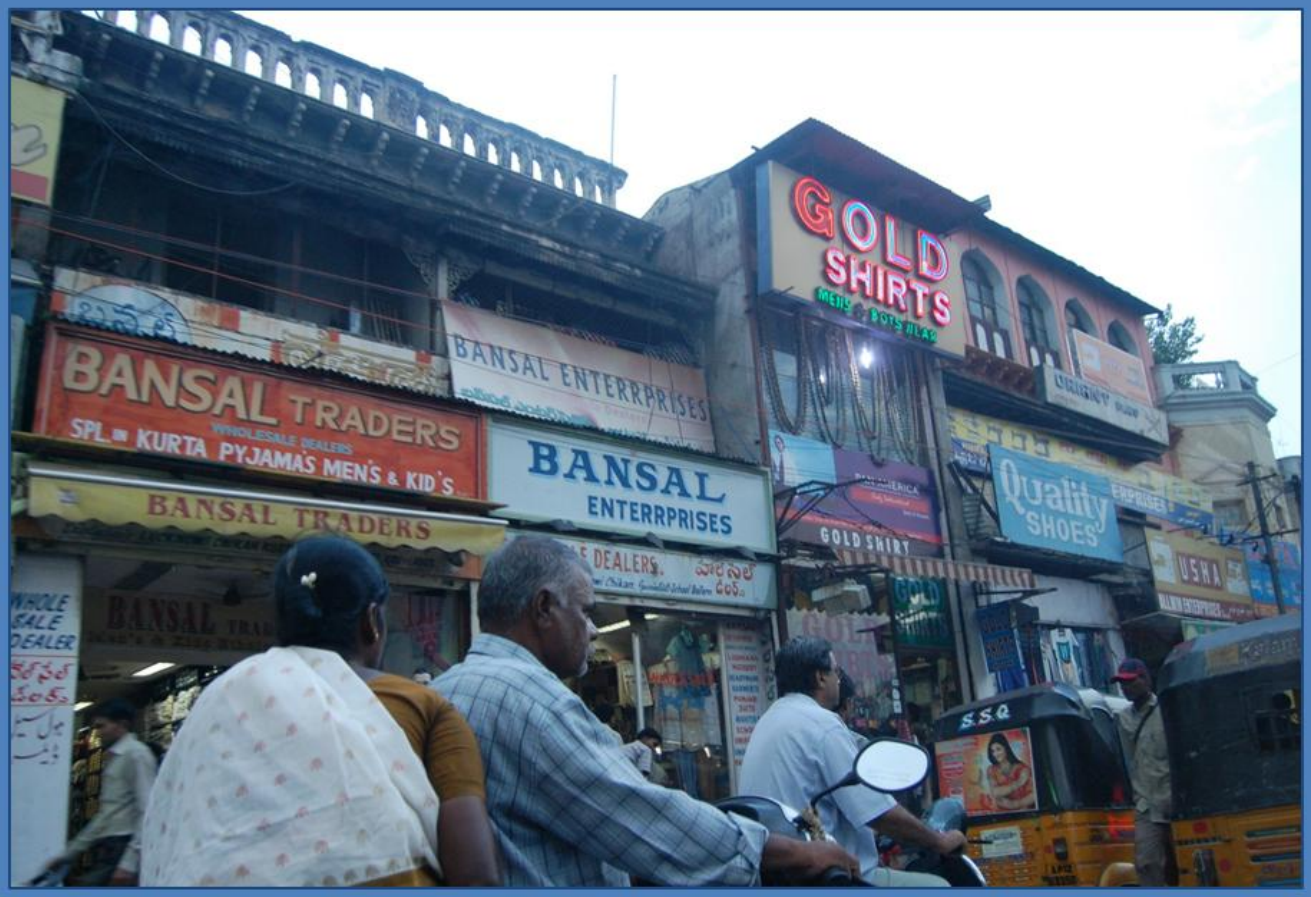
CAMP India

2010 Edition



Clean Air Management Profile

CLEAN AIR INITIATIVE for Asian Cities
10
2001-2011

Clean **A**ir **M**anagement **P**rofile**:**

India

2010 Edition

Clean Air Initiative for Asian Cities (CAI-Asia)
www.cleanairinitiative.org

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About CAI-Asia

The Clean Air Initiative for Asian Cities (CAI-Asia) promotes better air quality and livable cities by translating knowledge to policies and actions that reduce air pollution and greenhouse gas emissions from transport, energy and other sectors. CAI-Asia was established in 2001 by the Asian Development Bank, the World Bank and USAID, and is part of a global initiative that includes CAI-LAC (Latin American Cities) and CAI-SSA (Sub-Saharan Africa).

Since 2007, this multi-stakeholder initiative is a registered UN Type II Partnership with more than 200 organizational members and eight Country Networks (China, India, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, and Vietnam). The CAI-Asia Center is its secretariat, a non-profit organization headquartered in Manila, Philippines with offices in China and India. Individuals can join CAI-Asia by registering at the Clean Air Portal: www.cleanairinitiative.org. Its flagship event, the Better Air Quality conference, brings together over 500 air quality stakeholders.

