesh) and 40 per cent (India).

Although the treaties have been signed, there are still a number of issues which remain unresolved. However, in general, the treaties have generated a sense of goodwill between India and its neighbours, which bodes well for future collaborations.

## REFERENCES

- Annual Report 1999, World Bank
- Annual Report 1999, Asia-Pacific Centre for Security Studies
- Centre for Science and Environment (1999). Perpetual Thirst: Faucets of the problem, *Down to Earth* Vol. 7 (19), February 28
- Central Ground Water Board, Ministry of Water Resources
- Centeno J.A., Mullick F.G., Martinez L., Page N.P., Gibb H. and Longfellow D. (2002). Pathology Related to Chronic Arsenic Exposure. *Environ Health Perspect* 110(suppl 5),883–886
- Chen Y. and Ahsan H. (2004). Cancer Burden from Arsenic in Drinking Water in Bangladesh. *American Journal of Public Health*, 94(5), 741- 744
- Compendium of Environment Statistics India 2007, Ministry of Statistics & Programme Implementation
- Dynamic Ground Water Resources of India 2006, Central Ground Water Board, Ministry of Water Resources
- National Water Policy 1987, Ministry of Water Resources
- Ramesh R. and Yadava M.G. (2005). Climate and Water Resources of India, *Current Science*, Vol 89 (5)
- Status of Water Quality in India 2007-08, Central Pollution Control Board



# BIODIVERSITY

India is one of the 17 identified mega diverse countries of the world. From about 70 per cent of the total geographical area surveyed so far, 45,500 plant species (including fungi and lower plants) and 91,000 animal species, representing about seven per cent of the world's flora and 6.5 per cent of the world's fauna, respectively, have been described. Nearly 6,500 native plants are still used prominently in the indigenous healthcare systems.

From the biodiversity standpoint, India has some 59,353 insect species, 2,546 fish species, 240 amphibian species, 460 reptile species, 1,232 bird species and 397 mammal species, of which 18.4 per cent are endemic and 10.8 per cent are threatened. The country is home to at least 18,664 species of vascular plants, of which 26.8 per cent are endemic. With only 2.4 per cent of the total land area of the world, the known biological diversity of India contributes 8 per cent to the known global biological diversity. It has been estimated that at least 10 per cent of the country's recorded wild flora, and possibly the same percentage of its wild fauna, are on the threatened list, many of them on the verge of extinction.

India has two biodiversity hot spots, namely:

1. The Eastern Himalayas
2. The Western Ghats

And, it is composed of diverse ecological habitats:

1. Forests
2. Grasslands
3. Wetlands
4. Coastal and Marine ecosystems
5. Desert ecosystems

## BIODIVERSITY PROFILE OF INDIA

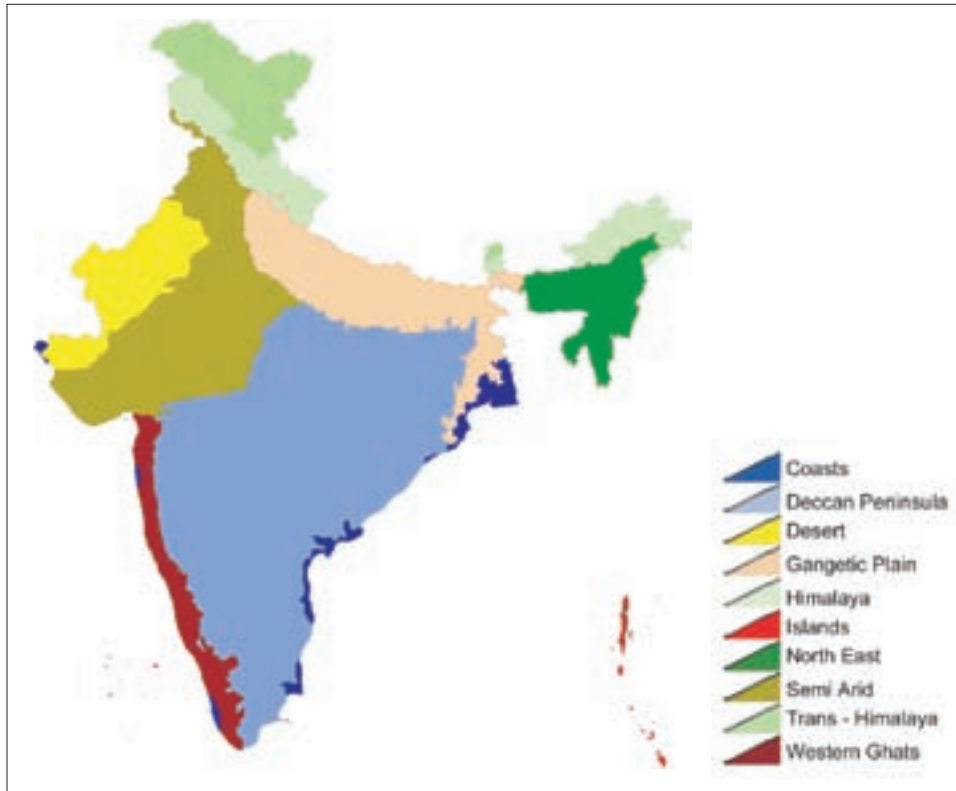
India, with varied terrain, topography, land use, geographic and climatic factors, can be divided into ten recognizable biogeographic zones (Rodgers *et al.*, 2000). These zones encompass a variety of ecosystems - mountains, plateaus, rivers, forests, deserts, wetlands, lakes, mangroves, coral reefs, coasts and islands.

**Trans-Himalayan Region**, constituting 5.6 per cent of the total geographical area, includes the high altitude, cold and arid mountain areas of Ladakh, Jammu & Kashmir, North Sikkim, Lahaul and Spiti areas of Himachal Pradesh. This zone has sparse alpine steppe vegetation that harbours several endemic species and is a favourable habitat for the biggest populations of wild sheep and goat in the world and other rare fauna that includes Snow Leopard (*Uncia uncia*) and the migratory Black-necked Crane (*Grus nigricollis*). The cold dry desert of this zone represents an extremely fragile ecosystem.

**Himalayan Zone**, in the far North, constituting 6.4 per cent of the total geographical area includes some of the highest peaks in the world and makes India one of the richest areas in terms of habitats and species. The steep slopes, unconsolidated soils and intense rainfall render the zone extremely fragile. The alpine and sub-alpine forests, grassy meadows and moist mixed deciduous forests provide diverse habitat for endangered species of bovids such as Bharal (*Pseudois nayaur*), Ibex (*Capra ibex*), Markhor (*Capra falconeri*), Tahr (*Hemitragus jemlabicus*), and Takin (*Budoreas taxicolor*). Other rare and endangered species restricted to this zone include Hangul (*Cervus eldi eldi*) and Musk Deer (*Moschus moschiferus*).

**Indian Desert Zone**, constituting 6.6 per cent of the total

**Figure 2.4.1: Biogeographic Classification of India**



Source : State of Environment Atlas of India 2007, MoEF

geographical area, includes the Thar and the Kutch deserts and has large expanses of grassland that supports several endangered species of mammals such as Wolf (*Canis lupus*), Caracal (*Felis caracal*), Desert Cat (*Felis libyca*) and birds of conservation interest viz., Houbara Bustard (*Chamydotis undulate*) and the Great Indian Bustard (*Ardeotis nigriceps*).

**Semi-arid Region**, constituting 16.6 per cent of the total geographical area, is a transition zone between the desert and the dense forests of Western Ghats. Peninsular India has two large regions, which are climatically semi-arid. This semi-arid region also has several artificial and natural lakes and marshy lands. The dominant grass and palatable shrub layer in this zone supports the highest wildlife biomass. The cervid species of Sambar (*Cervus unicolor*) and Chital (*Axis axis*) are restricted to the better wooded hills and moister valley areas respectively. The Lion (*Leo persica*), an endangered carnivore species (restricted to a small area in Gujarat), Caracal (*Felis caracal*), Jackal (*Canis aureus*) and Wolf (*Canis lupus*) are some of the endangered species that are characteristic of this region.

**Western Ghats**, constituting 4.0 per cent of the total geographical area, is one of the major tropical evergreen forest regions in India. The zone stretches from the hills to the South of the Tapti River in the North to Kanyakumari in the South and in the West, this zone is bound by the coast. This zone represents one of the biodiversity 'hot spots' with some 15,000 species of higher plants, of which 4,000 (27 per cent) are endemic to the region.

The Western Ghats harbour viable populations of most of the vertebrate species found in peninsular India, besides an endemic faunal element of its own. Significant species endemic to this region include Nilgiri Langur (*Presbytis jobni*), Lion Tailed Macaque (*Macaca silenus*), Grizzled Giant Squirrel (*Ratufa macroura*), Malabar Civet (*Viverricula megaspila*), Nilgiri Tahr (*Hemitragus bylocrius*) and Malabar Grey Hornbill (*Ocyzerous griseus*). The Travancore Tortoise (*Indotestudo forstem*) and Cane turtle (*Heosemys silvatica*) are two endangered taxa restricted to a small area in central Western Ghats.

**Deccan Plateau**, constituting 42 per cent of the total geographical area, is a semi-arid region that falls in the rain shadow area of the Western Ghats. This bio-geographic zone of peninsular India is by far the most extensive zone, covering India's finest forests, particularly in the States of Madhya Pradesh, Maharashtra and Orissa. Majority of the forests are deciduous in nature but there are regions of greater biological diversity in the hill ranges. The zone comprising of deciduous forests, thorn forests and degraded scrubland support diverse wildlife species. Species such as Chital (*Axis axis*), Sambar (*Cervus unicolor*), Nilgai (*Boselaphus tragocamelus*) and Chousingha (*Tetracerus quadricornis*) are abundant in this zone. Some other species like Barking deer (*Muntiacus muntjak*) and Gaur (*Antilope cervicapra*) are more frequent in, or are restricted to moister areas, but are still found in fairly large numbers. Species with small populations include the Elephant (*Elephas maximus*) in Bihar-Orissa and Karnataka-Tamil Nadu belts, Wild

Buffalo (*Bubalus bubalis*) in a small area at the junction of Orissa, Madhya Pradesh and Maharashtra and the hard ground Swamp Deer (*Cervus duvauceli*), now restricted to a single locality in Madhya Pradesh.