List of Abbreviations

AQG	Air Quality Guideline
AQM	Air Quality Management
NH_3	Ammonia
As	Arsenic
ADB	Asian Development Bank
ASSOCHAM	Associated Chambers of Commerce and Industry of India
ALGI	Association of Local Governance of India
ABC	Atmospheric Brown Cloud
ARAI	Automotive Research Association of India
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BRTS	Bus Rapid Transit System
CO_2	Carbon dioxide
CO	Carbon monoxide
CLI	Central Labour Institute
CPCB	Central Pollution Control Board
CSE	Centre for Science and Environment
CREP	Charter on Corporate Responsibility for Environmental Protection
CNG	Compressed Natural Gas
CII	Confederation of Indian Industry
CAA	Constitutional Amendment Act
CAAQMS	Continuous ambient air quality monitoring stations
DCE	Delhi College of Engineering
DIC	Distributed Information Center
EF	Emission factor
EP	Emission profile
EIA	Environment Impact Assessment
EPCA	Environment Pollution (Prevention and Control) Authority
EWG	Environment Working Group
EIC	Environmental Information Centre
ENVIS	Environmental Information System
FICCI	Federation of Industries and Commerce of India
GIS	Geographic information system
GHG	Greenhouse Gas
GDP	Gross domestic product
GEMI	Gujarat Environmental Management Institute
GPCB	Gujarat Pollution Control Board
HMV	Heavy Motor Vehicles
HSD	High sulfur diesel
HUDA	Hyderabad Urban Development Area
HC	Hydrocarbons
H_2S	Hydrogen sulfide

ITO	Income Tax Office
IIFCL	India Infrastructure Finance Company Limited
IMD	India Meteorological Department
IAAPC	Indian Association for Air Pollution Control
ICC	Indian Chamber of Commerce
ICMA	Indian Chemical Manufacturers Association
IICHE	Indian Institute of Chemical Engineers
IIE	Indian Institute of Engineers
IITB	Indian Institute of Technology Bombay
IITK	Indian Institute of Technology Kanpur
IIT-Madras	Indian Institute of Technology Madras
IITM	Indian Institute of Tropical Meteorology
IMD	Indian Meteorological Department
INSA	Indian National Science Academy
ITRC	Industrial Toxicology Research Centre
IT	Information technology
IMS	Inspection and Maintenance System
IES	Integrated Environmental Strategies
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
kgoe	Kilogram of equivalent
KW	Kilowatt
Pb	Lead
LIDAR	Light Detection and Ranging
LGP	Liquefied petroleum gas
MPCB	Maharashtra Pollution Control Board
MRTS	Mass Rapid Transit System
MW	Megawatt
CH_4	Methane
MINAS	Minimum National Standards
MoC	Ministry of Coal
MoES	Ministry of Earth Sciences
MoEF	Ministry of Environment and Forests
MoHFW	Ministry of Health and Family Welfare
MoNRE	Ministry of New and Renewable Energy
MoPNG	Ministry of Petroleum and Natural Gas
MoP	Ministry of Power
MoRD	Ministry of Rural Development
MoRTH	Ministry of Transport and Highways
MoUD	Ministry of Urban Development
MWp	Megawattpeak
NAMP	National Air Quality Monitoring Programme
NAAQM	National Ambient Air Quality Monitoring
NAAQS	National Ambient Air Quality Standards

NAAQSR	National Ambient Air Quality Status Report
NCR	National Capital Region
NCT	National Capital Territory
NEAA	National Environmental Appellate Authority
NEERI	National Environmental Engineering Research Institute
NEPA	National Environmental Protection Authority (NEPA)
NIOH	National Institute of Occupational Health
Ni	Nickel
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
N_2O	Nitrous oxide
NGO	Non-government organization
O_3	Ozone
PM	Particulate matter
PCRA	Petroleum Conservation Research Association
DDPCC	Pollution Control Committee of Daman-Diu & Dadra Nagar Haveli
PCC	Pollution Control Committee
PUC	Pollution under Control
PAH	Polycyclic Aromatic Compound
PIL	Public Interest Litigation
QA/QC	Quality control/quality assurance
SRPM	Respirable Suspended Particulate Matter
SOCLEEN	Society for Clean Environment
SIAM	Society of Indian Automobile Manufactures
SPV	Solar Photovoltaic
SA	Source apportionment
SASEC	South Asian Subregional Economic Cooperation
SEPC	Spatial Environmental Planning Cell
SPCB	State Pollution Control Board
SO_2	Sulfur dioxide
SPM	Suspended Particulate Matter
TA	Technical assistance
TERI	The Energy and Resources Institute
TSP	Total Suspended Particulates
UT	Union Territory
US AID	United States Agency for International Development
US EPA	United States Environmental Protection Agency
WB	World Bank
WHO	World Health Organization

Introduction

Air pollution levels in the megacities of Asia show a stabilizing trend but still exceed World Health Organization guidelines. Studies also show poor air quality, not only in the megacities of Asia, but also in smaller cities. While megacities often receive support for improving air quality; similar assistance seldom reaches smaller cities.

CAMP India – 2010 Edition provides background information and findings on the:

State of the Air (Chapter 2): What is the air quality in cities? Which of the cities in the country are experiencing air pollution challenges or will soon enter into this situation?

Legal framework for Air Quality Management (Chapter 3): What is the air quality management system in place in cities? What is the legal framework for air quality management in the country and in cities? What power and resources are available to cities to develop and implement clean air action plans?

Stakeholders (Chapter 4): Do stakeholders take an active part in air quality management for cities? How do cities engage stakeholders in air quality management?

1. General Information

Understanding the air pollution problem of a country requires an examination of the geography, climate, drivers (urbanization, industry and economy, energy, and transport), sources, status, and impacts of air pollution. This Chapter provides an overview of the air pollution challenge in India.

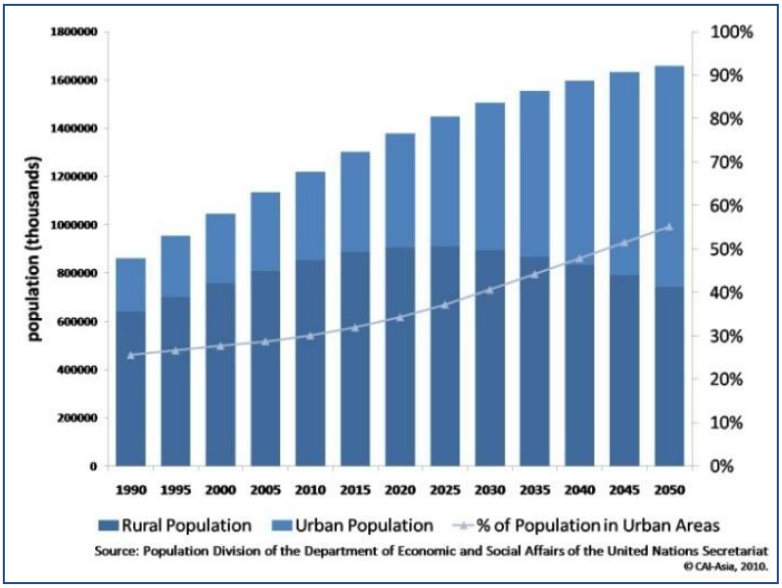
India consists of diverse physio-geographical features that may be classified into (a) the Great Mountain Wall (the Himalayan range in the north), (b) the Northern Plains, (c) the Great Peninsular Plateau, (d) the Coastal Plains, and (e) the Islands. The geographic nature of the Himalayan mountain range and the Great Peninsular Plateau intersperses the country with large valleys and highlands. The high mountain walls encourage the low dispersion of pollutants encouraging poor air quality. The plains of the Ganga and the Indus, about 2,400 km long are surrounded by three distinct river systems - the Indus, the Ganga and the Brahmaputra. These areas were the first sites of development and the main locations for urbanization. The Indian megacities i.e. Delhi and Kolkata can be found in these areas.

India covers an area of 3,287,590 square kilometers. As the 7th largest country in the world, India is unique, marked by snowy mountains, tropical forests, and the coastal plains. Lying entirely in the northern hemisphere, the mainland extends between latitudes 8° 4' and 37° 6' north, longitudes 68° 7' and 97° 25' east and measures about 3,214 km from north to south between the extreme latitudes and about 2,933 km from east to west between the extreme longitudes. It has a land frontier of about 15,200 km. The total length of the coastline of the mainland, Lakshadweep Islands and Andaman & Nicobar Islands is 7,516.6 km.

The climate of India may be broadly described as tropical monsoon type. However, several microclimates exist depending on the geographic location. There are four seasons officially declared by the Indian Meteorological Department (IMD): winter (January-February), hot weather summer (March-May), rainy southwestern monsoon (June-September) and post-monsoon, also known as northeast monsoon in the southern Peninsula (October-December). In the lower mainland, temperature inversions, in which a layer of warm air traps a layer of cold air next to the ground, are also common. Inversions limit area ventilation by forming a pollution blanket over the air basin. India's climate is affected by two seasonal winds - the northeast monsoon and the southwest monsoon. The north-east monsoon, commonly known as winter monsoon blows from land to sea. This pushes the air (with their pollutants to Indian peninsula. Meanwhile, south-west monsoon, known as 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 the year.[1]

[1] Know India. http://india.gov.in/knowindia.php; ADB and CAI-Asia 2006. *Country Synthesis Report on Urban Air Quality Management India Discussion Draft*. http://cleanairinitiative.org/portal/node/4653; IMD. http://www.imd.gov.in/

Figure .1. Population and Urbanization of India



India accounts for 2.4% of the world surface area but supports 16.7% of the world population. The population of India reached 1,028 million at the beginning of the twenty-first century. Compared with other developing countries in the region, the share of urbanization in India is relatively low at only 30% (Annex A) with most still living in rural areas. However, the absolute number of people migrating to the city is still numerous (Figure 1) with population growth centered on metropolitan areas in the Indo-Ganges basin.

The Indo-Ganges Basin is one of the most densely populated regions in the world. Urbanization, motorization coupled with domestic dependence on traditional fuels leaves the urban population most affected by air pollution. Pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), lead (Pb), ozone (O_3), benzene, and hydrocarbons (HC) are emitted at near-ground level, which is extremely dangerous for city inhabitants. The urban poor, 50-60% of who live in slums, have the least protection and security against harmful emissions.

Industrial development has contributed significantly to the economic growth. Services especially information technology (IT) related work has become a major contributor to the economy with GDP share of over 50%. Manufacture's share would be over 35% in 2007-08 reflecting the growth trends of electronics, textiles, pharmaceuticals, basic chemicals etc. The economic boom has led to increased investments and activities in the construction, mining, and iron and steel, which has increased demand in the highly polluting processes of brick making units, sponge iron plants and steel re-rolling mills. The industrial units in India are largely located in the states of Gujarat, Maharashtra, Uttar Pradesh, Bihar, West Bengal and Madhya Pradesh. These highly industrialized are greatly polluted and highly populated. These states have the highest concentration of SO_2 and NO_x emissions in India (Figure 2 and 3). Industry is also the largest consumer of energy; consuming about 50% of the total commercial energy produced in the country. Commercial sources include coal and lignite (57%), oil and gas (33%), hydroelectric power (3%), and nuclear power (0.2%). Energy-intensive industries include fertilizer, aluminum, textile, cement, iron and steel, pulp and paper, and chlor-alkali accounting for 80% total industrial energy consumption.