**Gangetic Plain**, constituting 10.8 per cent of the total geographical area, is a flat alluvial region lying to the North and South of the Ganga River and its major tributaries and in the foothills of the Himalayas. The Gangetic plain is topographically homogenous for hundreds of kilometers. The characteristic fauna of this region include Rhino (*Rhinoceros unicornis*), Elephant (*Elephas maximus*), Buffalo (*Bubalus bubalis*), Swamp Deer (*Cervus duvauceli*), Hog-Deer (*Axis porcinus*) and Hispid Hare (*Caprolagus hispidus*). This zone gains considerable ecological significance in the context of increasing industrialization and pollution and the consequent environmental degradation and deforestation.

**North-East Region**, constituting 5.2 per cent of the total geographical area, represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographical regions as well as being a meeting point of the Himalayan mountains and peninsular India. The North-East is thus the bio-geographical 'gateway' for much of India's fauna and flora and also a biodiversity hotspot. A diverse set of habitats coupled with long term geological stability has allowed the development of significant levels of endemism in all animal and plant groups. Many of the species contributing to this biological diversity are either restricted to the region itself, or to the smaller localized areas of the Khasi Hills.

The country's extensive **Coasts**, constituting 2.5 per cent of the total geographical area with sandy beaches, mangroves, mud

flats, coral reefs and marine angiosperm pastures make them the wealth and health zones of India. The coastline from Gujarat to Sunderbans is estimated to be 5,423 km long. A total of 25 islets constitute the Lakshadweep, which are of coral origin, and have a typical reef lagoon system, rich in biodiversity. However, the densely populated Lakshadweep islands virtually have no natural vegetation.

**Andaman and Nicobar Islands**, constituting 0.3 per cent of the total geographical area are one of the three tropical moist evergreen forests zones in India. The islands house an array of flora and fauna not found elsewhere. The elongated North-South oriented groups of 348 Andaman Islands have a bio-geographical affinity with Myanmar. The Nicobar Islands, lying only 90 kms away from Sumatra have much stronger Indonesian and South-East Asian elements. These islands are centres of high endemism and contain some of India's finest evergreen forests and support a wide diversity of corals. However, endemic island biodiversity is found only in the Andaman and Nicobar Islands.

Wetlands occur in various geographical regions such as the cold arid zones of Ladakh, warm arid zones of Rajasthan, tropical monsoonic Central India, North Eastern region, South peninsular region and the coastal wetlands.

## HOT SPOTS IN INDIA

India has two identified biodiversity hot spots. These are the Eastern Himalayas and the Western Ghats.

### Eastern Himalaya

Phyto-geographically, the Eastern Himalaya forms a distinct floral region and comprises of Nepal, Bhutan, states of East and North-East India, and a contiguous sector of Yunnan province in South-Western China. In the whole of Eastern Himalaya, there are an estimated 9,000 plant species, out of which 3,500 (i.e. 39 per cent) are endemic. In the Indian portion, there occurs some 5,800 plant species, roughly 2,000 (i.e. 36 per cent) of which are endemic. At least 55 flowering plants endemic to this area are recognised as rare, for example, the Pitcher Plant (*Nepenthes khasiana*).

The area has long been recognised as a rich centre of primitive flowering plants and is popularly known as the 'Cradle of Speciation'. Species of several families of monocotyledons, Orchidaceae, Zingiberaceae and Arecaceae are found in the area. Gymnorperms and Pteridophytes (ferns) are also well represented here.

The area is also rich in wild relatives of plants of economic significance e.g. rice, banana, citrus, ginger, chilli, jute and sugarcane. It is also regarded as the centre of origin and diversification of five palms of commercial importance, namely-coconut, arecanut, palmyra palm, sugar palm and wild date palm. Tea (*Thea sinensis*) has been cultivated in this region for the last 4,000 years. Many wild and allied species of tea, the leaves of which are used as a substitute for tea, are found in the North East, in their natural habitats.



*Nepenthes Khasiana* - commonly known as Pitcher Plant

The Taxol plant (*Taxus wallichiana*) is sparsely distributed in the region and is listed under the red data category due to its over-exploitation for extraction of a drug effectively used against cancer.

As regards faunal diversity, 63 per cent of the genera of land mammals in India are found in this region. During the last four decades, two new mammals have been discovered from the region - Golden Langur from Assam-Bhutan region, and Namdapha Flying Squirrel from Arunachal Pradesh, indicating the species richness of the region. The region is also a rich centre of avian diversity - more than 60 per cent of the bird species found in India have been recorded in the North East. The region also hosts two endemic genera of lizards, and 35 endemic reptilian species, including two turtles. Of the 240 Indian amphibian species, at least 68 species are known to occur in the North East, 20 of which are endemic.

From Namdapha National Park itself, a new genus of mammal, a new subspecies of a bird, six new amphibians species, four new species of fish, at least 15 new species of beetles and six new species of flies have been discovered.

### Western Ghats

The Western Ghats region is considered to be one of the most important bio-geographic zones of India, as it is one of the richest centres of endemism. Due to varied topography and micro-climatic regimes, some areas within the region are considered to

be active zones of speciation. The region has 490 arborescent taxa, of which as many as 308 are endemic.

About 1,500 endemic species of dicotyledonous plants are reported from the Western Ghats. 245 species of orchids belonging to 75 genera are found here, of which 112 species in ten genera are endemic to the region.

As regards the fauna, as many as 315 species of vertebrates belonging to 22 genera are endemic, including 12 species of mammals, 13 species of birds, 89 species of reptiles, 87 species of amphibians and 104 species of fish.

The extent of endemism is high amongst amphibian and reptile species. There occur 117 species of amphibians in the region, of which 89 species (76 per cent) are endemic. Of the 165 species of reptiles found in Western Ghats, 88 species are endemic.

Many of the endemic and other species are listed as threatened. Nearly 235 species of endemic flowering plants are considered endangered. Rare fauna of the region include - Lion Tailed Macaque, Nilgiri Langur, Nilgiri Tahr, Flying Squirrel, and Malabar Gray Hornbill.

## BIOMES

### Wetlands

Wetlands in India are distributed in different geographical regions, ranging from the Himalaya to the Deccan plateau. The



Bengal Tiger

**Table 2.4.1: State-wise List of Wetlands of International Importance in India under Ramsar Convention**

Sl. No.	State/UT	Name of Ramsar Site	Area (ha.)	Date of Declaration
1	Andhra Pradesh	Kolleru Lake	90100	19/08/02
2	Assam	Deepor Beel	4000	19/08/02
3	Himachal Pradesh	Pong Dam Lake Renuka Wetland Chandertal Wetland	15662 20 49	19/08/02 08/11/05 08/11/05
4	Jammu & Kashmir	Wular Lake Tsomoriri Hokersa Wetland Surinsar-Mansar Lakes	18900 12000 1375 350	23/03/90 19/08/02 08/11/05 08/11/05
5	Kerala	Ashtamudi Wetland Sasthamkotta Lake Vembanad-Kol Wetland	61400 373 151250	19/08/02 19/08/02 19/08/02
6	Madhya Pradesh	Bhoj Wetland	3201	19/08/02
7	Manipur	Loktak Lake	26600	23/03/90
8	Orissa	Chilika Lake Bhitarkanika Mangroves	116500 65000	01/10/81 19/08/02
9	Punjab	Harike Lake Kanjili Ropar	4100 183 1365	23/03/90 22/01/02 22/01/02
10	Rajasthan	Sambhar Lake Keoladeo National Park	24000 2873	23/03/90 01/10/83
11	Tamil Nadu	Point Calimere Wildlife and Bird Sanctuary	38500	19/08/02
12	Tripura	Rudrasagar Lake	240	08/11/05
13	Uttar Pradesh	Upper Ganga River (Brijghat to Narora Stretch)	26590	08/11/05
14	West Bengal	East Kolkata Wetlands	12500	19/08/02
		<b>Total sites 25</b>	<b>677131</b>	

Source: National Biodiversity Action Plan, 2008, MoEF

variability in climatic conditions and topography is responsible for significant diversity. Based on their origin, vegetation, nutrient status and thermal characteristics, they are classified into following different types:

- **Glaciatic Wetlands** (e.g., Tsomoriri in Jammu and Kashmir, Chandertal in Himachal Pradesh)
- **Tectonic Wetlands** (e.g., Nilnag in Jammu and Kashmir, Khajjiar in Himachal Pradesh, and Nainital and Bhitmal in Uttaranchal)
- **Oxbow Wetlands** (e.g., Dal Lake, Wular Lake in Jammu and Kashmir and Loktak Lake in Manipur and some of the wetlands in the river plains of Brahmaputra and Indo-Gangetic region. Deepor Beel in Assam, Kabar in Bihar, Surahthal in Uttar Pradesh)
- **Lagoons** (e.g., Chilika in Orissa)
- **Crater Wetlands** (Lonar lake in Maharashtra)
- **Salt Water Wetlands** (e.g., Pangong Tso in Jammu and Kashmir and Sambhar in Rajasthan)
- **Urban Wetlands** (e.g., Dal Lake in Jammu and Kashmir, Nainital in Uttaranchal and Bhoj in Madhya Pradesh)
- **Ponds/Tanks, Man-made Wetlands** (e.g., Harike in Punjab and Pong Dam in Himachal Pradesh)
- **Reservoirs** (e.g., Idukki, Hirakud dam, Bhakra-Nangal dam)
- **Mangroves** (e.g., Bhitarkanika in Orissa)
- **Coral reefs** (e.g., Lakshadweep)
- **Others - Creeks** (Thane Creek in Maharashtra), seagrasses, estuaries, thermal springs are some other types of wetlands in the country.

There are in all 104 identified wetlands under the National Wetland Conservation & Management Programme (NWCMP).

### Ramsar Convention

India is a signatory to the Ramsar Convention and plays an important role in conservation and wise use of wetlands. On the basis of the country's initiatives in the field of wetland conservation, India was nominated as a member of the Standing Committee from 1993-1996 and from 1999-2002. So far, 25 sites from India have been identified as Ramsar sites of international importance and six new sites are under process of designation (Table 2.4.1).