Figure 2. Sectoral and Manufacturing Industries Contribution to GDP

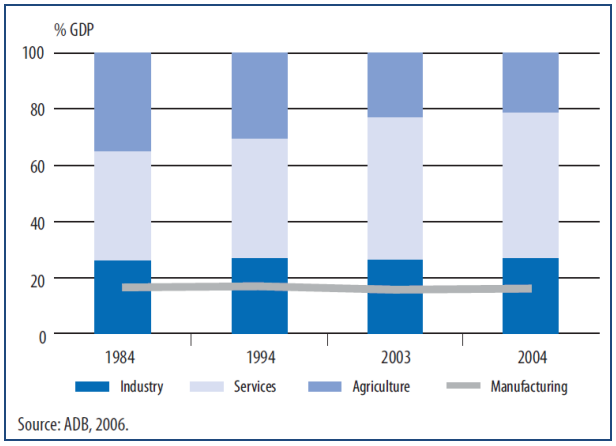
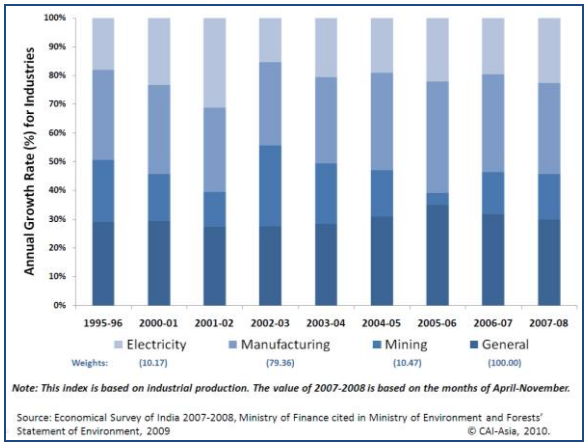


Figure 3. Annual Growth Rate (%) for Industries

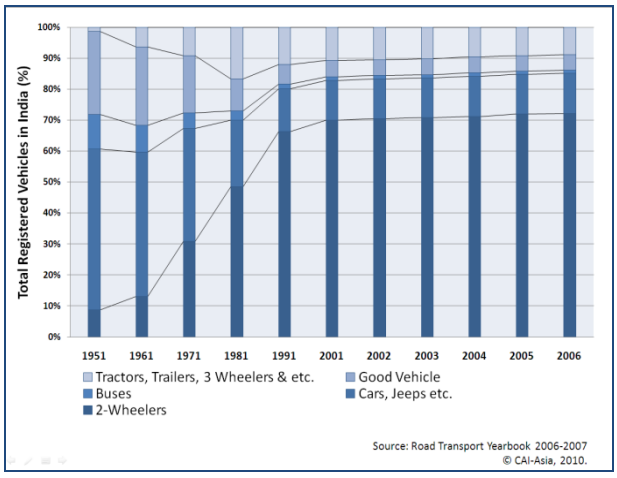


Graph: ADB and CAI-Asia, 2006

Transport is the main consumer of petroleum products—mainly in the form of high sulfur diesel (HSD) and gasoline accounting for half of the total consumption. The trend of urbanization, rise of disposable income coupled with the lack of appropriate mass transport system have lead to significant increases in motorization (Figure 4 and 5). In Delhi, vehicles have increased 51-one times over a thirty year period. Unbelievably, as much as 17% 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.

Figure 4. Total Registered Vehicles in India

Figure 5. Vehicle Composition in India



Another factor in rising motorization is that India is the leading manufacturer of vehicles especially motorcycles in the region. The total number of registered motor vehicles in India has increased from 1.86 million in 1971 to 67 million in 2003. Motorized two-wheelers (motorcycles, scooters, and mopeds) account for over 70% of the total registered fleet that will clearly impact on CO and HC emissions. Government's interest in reducing vehicles for personal use is a complex issue, since motorization is also an economic interest. As world's largest motorcycle manufacturer, the second largest two-wheeler and tractor manufacturer, and the fifth largest commercial vehicle manufacturer and the fourth largest car market in Asia, India has an economic incentive to create and sell more vehicles to the detriment of air quality.

In rural areas, the burning of agricultural waste is a common practice among Indian farmers. Apart from affecting the soil fertility, large amounts of emissions of methane (CH_4), CO, NO_x, and SO_2 led to various health hazards like respiratory, skin and eye diseases as well as visibility deterioration and regional haze. More than 80% of paddy straw (18.4 million tonnes) and almost 50 %wheat straw (8.5 million tonnes) produced in Punjab is burnt in fields every year. Intensive agriculture is also a contributor to greenhouse gases (GHG) like Carbon dioxide (CO_2), CH_4, and nitrogen dioxide (NO_2), aggravating climate change. From a country-level, emissions from agriculture are reported to be 28 %of the aggregate national emissions. These include emissions from enteric fermentation in livestock, manure management, rice cultivation and agricultural waste burning.

Although India's per capita energy consumption is relatively low at 500 kilogram of equivalent (kgoe) when compared with their population and the global average of 1800 kgoe, the great population of India makes it one of the largest consumers of energy in the world. Much of the energy is on coal, at least in the short term, which is a major source of SO_2 emissions.[2]

For power generation, India uses about 78% of the country's coal production. The use of coal, especially cheap poor quality coal with and low calorific value [high ash content (40–50%)] is widespread in many regions which explains India's relatively high carbon intensity and high air pollutant emissions especially SO_2 (Figure 6).

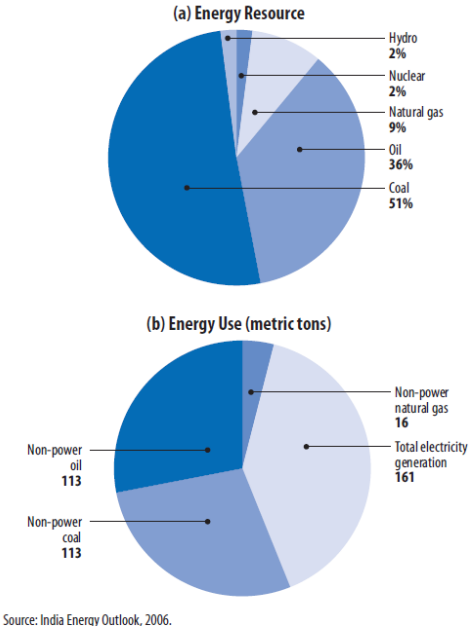
Fossil fuels

The energy sector of India is mainly powered by coal and oil. About 72% of power generation is thermal-based, using predominantly coal.