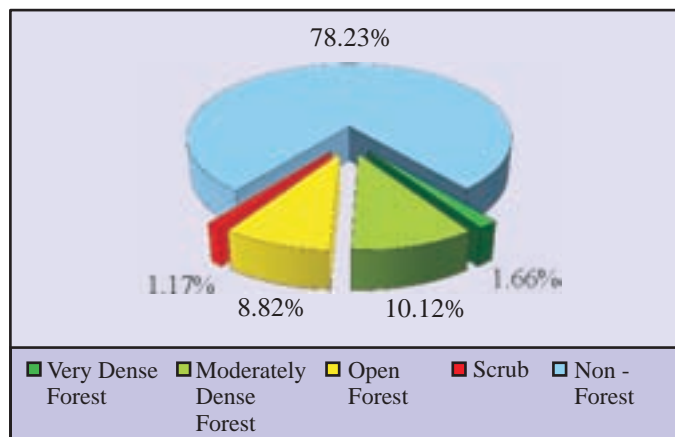
### Forests

As per the latest report of the Forest Survey of India (2005), forests cover 23.6 per cent of India's total geographic area, which includes 3.04 per cent of the tree cover. Area under grasslands is about 3.9 per cent and deserts cover about 2 per cent. It is estimated that India has about 4.1 million hectares of wetlands (excluding paddy fields and mangroves).

Between 1990 and 2000, India gained an average of 3,61,500 hectares of forest per year. This amounts to an average annual reforestation rate of 0.57 per cent. Between 2000 and 2005, this rate of decreased by 92.3 per cent to 0.04 per cent per annum. In total, between 1990 and 2005, India gained 5.9 per cent in forest cover, or around 3.762 Mha. Measuring the total rate of habitat conversion (defined as change in forest area plus change in woodland area minus net plantation expansion) for the 1990-2005 interval, India gained one per cent in forest and woodland habitat.

India possesses a distinct identity, not only because of its geography, history and culture but also because of the great diversity of its natural ecosystems. The panorama of Indian

Figure 2.4.2: Forest Cover in India



Source: State of Forest Report 2005, Forest Survey of India

forests ranges from evergreen tropical rain forests in the Andaman and Nicobar Islands, the Western Ghats, and the North-Eastern States, to dry alpine scrub high in the Himalayas to the north. Between the two extremes, the country has semi-evergreen rain forests, deciduous monsoon forests, thorn forests, subtropical pine forests in the lower mountain zone and temperate mountain forests (Lal, 1989).

The main areas of tropical forest are found in the Andaman and Nicobar Islands, the Western Ghats which fringe the Arabian Sea coastline of peninsular India and the greater Assam region in the North-East. Small remnants of rain forest are found in Orissa state. Semi-evergreen rain forest is more extensive than the evergreen formation, partly because evergreen forests tend to degrade to semi-evergreen with human interference.

The tropical vegetation of North-East India (which includes the states of Assam, Nagaland, Manipur, Mizoram, Tripura and



Sesamum orientale

Meghalaya as well as the plain regions of Arunachal Pradesh) typically occurs at elevations up to 900 m. It embraces evergreen and semi-evergreen rain forests, moist deciduous monsoon forests, riparian forests, swamps and grasslands. Evergreen rain forests are found in the Assam Valley, the foothills of the eastern Himalaya and the lower parts of the Naga Hills, Meghalaya, Mizoram and Manipur where the annual rainfall exceeds 2,300 mm. In the Assam Valley, the giant *Dipterocarpus macrocarpus* and *Shorea assamica* occur singly, occasionally attaining a girth of up to 7 m and a height of up to 50 m. The monsoon forests are mainly moist Sal (*Shorea robusta*) forests, which occur widely in this region. The Andaman and Nicobar islands have tropical evergreen rain forests and tropical semi-evergreen rainforests as well as tropical monsoon forests. The tropical evergreen rain forests are only slightly less grand in stature and rich in species than on the mainland. The dominant species is *Dipterocarpus grandiflorus* in hilly areas, while *Dipterocarpus kerrii* is



*Egretta Gularis* - a Western reef egret

dominant on some islands in the southern parts of the archipelago. The monsoon forests of the Andamans are dominated by *Pterocarpus dalbergioides* and *Terminalia* spp.

### Marine Environment

The near shore coastal waters of India are extremely rich fishing areas. The total commercial marine catch for India has stabilized over the last ten years at between 1.4 and 1.6 million tonnes, with fishes from the clupeoid group, e.g. Sardines (*Sardinella* sp.), Indian Shad (*Hilsa* sp.) and Whitebait (*Stolephorus* sp.) accounting for approximately 30 per cent of all landings.

The Indian reef area is estimated to be 2,375 km<sup>2</sup>. Coral reefs occur along only a few sections of the mainland, principally the Gulf of Kutch, off the southern mainland coast, and around a number of islands opposite Sri Lanka. This general absence is largely due to the presence of major river systems and the sedimentary regime on the continental shelf. Elsewhere, corals are also found in Andaman & Nicobar and Lakshadweep island groups, although their diversity is reported to be lower than in South-East India.

Indian coral reefs have a wide range of resources which are of commercial value. Exploitation of corals, coral debris and coral sands is widespread in the Gulf of Mannar and Gulf of Kutch reefs, while ornamental shells, chanks and pearl oysters are the basis of an important reef industry in the south of India. Sea fans and seaweeds are exported for decorative purposes, and there is a spiny lobster fishing industry along the South-East coast, notably at Tuticorin, Madras and Mandapam. Commercial exploitation of aquarium fishes from Indian coral reefs has gained importance only recently and as yet no organized effort has been made to exploit these resources. Reef fisheries are generally at the subsistence level and yields are not recorded.

Other notable marine area includes seagrass beds which, although not directly exploited, are valuable as habitats for commercially harvested species, particularly prawns, and mangrove stands. In the Gulf of Mannar, the green tiger prawn *Penaeus semisulcatus* is extensively harvested for the export market. Seagrass beds are also important feeding areas for the Dugong (*Dugong dugon*) and several species of marine turtle.

Five species of marine turtle occur in Indian waters - Green turtle (*Chelonia mydas*), Loggerhead (*Caretta caretta*), Olive Ridley (*Lepidochelys olivacea*), Hawksbill (*Eretmochelys imbricata*) and Leatherback (*Dermochelys coriacea*). Most of the marine turtle populations found in the Indian region are in decline. The principal reason for the decrease in numbers is deliberate human predation. Turtles are netted and speared along the entire Indian coast. In South-East India, the annual catch is estimated at 4,000-5,000 animals, with *C. mydas* accounting for about 70 per cent of the harvest. *C. caretta* and *L. olivacea* are the most widely consumed species (Salm, 1981). *E. imbricata* is occasionally eaten but it has caused deaths and so is usually caught for its shell alone. *D. coriacea* is boiled for its oil, which is used for caulking boats and as a protection from marine borers. Incidental netting is widespread.



*A Mangrove Corridor in Andaman & Nicobar Islands*

### **Mangroves**

Mangroves are salt-tolerant forest ecosystems found mainly in tropical and sub-tropical inter-tidal regions of the world. They comprise of trees or shrubs that have the common trait of growing in shallow and muddy salt water or brackish waters, especially along quiet shorelines and in estuaries. They exhibit a remarkable capacity for saltwater tolerance. Mangrove forests are one of the most productive and biodiverse wetlands on earth. Yet, these unique coastal tropical forests are among the most threatened habitats in the world.

### **Status of Mangroves in India**

Mangroves in India account for about five per cent of the world's mangrove vegetation and are spread over an area of about 4,500 km<sup>2</sup> along the coastal States/UTs of the country. Sunderbans in West Bengal accounts for a little less than half of the total area under mangroves in India. The Forest Survey of India has been assessing the vegetation cover of the country, including mangroves using remote sensing since 1983. It published its first assessment of mangroves of India in 1987 and estimated it to be 4,046 km<sup>2</sup>. Thereafter, mangroves have been assessed regularly on a two-year cycle. West Bengal has the maximum mangrove cover in the country, followed by Gujarat and Andaman & Nicobar Islands.

Mangroves mapping was done in 2005, utilizing their unique reflectance characteristics. In the assessment, mangrove cover has also been categorized into very dense mangrove (canopy

density of more than 70 per cent), moderately dense mangrove (canopy density between 40-70 per cent) and open mangrove (canopy density between 10-40 per cent). The current assessment shows that the mangrove cover in the country is 4,445 km<sup>2</sup>, which is 0.14 per cent of the country's total geographic area. The very dense mangrove comprises 1,147 km<sup>2</sup> (25.8 per cent of mangrove cover), moderately dense mangrove is 1,629 km<sup>2</sup> (36.6 per cent)



*Small Green Bee-eater Merops orientalis*

while open mangrove covers an area of 1,669 km<sup>2</sup> (37.6 per cent) (Figures 2.4.3 & 2.4.4).

Compared with 2003 assessment, there has been a marginal decrease in the mangrove cover of the country mainly because of the Tsunami that hit Andaman & Nicobar Islands on 26 December, 2004. Gujarat has shown an increase in mangrove cover mainly owing to plantations and adoption of protection measures.

### Medicinal and Aromatic Plants

Medicinal and aromatic plants have been used in the country for a long time for their medicinal properties. About 2,000 native plant species have curative properties and 1,300 species are known for their aroma and flavour. For the Indian systems of medicine, popularly known as Ayurveda, Unani and Siddha, herbal drugs are in great demand in the country. There is already a spurt in demand for plant-based drugs and lately, many such species of medicinal values are being brought under systematic

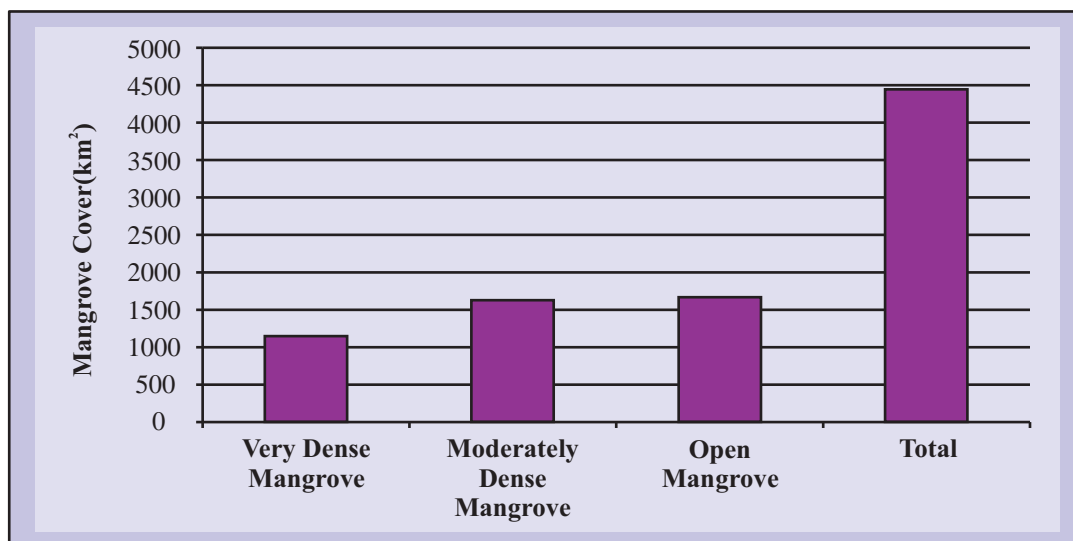
cultivation. India has been considered a treasure house of valuable medicinal and aromatic plant species.

The Ministry of Environment and Forests, Government of India has identified and documented over 9,500 plant species considering their importance in the pharmaceutical industry. Out of these, about 65 species have large and consistent demand in world trade. India, however, produces only limited quantities of these. In terms of market share in production value, India holds only the sixth place with a mere 7 per cent share. On the contrary, we still import about ten types of essential oils to the tune of 8,000 tonnes per annum. Indian exports are thus guided by what may be termed as a trader's vision rather than by a knowledge-products vision.

### Sacred groves

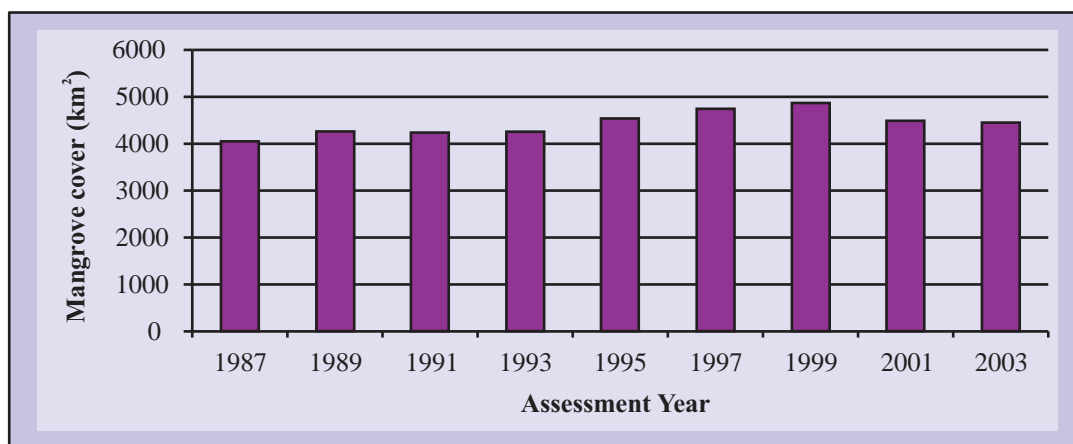
India has over 19,000 sacred groves. Sacred groves are initiatives of communities for conserving biodiversity based on their religious beliefs but of late, these are being degraded or

**Figure 2.4.3: Type of Mangrove Cover in India**



Source: State of Forest Report, 2005, Forest Survey of India

**Figure 2.4.4: Total Mangrove Cover in India**



Source: State of Forest Report, 2005, Forest Survey of India

converted to plantations. Since there are several medicinal plants and wild relatives of crop plants occurring naturally in these areas, the sacred groves need to be conserved. Traditional norms and practices for conservation of neighbourhood forests and common land are also diminishing, although certain rural and tribal communities continue to safeguard their biological resource base even at the cost of their livelihood and sustenance.



*Heracleum wallichii*-Alpine Medicinal Plant

## PRESSURES

### Threats to Biodiversity

Traditional and substantial dependence on biodiversity resources for fodder, fuel wood, timber and minor forest produce has been an accepted way of life for the rural population that accounts for nearly 74 per cent of India's population. With radical demographic changes, the land to man ratio and forest to man ratio has rapidly declined. The lifestyles and the biomass resource needs having remained unchanged, the remnant forests have come under relentless pressure of encroachment for cultivation, and unsustainable resource extraction rendering the very resource base unproductive and depleted of its biodiversity. Coupled with these incongruities and aberrations in land use, the unsound development strategies have led to increasing threats to biodiversity resources by way of illegal encroachment of 0.07 Mha. of forest, cultivation of 4.37 Mha. and diversion of forest for river valley projects (0.52 Mha.), industries and townships (0.14 Mha.), transmission lines and roads (0.06 Mha.) and an additional 1.5 Mha. for miscellaneous purposes (TERI, 1999). The unabated pace of development of infrastructure to harness hydropower, driven by necessity to meet the growing requirements of water for inputs to irrigation, domestic use and industrial purposes, has led to the construction of over 4,000 dams across India. The creation of valley bottom reservoirs in wilderness areas has brought on the destruction of some of the finest forests and biodiversity-rich unique ecosystems. Deforestation due to hydropower and mining projects are perhaps the greatest threats to biodiversity in India.

Human activities are directly and indirectly responsible for current high rates of biodiversity loss. Some of the major issues are:

- Habitat loss, fragmentation and degradation result due to agricultural activities, extraction (including mining, fishing, logging and harvesting) and development (human settlements, industry and associated infrastructure). Habitat loss and fragmentation leads to the formation of isolated, small, scattered populations. These small populations are increasingly vulnerable to inbreeding depression, high

#### Box 2.4.1 : Bishnois – Committed to Conservation

The Bishnoi tribe of Western Rajasthan has, over the centuries, protected the trees and wild animals in and around their villages. Bishnois do not cut trees for fuel and timber; they remove only the dead trunks and twigs. Spotted deer, black buck and blue bulls can be seen foraging fearlessly in their fields. Even if the crop is consumed by herds of deer, the Bishnois do not chase away the animals.

In 1730 A.D., Maharaja Abhaya Singh of Jodhpur ordered cutting of trees in large numbers to provide timber for building a fortress. He sent soldiers to Bishnoi villages to cut down Khejari trees growing in the area. When soldiers applied the axe, the Bishnoi villagers pleaded to spare the trees. When the soldiers did not relent, they hugged the trees and as many as 363 of them laid down their lives to save the trees. The Bishnois worship nature in all its manifestations, conserve trees and medicinal plants, provide food and water to animals, and are vegetarians in their diet.

**Table 2.4.2: Threatened Species**

Mammals	Birds	Reptiles	Amphibians	Fishes	Molluscs	Other Inverts	Plants	Total
96	76	25	65	40	2	109	246	659

INDIA	EX	EW	Subtotal	CR	EN	VU	Subtotal	LR/cd	NT	DD	LC	Total
Animals	1	0	1	51	105	257	413	2	252	231	1631	2,530
Plants	7	2	9	45	112	89	246	1	22	18	70	366

IUCN Red List Categories: EX - Extinct, EW - Extinct in the Wild, CR - Critically Endangered, EN - Endangered, VU - Vulnerable, LR/cd - Lower Risk/conservation dependent, NT - Near Threatened (includes LR/nt - Lower Risk/near threatened), DD - Data Deficient, LC - Least Concern (includes LR/lc - Lower Risk, least concern).

Source: IUCN Red List, 2008

infant mortality and are susceptible to stochastic environmental events, and consequently, possible extinction. Changes in forest composition and quality, and the resultant habitat type lead to decline in primary food species for wildlife.

- Poaching and hunting
- Invasive species
- Over-exploitation of wild bio resources
- Pollution of atmosphere, water and soil
- Global climate change

## RESPONSE

### 1) Wild Life (Protection) Act, 1972

In respect of Wildlife Conservation, the following actions will be pursued:

- a) Expand the Protected Area (PA) network of the country, including Conservation and Community Reserves, to give fair representation to all bio-geographic zones of the country. In doing so, develop norms for delineation of PAs in terms of the Objectives and Principles of the National Environment Policy, in particular, participation of local communities, concerned public agencies, and other stakeholders, who have a direct and tangible stake in protection and conservation of wildlife, to harmonize ecological and physical features with needs of socio-economic development.
- b) Revisit the norms, criteria and needs of data for placing particular species in different schedules of the Wildlife Protection Act.
- c) Formulate and implement programmes for conservation of endangered species outside protected areas, while reducing the scope for man-animal conflict.
- d) Empower, build capacities, and facilitate access to finance and technology for local people, in particular tribals, who are relocated from PAs, or live in the fringe areas, for provision of eco-tourism services in the PAs.
- e) Paralleling multi-stakeholder partnerships for afforestation, formulate and implement similar partnerships for enhancement

of wildlife habitat in Conservation Reserves and Community Reserves, to derive both environmental and eco-tourism benefits.

- f) Promote site-specific eco-development programmes in fringe areas of PAs, to restore livelihoods and access to forest produce by local communities, owing to access restrictions in PAs.
- g) Strengthen capacities and implement measures for captive breeding and release into the wild, identified endangered species.
- h) Review and tighten the provisions of relevant legislation to enhance their deterrence. Further, strengthen institutional measures and capacities of enforcement authorities, with respect to intelligence collection, investigation, and prosecution, to deal with wildlife crime.
- i) Ensure that human activities on the fringe areas of PAs do not degrade the habitat or otherwise significantly disturb wildlife.