Renewable energy

The potential for renewable energy (solar, wind, biomass, and small hydro) is also high at an estimated 100,000 megawatts.

Figure 6. India's Primary Energy Resources and Energy Use (2009)



Graph: ADB and CAI-Asia, 2006

[2] MoEF. 2009. *State of the Environment India 2009*. http://moef.nic.in/downloads/home/home-

Nuclear energy

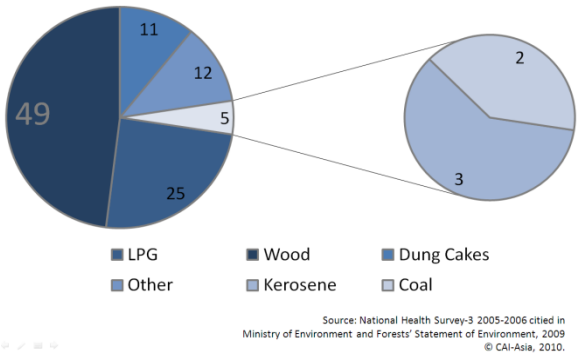
Nuclear-based generating capacity has declined in spite of a high degree of self-reliance in nuclear technology. India also has substantial reserves of thorium and uranium ore, but only 44% are economically exploitable.

Traditional fuels

National Family Health Survey-3 found that 71% of India's households and 91% of rural households use traditional fuels i.e. wood, dung, and charcoal for cooking and heating needs (Figure 7).

Burning of traditional fuels introduces large quantities of CO_2 in the atmosphere, when the combustion is complete, but if there is an incomplete combustion followed by oxidation, and then CO is produced, in addition to hydrocarbons.[3]

Figure 7. Proportion of Households by Type of Fuel Usage



Source: National Health Survey-3 2005-2006 citied in Ministry of Environment and Forests' Statement of Environment, 2009
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Emission Inventory

An emissions inventory is a database that lists, by source, the amount of air pollutants discharged into the atmosphere of a community during a given time period. The development of a complete emission inventory is an important step in the AQM process. They can help determine significant sources of air pollutants, emission trends, target regulatory actions, and estimate air quality through computer dispersion modeling.

An emission factor (EF) may be used to estimate emissions when actual emission data is not available. In India, emission factor development for the energy, industry, and transport is nearly completed. The preparation of urban, state, and national air emission inventories is not mandated by law. Despite this, many pollution control boards do have emission inventories for point sources especially industries and for vehicular sources EFs are used. Aside from government, several organizations and academic institutions have conducted different studies to identify sources but mostly for large urban areas. A programmatic approach to update emission inventories must be strengthened along with strong coordination within Ministries, State Pollution Control Boards (SPCBs), and administrations.

In 2002, the United States Environmental Protection Agency (US EPA) and the United States Agency for International Development (US AID) New Delhi Mission initiated the Integrated Environmental Strategies (IES) program in India to help Indian policymakers identify, evaluate, and eventually implement a variety of mitigation opportunities with local and global co-benefits. It generated the first-ever emissions inventory of all reported combustion sources in Hyderabad Urban Development Area (HUDA) as well as the quantified emissions reductions due to several clean-fuel mitigation programs. The study showed that the primary

[3] 1

source of air pollution in Hyderabad is transport followed by industry. Particulate matter (PM) levels often exceed the allowable ambient air quality standards at the major traffic junctions and industrial areas.[4]

In response to Climate Change, the MoEF released a specialized Greenhouse Gas Inventory of 2007 emissions, and intends to publish an updated inventory every two years. This addresses a major concern of the Copenhagen Climate Summit which needed key developing countries to report on their emissions. The report analyzes emissions from electricity use, transportation, agriculture, and land use change (Annex C).[5]

Source Apportionment

Source apportionment (SA) study is primarily based on measurements of various pollutants tracking pollutant sources and contamination through receptor modeling. The Auto Fuel Policy of India recommends the carrying out source apportionment studies for vehicular emissions. Accordingly, source apportionment studies have been initiated in six major cities: Delhi, Mumbai, Chennai, Bangalore, Pune, and Kanpur. Responsible institutions have already been identified together with the selection of air monitoring sites, methodology, and testing periods (Table 1). The study is now completed.[6]

Related projects include the development of EFs for vehicles and the development of emission profiles (EP) for vehicular as well as non-vehicular sources. These would help provide necessary inputs to SA studies. Results have yet to be released. [7]

Table 1. Executing Institutes of SA Studies

Project	Institute
SA for Bangalore	The Energy and Resources Institute (TERI)
SA for Chennai	Indian Institute of Technology Madras (IIT-Madras)
SA for Delhi	National Environmental Engineering Research Institute (NEERI)
SA for Kanpur	Indian Institute of Technology Kanpur (IITK)
SA for Mumbai	NEERI
SA for Pune	ARAI
EF for Vehicles	Automotive Research Association of India (ARAI)
EP (other sources)	Indian Institute of Technology Bombay (IITB) and NEERI
EP (vehicles)	ARAI

[4] ADB and CAI-Asia 2006. *Country Synthesis Report on Urban Air Quality Management India Discussion Draft.* http://cleanairinitiative.org/portal/node/4653; US EPA. India Source Apportionment documents. http://www.epa.gov/ies/india/apportionment_documents.html; US EPA. India IES Emission Inventory. http://www.epa.gov/ies/pdf/india/ies_emission_inven.pdf

[5] 2

[6] CPCB. 2010. *Air quality monitoring, emission inventory and source apportionment study for Indian cities.* http://moef.nic.in/downloads/public-information/Rpt-air-monitoring-17-01-2011.pdf