### 2) The National Forest Policy, 1988

The National Forest Policy, 1988, and the Indian Forest Act, as well as the regulations under it, provide a comprehensive basis for forest conservation. The National Forest Commission, set up in 2003, is reviewing the policy, legislative and institutional basis of forest management. Nevertheless, it is necessary, considering some of the underlying causes of forest loss, to take some further steps. These include the following :

- a) Legal recognition of the traditional entitlements of forest-dependant communities, taking into consideration the provisions of the Panchayat (Extension to the Scheduled Areas) Act, 1996 (PESA). This would remedy a serious historical injustice, secure their livelihoods, reduce possibilities of conflict with the Forest Departments, and provide long-term incentives to these communities to conserve the forests.
- b) Formulate innovative strategy to increase forest and tree cover from 23.69 per cent in 2003 to 33 per cent of the country's land area by 2012, through afforestation of degraded forest land, wastelands, and tree cover on private or revenue lands.
- c) Formulate appropriate methodology for reckoning and restoring the environmental values of forests, which are unavoidably diverted to other uses.

d) Formulate and implement a 'Code of Best Management Practices' for dense natural forests, to realize the objectives and principles of National Environment Policy. Forests of high indigenous genetic diversity should be treated as entities with incomparable value.

e) Denotify Bamboo and similar other species as 'Forest Species' under the Forest Conservation Act, to facilitate their cultivation outside notified forests, and encourage their productive utilization in economic activities.

f) Promote plantation of only such species as are conducive to the conservation and sustainability of given ecosystems.

g) It is essential that women play a greater role in the management of natural resources. While they have to bear the burden of natural resource degradation, they have little control over the management of these resources. Relevant provisions of the National Policy for the Empowerment of Women provide a framework for incorporating elements of proposed actions.

### 3) Biological Diversity Act, 2002

To regulate access to genetic resources and associated sharing arrangements, apart from developing policies and programmes on long term conservation and protection of biological resources and associated knowledge, the Biological Diversity Act, 2002 was promulgated. The National Biodiversity Authority (NBA) set up at Chennai on 1<sup>st</sup> October 2003 as per the provisions of the Biological Diversity Act, 2002 is mandated to facilitate implementation of the Act.

### 4) National Biodiversity Action Plan (NBAP)

The Union Ministry of Environment and Forests (MoEF), the

nodal agency for implementing the provisions of Convention on Biological Diversity (CBD) in India, developed a strategy for biodiversity conservation at macro-level in 1999 and enacted the Biological Diversity Act in 2002, followed by the Rules thereunder in 2004. There is a need now to develop and implement a suitable national action plan for promoting biodiversity conservation, sustainable use of its components and equitable sharing of benefits arising from such use. The National Environment Policy, 2006, seeks to achieve balance and harmony between conservation of natural resources and development processes and also forms the basic framework for the National Biodiversity Action Plan.

The objectives of the NBAP are founded in the backdrop of the cardinal principles already set out in the NEP 2006. The most important of these principles is that human beings are at the centre of sustainable development concerns. The other relevant principles on which the objectives are premised include the right to development, precautionary approach, economic efficiency, entities with 'incomparable value', equity, public trust doctrine, decentralization, integration, preventive actions, and environmental offsetting.

The objectives are broad-based and relate to current perceptions of key threats and constraints to biodiversity conservation and are as follows.

- i. Strengthening and integration of in situ, on-farm and ex situ conservation
- ii. Augmentation of natural resource base and its sustainable utilization; Ensuring inter and intra-generational equity



*Our National Bird Peacock*

- iii. Regulation of introduction of invasive alien species and their management
- iv. Assessment of vulnerability, and adaptation to climate change and desertification
- v. Integration of biodiversity concerns in economic and social development
- vi. To prevent, minimize and abate impacts of pollution
- vii. Development and integration of biodiversity databases
- viii. Strengthening implementation of policy, legislative and administrative measures for biodiversity conservation and management
- ix. Building of national capacities for biodiversity conservation and appropriate use of new technologies
- x. Valuation of goods and services provided by biodiversity and use of economic instruments in the decision-making processes
- xi. International cooperation to consolidate and strengthen bilateral, regional and multilateral cooperation on issues related to biodiversity.

## 5) Forest Certification

Forest certification has emerged as one of the market mechanisms to address environmental concerns of the green consumers on one hand and help promote sustainable forest management on the other. Forest certification also contributes to the promotion of economically viable, environmentally appropriate and socially beneficial management of forests as defined by the Helsinki criteria. Forest certification was launched over a decade ago to help protect forests from destructive logging practices. Like the 'organically grown' label on produce, forest certification was intended as a seal of approval, a means of notifying consumers that a wood or paper product comes from forests managed in accordance with strict environmental and social standards.

At present, most of the certified forests are in the developed countries. Globally, as of July 2005, the total area of certified forests was estimated at about 245 Mha.

The process of certification in tropical timber producing countries like India has been slow on account of several reasons



*Rhino in Kaziranga National Park*

including inflexibility of international certification standards like FSC (Forest Stewardship Council) and PEFC (Pan European Forest Certification Council), lack of recognition of broader local land-use issues, wide-range of NTFPs (Non-Timber Forest Products) conflicts, incompatibility between legal settings and certification standards and high costs of certification. There are only two FSC certificates existing in India as on date.

It is also important to note that there seems to be no domestic market for forest certified products in the country till now. However, there could be potential export markets for certain products based on forest resources as raw material, for example, wood/natural fibre based handicraft products.

As a first step in the direction for initiating forest certification processes in the country, a National Working Group has been set up involving officials of the MoEF and SFDs (State Forest Departments), industry representatives and environment based NGOs, institutional experts and independent experts having international expertise in forest certification.

#### **6) Coastal Management Zone Draft Notification, 2008**

Ministry of Environment and Forests issued the Coastal Regulation Zone Notification in 1991, under which coastal stretches were declared Coastal Regulation Zones (CRZ) and restrictions were imposed on the setting up and expansion of industries, operations and processes in the said Zones for its protection. The Government had constituted an Expert Committee under the Chairmanship of Prof. M.S. Swaminathan to review the various issue pertaining to implementation of the Coastal Regulation Zone Notification, 2004. The Committee submitted its report along with its recommendations to the Ministry in April, 2005. Based on these recommendations, the Ministry has formulated a draft CMZ Notification. This draft has been discussed with various stakeholders and based on the suggestions received, the draft notification is under finalization.

#### **7) Ex-situ Conservation**

Attention has been paid to *ex-situ* conservation measures also as they complement *in-situ* conservation measures and are even otherwise important. There are about 70 botanical gardens, including 33 University botanical gardens. Also, there are 275 centres of *ex-situ* wildlife preservation in the form of zoos, deer parks, safari parks, aquaria etc. A Central Zoo Authority supports, oversees, monitors and coordinates the development and management of zoos in the country. A scheme entitled Assistance to Botanical Gardens provides one-time assistance to botanical gardens to institute and strengthen measures for *ex-situ* conservation of cultivated plants and domesticated animals. While zoological parks have been looked upon essentially as centres of education and recreation, they have played an important role in the conservation of species such as Manipur Thamin Deer and the White-Winged Wood Duck.

The Indian National Gene Bank established by the ICAR as a part of the National Bureau of Plant Genetic Resources, has conserved more than 1,50,000 accessions and samples. The

capacity of this gene bank has been increased to about one million, making it the largest gene bank of the world. It has more than 7,100 accessions of underutilized crops.

#### **8) In-situ conservation**

Approximately, 4.83 per cent of the total geographical area of the country has been earmarked for extensive *in-situ* conservation of habitats and ecosystems through a protected area network of 99 National Parks and 523 Wildlife Sanctuaries. The results of this network have been significant in restoring viable populations of large mammals such as tigers, lions, rhinoceros, crocodiles and elephants. To conserve the representative ecosystems, the Biosphere Reserve Programme is being implemented. In all, 15 biodiversity rich areas of the country have been designated as Biosphere Reserves. Programmes have also been launched for scientific management and wise use of fragile ecosystems. Specific programmes for management and conservation of wetlands, mangroves and coral reefs systems are being implemented. National and sub-national level committees oversee and guide these programmes to ensure strong policy and strategic support.

#### **Number and Extent of Protected Areas**

The network of protected areas presently covers 4.83 per cent of the country's total land area and includes 99 national parks and 523 wildlife sanctuaries. Of these, 100 cover both terrestrial and freshwater ecosystems and 31 are marine protected areas. There are also 15 Biosphere Reserves and several Reserved Forests, which are part of the most strictly protected forests outside the protected areas.

#### **Biodiversity and Protected Areas**

India has some 2,356 known species of amphibians, birds, mammals and reptiles according to figures from the World Conservation Monitoring Center. Of these, 18.4 per cent are endemic, meaning they exist in no other country, and 10.8 per cent are threatened. India is home to at least 18,664 species of vascular plants, of which 26.8 per cent are endemic. About 4.9 per cent of the country's area is protected under IUCN categories I-V.

1. Nature Reserves, Wilderness Areas, and National Parks (categories I and II)
2. Areas Managed for Sustainable Use and Unclassified Areas (category VI and 'other')
3. Natural Monuments, Species Management Areas, and Protected Landscapes and Seascapes (categories III, IV, and V)

#### **Biosphere Reserves**

The programme of Biosphere Reserve was initiated under the 'Man & Biosphere' (MAB) programme of UNESCO in 1971. The purpose of the formation of the biosphere reserve is to conserve *in-situ* all forms of life, along with its support systems, in their totality, so that it could serve as a referral system for monitoring and evaluating changes in natural ecosystems. The first biosphere reserve of the world was established in 1979. Since then the

network of biosphere reserves has increased to 531 in 105 countries across the world (MAB, 2008). Presently, there are 15 existing biosphere reserves in India (Table 2.4.3).

### Project Tiger

As per the recommendations of a special task-force of the Indian Board of Wildlife, Project Tiger was launched in 1973 with the following objectives:

- To ensure maintenance of the available population of tigers

in India for scientific, economic, aesthetic, cultural and ecological value.

- To preserve, for all times, the areas of such biological importance as a national heritage for the benefit, education and enjoyment of the people.

Starting with nine reserves in 1973-74, the number has grown to 29 in 2006 (Table 2.4.4). A total area of 38,620 km<sup>2</sup> corresponding to 1.17 per cent of the total geographical area of the country is covered by Project Tiger.