[7] ADB and CAI-Asia 2010. *Country Synthesis Report on Urban Air Quality Management India Discussion Draft.* http://cleanairinitiative.org/portal/node/4653; CPCB. Source Apportionment Studies. http://cpcb.nic.in/Source_Apportionment_Studies.php; MoEF. 2009. *State of the Environment India 2009*. http://moef.nic.in/downloads/home/home-SoE-Report-2009.pdf; US EPA. India Source Apportionment documents. http://www.epa.gov/ies/india/apportionment_documents.html

2. State of the Air

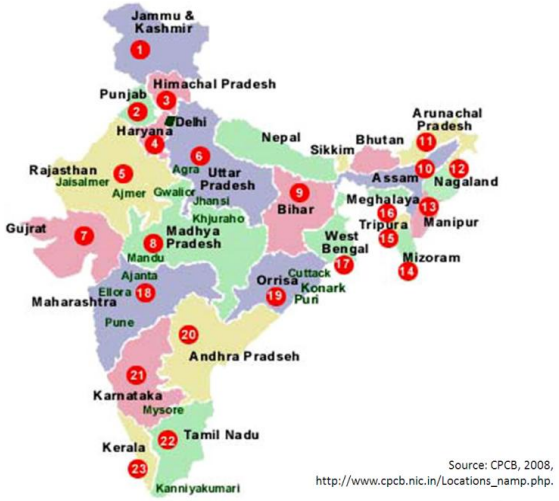
Air quality data and trends highlight an emerging phenomenon of conflicting trends for different categories of cities reflecting the complex forces behind the impact of growth on environmental action and outcome.

2.1. Air Quality monitoring, forecasting, and reporting systems

Air Quality Monitoring

India's air quality monitoring network, originally called the National Ambient Air Quality Monitoring (NAAQM) was initiated in 1984 with seven stations in Agra and Ampara. The network was established by Central Pollution Control Board (CPCB) in coordination with the SPCBs under the Air (Pollution and Control) of Pollution Act, 1981 to collect, compile and disseminate information on air quality. The CPCB has expanded the program and is now executing the nation-wide renamed National Air Quality Monitoring Programme (NAMP). NAMP determines status and trends of ambient air quality to see if compliant the NAAQS. The NAAQS have been notified for seven parameters: Suspended Particulate Matter (SPM), PM_{10},[8] NO_2, SO_2, CO, Ammonia (NH_3) and Pb. Additional parameters, such as Hydrogen sulfide (H_2S) and Polycyclic Aromatic Compounds (PAHs), are also being monitored in selected sites. Pollutants are monitored every 24 hours (i.e., 4-hourly sampling for gaseous pollutants and 8-hourly sampling for particulate matter) with a frequency of twice a week, to have at least 104 observations in a year for all stations. The NAAQS helps to identify non-attainment cities in order to develop the necessary preventive and corrective measures by taking into account the geographical and climate conditions in order to better understand the natural cleansing process of generated pollutants. As of 2009, the NAMP consists of 342 operational stations monitoring in 128 cities/towns in 28 States and four Union Territories (UTs) (Figure 8).[9]

Figure 8. Location and Distribution of Air Quality Monitoring Stations 2008

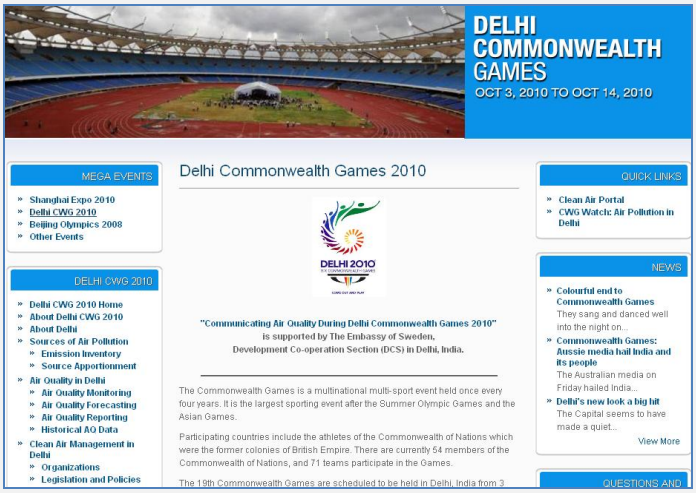


[8] SPM is another name for Total Suspended Particulates (TSP), particles with the aerodynamic diameter of less than 50 µm; while RSPM is equivalent to PM_{10}, particles with the aerodynamic diameters of less than 10 µm.
[9] CAI-Asia, 2009. Ambient Air Quality Standards Summary for India.

Monitoring activities is carried out through cooperation between various institutions, including the CPCB, SPCBs, Pollution Control Committees (PCCs), Universities and Research Institutes, including NEERI, Nagpur; CPCB in the city of Delhi; SPCBs in the respective states; PCCs in the respective UTs; and NEERI, Nagpur in six metro cities of the country. CPCB coordinates with these agencies to ensure the uniformity, consistency of air quality data by conducting several quality control/quality assurance (QA/QC) activities. They also provide technical and financial support to operate the monitoring stations. [10]

The Ministry of Environment and Forests (MoEF) has indicated plans to progressively expand and develop the NAMP with the proposed installation of CAAQMS in 16 more cities; and to date, 33 continuous ambient air quality monitoring stations (CAAQMS) have already been installed across the country. They have installed three additional continuous monitoring stations for the Commonwealth Games period and beyond (Figure 9).[11]

Box 1. Delhi's Race to Clean Air: Air Quality and the Commonwealth Games



Clean Air Mega Events Website

http://megaevents.cleanairinitiative.org/delhicwg2010

The XIX Commonwealth Games 2010 Delhi (CWG) took place in Delhi, India from 3 to 14 October 2010. Air quality during the Games is important as it influences athletic performance, spectator attendance, and tourism potential of the city. Prior to CWG, the Government of India has already designed a long-term air quality management plan for Delhi. The air quality measures taken during the Games are integrated in this plan. It provided an unique opportunity to incentivize the speed and the efficiency of these measures which include a) expanding air quality monitoring capacity by the addition of new stations and coverage of more pollutant parameters, b) conducting two air quality forecasting systems, c) communicating of real-time air pollution levels, d) retrofitting, relocation, or closing of industries, and e) advocating for better air quality to the public.

[10] 9
[11] 2

Air Quality Forecasting

The two forecasting efforts were conducted for the games are by CPCB and the Indian Institute of Tropical Meteorology (IITM). IITM under MOES established System of Air Quality forecasting and Research (SAFAR) as the official forecasting effort for CWG 2010 Delhi. SAFAR provided nearly real time air quality information for ozone, oxides of nitrogen, carbon monoxide, $PM_{2.5}$, PM_{10}, benzene, toluene, xylene, and black carbon and weather forecast prior 24 hours. 11 air quality monitoring stations, 34 automatic weather stations in NCR along with GPS sonde observations, and Doppler Weather radar have been installed.

The CPCB forecasting effort is based on a modeling exercise which combines atmospheric physics of weather forecasting and atmospheric chemistry among pollutants. Most common sources observed are vehicle exhaust and road dust, industrial emissions, residential fuel use, generator sets and garbage burning. Forecasting data was augmented with information on surveyed sources of air pollution. This includes information from the existing monitoring network operated by CPCB and laser-based Light Detection and Ranging (LIDAR) network deployed in the region to establish horizontal and vertical profiles of aerosols. Starting from September 1st, four stationary LIDARs was operational in Delhi at CPCB, National Physical Laboratories, Bhikaji Cama, and Janakpuri, and one mobile LIDAR operating during the Commonwealth Games, will be connected to the modeling system in real time.

Air Quality Reporting

Air quality data generated at the monitoring stations are transmitted to CPCB where these are checked, scrutinized, compiled, processed and analyzed for information on the annual mean, standard deviation etc. of the pollutants.

Archived data can be found in the section entitled Air Quality Data.[12] It provides data on four parameters: SO_2, NO_2, PM_{10}, and SPM, covering several urban and rural areas in India in the years of 2004-2007. Because of the continuous, automatic monitoring station at the Income Tax Office (ITO) Intersection, Delhi College of Engineering (DCE), CPCB, and Siri Fort in New Delhi, New Delhi has available information in real time[13]. The section also gives special monitoring information for the event of *Deepawali* (2008), the Indian festival of lights.[14] The analyzed data is presented in Annual National Ambient Air Quality Status Reports (NAAQSR) by the CPCB. Air pollution status of various pollutants is reported in terms of low, moderate, high, and critical in relation to the NAAQS. The 2008 NAAQSR included annual air quality trends for 16 cities and four mega cities (i.e., Chennai, Delhi, Kolkata, Mumbai). It also reported on government initiatives to control air pollution, including the Action Plan for the control of air pollution in 16 cities by the Honorable Supreme Court of India. Aside from NAAQSRs, air quality information is also presented in Annual State of the Environment Reports by the MoEF.

The Environmental Data Bank[15] makes use of the data from the CAAQMS. CAAQMS measures concentrations of the gaseous pollutants in ambient air at one-minute intervals. The 15-minute average values are transferred to the central computer at the monitoring station then uploaded to the website. The 15-minute average real time data is shown on the website with previous day's moving average data of the same period.

[12] CPCB. Air Quality Data. http://www.cpcb.nic.in/Data-2006_air.php
[13] CPCB. Real Time Air Quality Data. http://164.100.43.188/cpcbnew/movie.html
[14] CPCB. Air Quality Data. http://cpcb.nic.in/Air_Quality_Major_Cities.php
[15] CPCB. Environmental Data Bank. http://cpcbedb.nic.in/

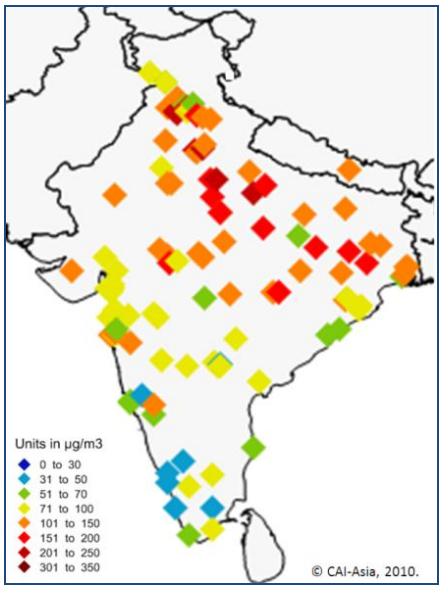
Dust ($PM_{2.5}$ and PM_{10}) is being monitored as hourly average and the data is directly transferred to the website. For manual monitoring stations, the monitoring is every fourth working day at each station. The collected samples are analyzed at the stations and the raw data is submitted to air laboratory every month for the final calculations. The data prepared in the NAMP format and kept in air laboratory. The same data are entered in to Environmental Data Bank on monthly basis. The CPCB provides necessary guidance to the officials of Gujarat Pollution Control Board (GPCB), Gujarat Environmental Management Institute (GEMI), Pollution Control Committee of Daman-Diu & Dadra Nagar Haveli (DDPCC), Maharashtra Pollution Control Board (MPCB) and other institutes and universities operating NAMP stations regarding online entry of monitoring data to Environmental Data Bank.