**Table 2.4.3: Number of Biosphere Reserves set up in India**

Sl. No.	Name	Date of Estbl.	Area (in km <sup>2</sup> )	Location
1	Achanakamar - Amarkantak	2005	<b>3835.51</b> (Core 551.55 & Buffer 3283.86)	Covers parts of Anupur and Dindori districts of Madhya Pradesh and parts of Bilaspur Districts of Chhattisgarh State
2	Agasthyamalai	12.11.2001	<b>1828</b>	Neyyar, Peppara and Shendurney Wildlife Sanctuaries and their adjoining areas in Kerala
3	Dehang-Dibang	02.09.98	<b>5111.5</b> (Core 4094.80 & Buffer 1016.70)	Part of Siang and Dibang Valley in Arunachal Pradesh
4	Dibru-Saikhowa	28.07.97	<b>765</b> (Core 340 & Buffer 425)	Part of Dibrugarh and Tinsukia Districts (Assam)
5	Great Nicobar	06.01.89	<b>885</b> (Core 705 & Buffer 180)	Southern most islands of Andaman and Nicobar (Andaman and Nicobar Islands)
6	Gulf of Mannar	18.02.89	<b>10,500</b> Total Gulf Area (Area of Island 5.55 km <sup>2</sup> )	Indian part of Gulf of Mannar between India and Sri Lanka (Tamil Nadu)
7	Khangchendzonga	07.02.2000	<b>2619.92</b> (Core 1819.34 & Buffer 835.92)	Parts of Khangchendzonga Hills and Sikkim
8	Manas	14.03.89	<b>2837</b> (Core 391 & Buffer 2446)	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darang Districts (Assam)
9	Nanda Devi	18.01.88	<b>5860.69</b> (Core 712.12, Buffer 5,148.570 & Transition 546.34)	Part of Chamoli, Pithoragarh, and Bageshwar Districts (Uttarakhand)
10	Nilgiri	01.09.86	<b>5520</b> (Core 1240 & Buffer 4280)	Part of Wayanad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani Hills (Tamil Nadu, Kerala and Karnataka)
11	Nokrek	01.09.88	<b>820</b> (Core 47.8 & Buffer 227.92 Transition Zone 544.60)	Part of Garo Hills (Meghalaya)
12	Pachmarhi	03.03.99	<b>4926</b>	Parts of Betul, Hoshangabad and Chindwara Districts of Madhya Pradesh
13	Simlipal	21.06.94	<b>4374</b> (Core 845, Buffer 2129 & Transition 1400)	Part of Mayurbhanj District (Orissa)
14	Sunderbans	29.03.89	<b>9630</b> (Core 1700 & Buffer 7900)	Part of delta of Ganga and Brahmaputra river system (West Bengal)
15	Kachch	29.01.08	<b>12454</b>	Parts of Kachch, Rajkot, Surendranagar and Patan district of Gujarat

Source: National Biodiversity Action Plan, 2008, MoEF

**Table 2.4.4: List of Tiger Reserves in India**

State	Tiger Reserve	Year of Establishment	Total Area (km <sup>2</sup> )
Assam	1. Kaziranga	2006	859
	2. Manas	1973-74	2840
	3. Nameri	1999-2000	344
Arunachal Pradesh	4. Namdapha	1982-83	1985
	5. Pakhui	1999-2000	862
Andhra Pradesh	6. Nagarjunsagar- Srisaillam	1982-83	3568
Bihar	7. Valmiki	1989-90	840
Chhattisgarh	8. Indravati	1982-83	2799
Jharkhand	9. Palamau	1973-74	1026
Karnataka	10. Bandipur Nagarhole (extension)	1973-74 1999-2000	866 643
	11. Bhadra	1998-99	492
Kerala	12. Periyar	1978-79	777
Madhya Pradesh	13. Bandhavgarh	1993-94	1162
	14. Bori-Satpura	1999-2000	1486
	15. Kanha	1973-74	1945
	16. Panna	1994-95	542
	17. Pench	1992-93	758
Maharashtra	18. Melghat	1973-74	1677
	19. Pench	1992-93	257
	20. Tadoba-Andheri	1993-94	620
Mizoram	21. Dampa	1994-95	500
Orissa	22. Simlipal	1973-74	2750
Rajasthan	23. Ranthambhore	1973-74	1334
	24. Sariska	1978-79	866
Tamil Nadu	25. Kalakad-Mundathurai	1988-89	800
Uttar Pradesh	26. Dudhwa Katernighat (Extension)	1987-88 1999-2000	811 551
	27. Corbett	1973-74	1316
West Bengal	28. Buxa	1982-83	759
	29. Sunderbans	1973-74	2585
<b>Total Area</b>			<b>38,620</b>

Source: Wildlife Institute of India, 2007

### Box 2.4.2: Forest Cover Change in Tiger Reserves



Forest Survey of India analyzed the forest cover of all the 28 Tiger Reserves (TRs) and in their outer surroundings (10 km strip), using remote sensing and GIS. Forest cover estimates based on satellite data of IRS-IC/ID (LISS III) of the years 1997, 2000 and 2002 has been used in the study. The change in the forest cover was analyzed for the period 1997-2002.

It was found that between 1997 and 2002, five TRs have shown an increase in forest cover, 11 TRs have shown decrease, and 12 TRs have shown no change. Major losses in forest cover have occurred in Nameri, Buxa, Manas, Indravati and Dampa TRs mainly due to socio-economic reasons and natural disasters.

Forest cover in the outer surroundings has increased in two TRs, decreased in 21 TRs and has not changed in five TRs. The total forest cover inside the TRs and their outer surroundings has increased by 94 km<sup>2</sup> and 124 km<sup>2</sup> respectively. The detailed report of the study may be obtained from FSI or from the National Tiger Conservation Authority.

### Project Elephant

It was launched in 1991-92 to assist the States having free ranging populations of wild elephants to ensure the long term survival of identified viable populations of elephants in their natural habitats. The project is being implemented in the states of Andhra Pradesh, Arunachal Pradesh, Assam, Jharkhand, Karnataka, Kerala, Meghalaya, Nagaland, Orissa, Tamil Nadu, Uttaranchal, Uttar Pradesh and West Bengal.

Major activities of Project Elephant include:

- Ecological restoration of existing natural habitats and migratory routes of elephants
- Development of scientific and planned management for conservation of elephant habitats and value population of wild Asiatic elephants in India
- Promotion of measures for mitigation of man-elephant conflict in crucial habitats and moderating pressures of human and domestic stock activities in crucial elephant habitats
- Strengthening of measures for protection of wild elephants from poachers and unnatural causes of death
- Research on Project Elephant management related issues
- Public education and awareness programmes
- Eco-development
- Veterinary care

### National Parks and Wildlife Sanctuaries

The Wildlife Act provided for setting up National Parks and Sanctuaries for wildlife conservation. The Government of India has pledged all efforts to conserve the natural heritage of the country and seeks not only to protect and preserve what remains of wild fauna and flora, but also to augment this priceless national asset.

a. Multi-pronged pressures on forests are exerted by increasing human population, cattle grazing, fuel and fodder collection, industry and forest fires, etc. The remaining good forest cover is, therefore, estimated to be just 11 per cent against the desirable 33

per cent of the total land area as per the National Forest Policy. Up to the late Seventies, forest land was a prime target for diversion for resettlement, agriculture and industrialization, and this trend was contained only by the Forest (Conservation) Act, 1980.

b. A two-pronged strategy to increase forest cover essentially comprises of:

- Improving canopy cover in the forest land.
- Undertaking afforestation in non-forest and degraded lands, preferably contiguous to forest blocks.

c. Realizing the role of forests in controlling soil erosion, moderation of floods, recharging of ground aquifers, as habitat for wildlife, conservation of biodiversity and gene pool, etc., programmes were launched as early as the Second Five Year Plan for extensive Watershed Management, followed later by establishment of a Protected Areas Network, under the Wildlife (Protection) Act, 1972, comprising Biosphere Reserves, National Parks and Sanctuaries - both terrestrial and aquatic. This Network now comprises of 15 Biosphere Reserves, 99 National Parks and 523 Wildlife Sanctuaries (Table 2.4.5). Another 217 sanctuaries, covering an area of 16,669.44 km<sup>2</sup>, are proposed in the Protected Area Network Report, along with dedicated conservation programmes such as Project Tiger, Crocodile Rehabilitation and Project Elephant. The Central Zoo Authority caters to the ex-situ conservation of wildlife through 275 zoos, deer parks, safari parks and aquaria, etc. India is also a signatory to several International Conventions like the Convention on International Trade in Endangered Species, International Whaling Convention (IWC), Convention on Migratory Species (CMS), World Heritage Convention (WHC), etc. India has recently taken the lead in formation of the Global Tiger Forum.

### National Lake Conservation Plan

Recognizing the importance of lakes, the Ministry of Environment & Forests, Government of India, launched the National Lake Conservation Plan (NLCP), a centrally sponsored scheme exclusively aimed at restoring the water quality and

ecology of the lakes in different parts of the country. The scheme was approved by the Government of India in the IX<sup>th</sup> Five Year Plan (Feb 2002) as 100 per cent central funding to 70:30 cost-sharing between the Centre and the concerned State Government. The objective of the scheme is to restore and

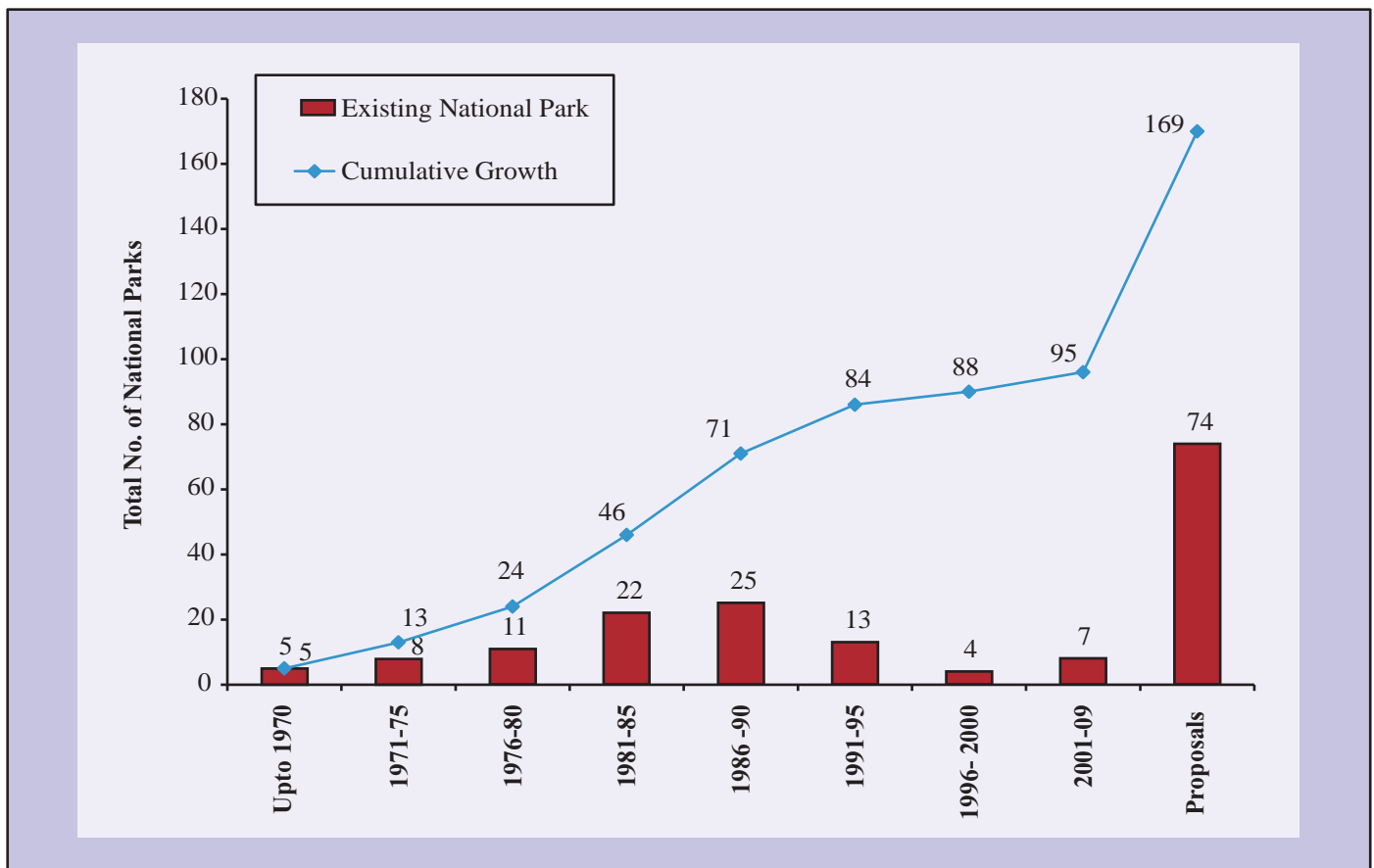
conserve the urban and semi-urban lakes of the country, degraded due to wastewater discharge into the lakes and other unique freshwater ecosystems, through an integrated ecosystem approach.

**Table 2.4.5: Current Protected Areas Statistics of India (as on March 2009)**

Geographical Area (G.A.) of India		32,87,263 km <sup>2</sup>	
Forest Area of India (FSI, 2005)		667,088 km <sup>2</sup>	
Percentage Forest Area of Geographical Area of India		20.29 %	
Current Protected Area Status			
National Parks	99	Area Covered	39,155 km <sup>2</sup>
Wildlife Sanctuaries	523	Area Covered	1,18,417 km <sup>2</sup>
Conservation Reserves	43	Area Covered	1,155.06 km <sup>2</sup>
Community Reserves	3	Area Covered	17.76 km <sup>2</sup>
Protected Areas	668	Area Covered	1,58,745 km <sup>2</sup>
National Parks % of G.A.	1.19%		
Wildlife Sanctuaries % of G.A.	3.60%		
Conservation Reserves % of G.A.	0.04%		
Protected Areas % of G.A.	4.83%		

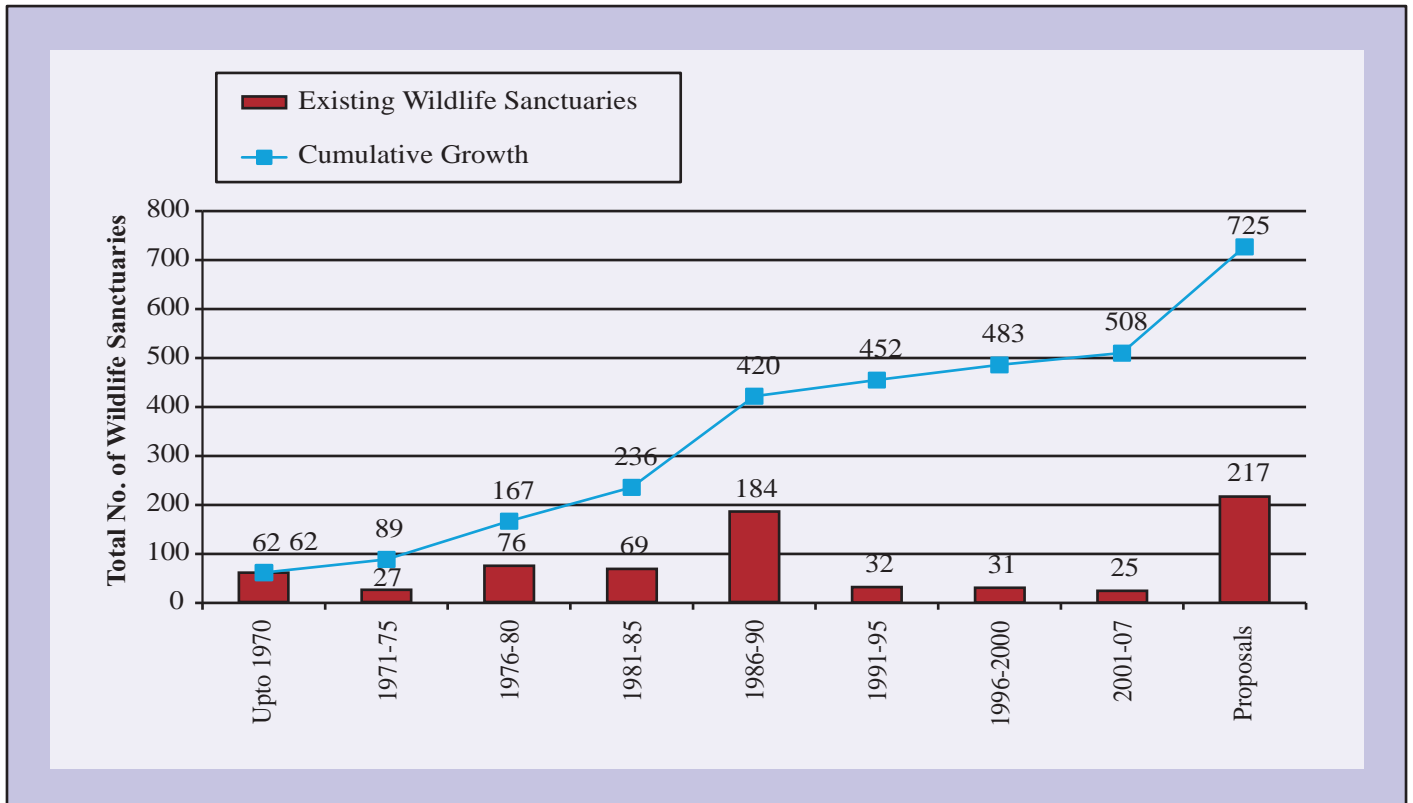
Source: Wildlife Institute of India, 2009

**Figure 2.4.5 : Growth of National Parks in India**



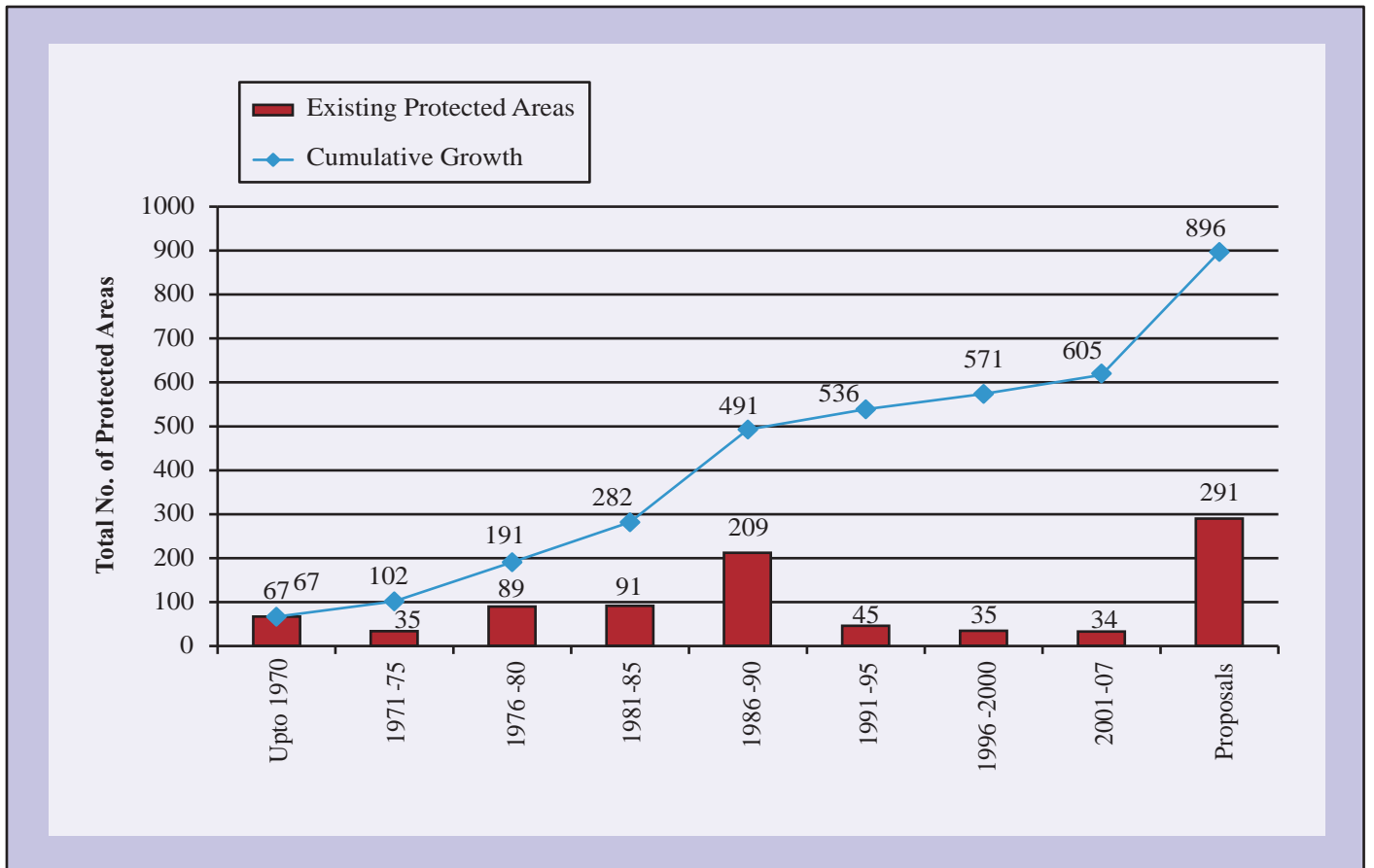
Source: Wildlife Institute of India, 2009

**Figure 2.4.6 : Growth of Wildlife Sanctuaries in India**



Source: Wildlife Institute of India, 2009

**Figure 2.4.7: Growth of Protected Areas in India**



Source: Wildlife Institute of India, 2009

## National Wetland Conservation and Management Programme (NWCMP)

Recognizing the importance of protecting wetlands, the Government of India operationalized a wetland conservation programme in 1985-86 in close collaboration with the concerned State Governments. Several steps were taken to arrest further degradation and shrinkages of water bodies due to encroachments, siltation, weed infestation, catchment erosion, surface runoff carrying pesticides and fertilizers from agriculture fields, and discharge of domestic sewage and effluents, which resulted in deterioration of water quality, prolific weed growth, decline in biodiversity and other associated problems.

There are a total of 104 identified wetlands under the National Wetland Conservation & Management Programme (NWCMP). These wetlands are eligible for financial assistance on a 100 per cent grant basis from the concerned State Governments for undertaking activities like survey and demarcation, weed control, catchment area treatment, de-siltation, conservation of biodiversity, pollution abatement, livelihood support, creation of minor infrastructure, educational awareness, capacity building of various stakeholders and community development. So far, 24 states have been covered.

## POLICY SUGGESTIONS

### Wetland Conservation

For wetland conservation, a holistic view is necessary, which looks at each identified wetland in terms of its causal linkages with other natural entities, human needs, and its own attributes.

The following actions could be considered:

- a) Set up a legally enforceable regulatory mechanism for identified valuable wetlands, to prevent their degradation and enhance their conservation. Develop a national inventory of such wetlands.
- b) Formulate conservation and prudent use strategies for each significant catalogued wetland, with participation from local communities, and other relevant stakeholders.
- c) Formulate and implement eco-tourism strategies for identified wetlands through multi-stakeholder partnerships involving public agencies, local communities, and investors.
- d) Take explicit account of impact on wetlands of significant development projects during the environmental appraisal of such projects; in particular, the reduction in the economic value of wetland environmental services should be explicitly factored into the cost-benefit analyses.
- e) Consider unique wetlands as entities with 'incomparable values', in developing strategies for their protection.
- f) Integrate wetland conservation, including conservation of village ponds and tanks, into sectoral development plans for poverty alleviation and livelihood improvement, and link efforts for conservation and sustainable use of wetlands with the ongoing rural infrastructure development and employment



*Malayan Giant Squirrel*

generation programmes. Promote traditional techniques and practices for conserving village ponds.

## ECO - TECHNOLOGY SOLUTIONS

Technological processes often lead to higher withdrawals and consumption of natural resources and higher addition of pollutants than what ecological limits permit. These contribute to underdevelopment through destruction of ecosystems.

The need for eco-technological solutions has been felt for sometime and a few sporadic and scattered innovations and efforts are being made silently in the areas of agriculture, mining and fishing for mitigating the adverse impacts. The successful adoption of alternative eco-technologies depend upon their integration into the existing livelihood systems. Stakeholders are both the experimenters and potential beneficiaries of alternative systems. Much of the biological diversity is in the custody of farmers who follow age-old farming and land-use practices and thereby are excellent conservators of biodiversity. However, due to the increasing demand for food, fodder and other natural resources there is a need to develop eco-technologies as they are the blend of traditional knowledge and modern technology.

The Patents Act, 1970 addresses several aspects of the issue of

disclosure. The Act mandatorily requires disclosure of source and geographical origin of biological material used in an invention while applying for patents. Failure to disclose or wrongful disclosure are considered as grounds for opposition to the grant of patent and the patent may be revoked. The Act also requires the applicant to furnish a declaration with regard to having obtained the necessary permission of the competent authority to use the biological material from India. There is a need to harmonize these provisions with the Biodiversity Conservation Act, in particular to enable local communities, holding the traditional knowledge for use of such biological

material, to benefit from providing access to such knowledge.

There is a need to formulate an appropriate system for Prior Informed Consent and Fair and Equitable Benefit sharing in respect of biological material and traditional knowledge to enable both the country and the local communities to derive economic benefits by providing access. These issues are complex and therefore, modalities for their implementation need to be carefully worked out. Finally, efforts should be made to attain greater congruence between these issues and trade related aspects of Intellectual Property Rights.

#### Box 2.4.3: New Technology for Mining

The process of open-cast mining scars the landscape, disrupts ecosystems and destroys microbial communities. Over the long term, open-cast mining reduces forest productivity, damages aquatic and atmospheric ecosystems and sometimes leads to substantial alterations in microclimates. Such changes, in turn, have adverse economic and social impacts on nearby communities whose residents majorly depend on the region's natural resources for their livelihoods.

The National Environmental Engineering Research Institute (NEERI) has developed a sustainable eco-friendly technology that reclaims and rejuvenates the 'soil spoils' left behind by open-cast mining. The strategy, which experts have labeled as the Integrated Biotechnological Approach (IBA), involves the use of diverse organic materials (for example, such industrial wastes as press-mud, a by-product of sugar mills, and treated sludge, a by-product of paper mills) to build soil productivity. These organic materials, which nourish the depleted soil, are supplemented by the planting of saplings that contain specialized cultures of endomycorrhizal fungi and such nitrogen-fixing bacteria such as *Rhizobium* and *Azotobacter*. IBA has increased the survival rate of plant species found on land that is scarred by open-cast mining to more than 80 per cent. At the same time, it has boosted the species growth rate by a factor of five. Barren, eroded slopes have been transformed into lush-green tree-lined landscapes. Equally importantly, the areas' biodiversity is slowly being regenerated. In fact, IBA forests ultimately produce commodities of high value, including timber, fruit and gum. In addition to these long-term environmental benefits, over the short term, the strategy generates jobs and income.

#### Box 2.4.4: Traditional Ethos

In spite of modernization, traditional ecological ethos continue to survive in many local communities in India. Investigations into the traditional resource use norms and associated cultural institutions prevailing in rural Bengal society (*Deb and Malhotra, 2001*) demonstrate that a large number of elements of local biodiversity, regardless of their use value, are protected by the local cultural practices. Some of these may not have known the conservation effect, yet may symbolically reflect a collective appreciation of the intrinsic or existence value of life forms, and respect for nature. Traditional conservation ethics are still capable of protecting much of the country's decimating biodiversity, as long as the local communities have a stake in the management of natural resources.

One example from North East India is particularly notable (*Tiwari et al. 1998*). The tribal communities of Meghalaya - Khasis, Garos, and Jaintias - have a tradition of environmental conservation based on various religious beliefs. As elsewhere in India, particular patches of forests are designated as sacred groves under customary law and are protected from any product extraction by the community. Such forests are very rich in biological diversity and harbour many endangered plant species, including rare herbs and medicinal plants.

Traditional water-harvesting structures too are also a habitat for a variety of species. Even if the pond size is small, as is the case with about 60 per cent of the 1.5 million total tanks in India (*Pandey, 2001*), it may still be a useful habitat for many species in rural ecosystems. Indeed, the island biogeography theory – valid in numerous cases - suggesting that larger areas support more species did not stand in the case of the 80 ponds studied in Switzerland (*Oertli et al., 2002*).

## REFERENCES

- Compendium of Environment Statistics India 2007, Ministry of Statistics & Programme Implementation
- Convention on biological diversity - National Biodiversity Strategy Action Plan
- Deb, D., Malhotra, K. C. (2001). Conservation Ethos in Local Traditions: The West Bengal Heritage. *Society and Natural Resources* 14: 711-724
- *India's Forests 2007, Ministry of Environment & Forests*
- Lal J.B.( 1989). India's Forests: Myth and Reality. Natraj Publishers, New Delhi, India
- National Biodiversity Action Plan 2008, Ministry of Environment & Forests
- Oertli, B. Joye, D. A., Castella, E., Juge, R., Cambin, D., and Lachavanne, J.-B. (2002). Does size matter? The relationship between pond area and biodiversity. *Biological Conservation* 104, 59-70
- Pandey, Deep N. (2001b). Ethnobotany for Small-Scale Forest Management in India. In Herbohn, J. *et al.* (eds) *Developing Policies to Encourage Small-Scale Forestry*. Australia, 220-231
- Rodgers, W.A., H.S. Panwar., H. S and Mathur, V. B. (2000). Wildlife Protected Area Network in India: A Review (Executive Summary). Wildlife Institute of India, Dehradun
- Salim R.V. 1981. Coastal resources of Sri Lanka, India and Pakistan: Description, Use and Management. U.S. Fish and Wildlife Service International Affairs Publication: pp 260
- State of Forest Report 2005, Forest Survey of India, Ministry of Environment & Forests
- TERI (1999). TERI Energy Data Directory & Yearbook 1999/2000. The Energy and Resources Institute, New Delhi
- Tiwari, B. K., Barik, S. K., and Tripathi, R. S. 1998. Biodiversity value, status, and strategies for conservation of sacred groves of Meghalaya, India. *Ecosystem Health* 4: 20-32
- The Integration of Biodiversity into National Environmental Assessment Procedures-National Case Studies-India. 2001.UNDP/UNEP/GEF
- IUCN – The International Union for the Conservation of Nature and Natural Resources
- Wildlife Institute of India, Dehradun



Gujarat Wetland