2.2. Trends of Air Pollution

a. Particulate Matter Status and Trend

Suspended Respirable Particulate Matter (SRPM) (PM_{10}) is the main air pollutant for public health concern. It has the highest percentage of exceedance among monitored pollutants. In 2008, the average of annual PM_{10} levels of residential monitoring stations in most cities (89.5 µg/m^3) exceeded the annual PM_{10} National Ambient Air Quality Standards (NAAQS) (60 µg/m^3). None of the cities were compliant with annual PM_{10} World Health Organization (WHO) air quality guideline (AQG) (20 µg/m^3) (Figure 9).The highest concentration from residential areas was observed at a monitoring station located at M/s Modi Oil & General Mills, Gobindgarh and at Sub-divisional Office, Satna for Industrial areas.[16]

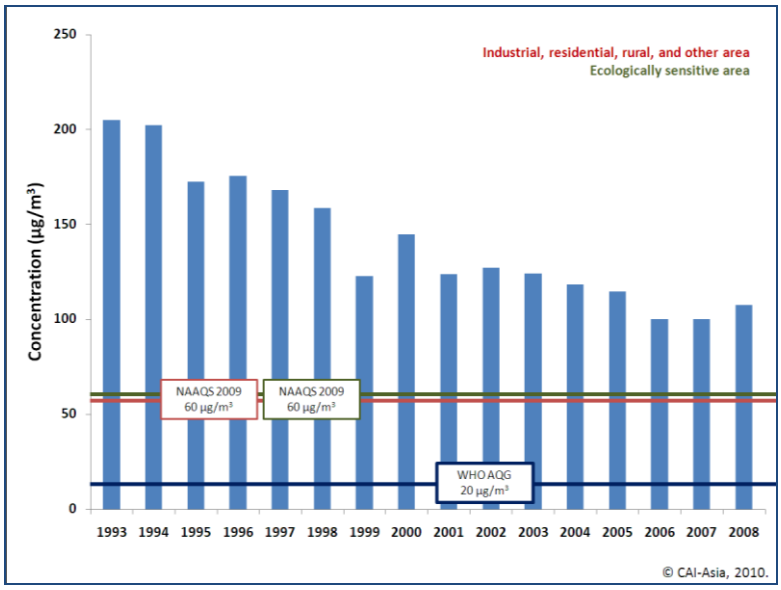
Figure 9. Annual average of PM_{10} in 137 Indian Cities 2008



[16] CPCB. 2008. *National Report of Ambient Air Quality Status*. http://www.cpcb.nic.in/upload/NewItems/NewItem_147_report-2008.pdf; MoEF. 2009. *State of the Environment India 2009*. http://moef.nic.in/downloads/home/home-SoE-Report-2009.pdf

A decreasing trend has been observed in PM_{10} levels (Figure 10).[17] Monitoring $PM_{2.5}$ has just been developed. There is not enough data to assess a trend.

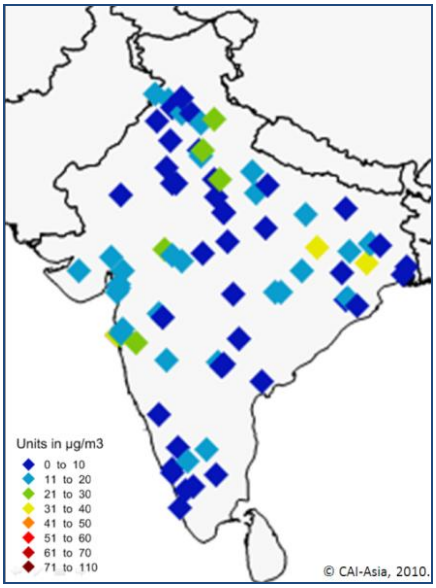
Figure 10. Average of Annual Average of PM_{10} Concentrations in 137 Indian Cities 2008



b. Sulfur dioxide Status and Trend

As of 2008, SO_2 did not exceed NAAQS (50 µg/m^3). Unlike the usual 24-Hr and Annual Mean levels, WHO recommends that SO_2 follows a more stringent 10-minutes and 24-Hr intervals based from recommendations resulting from epidemiological studies. The yearly guideline is not needed since 24-Hr guideline would be sufficient in assuring low annual average levels (Figure 11).

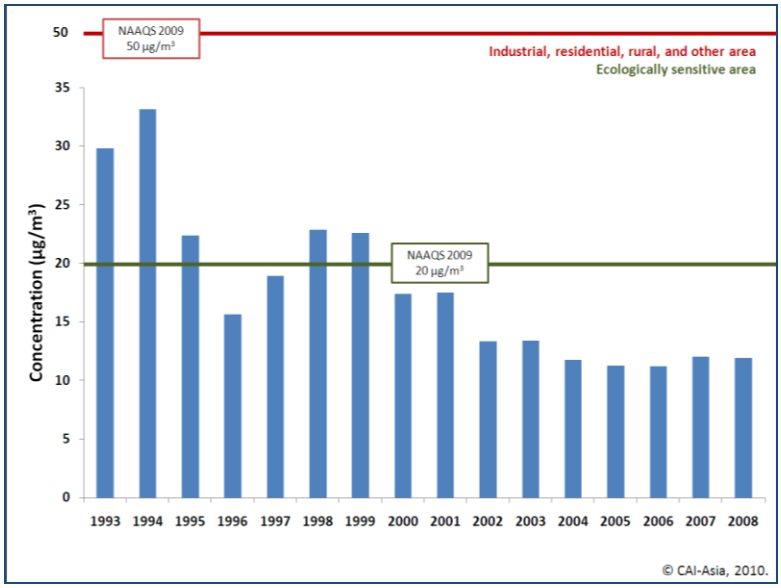
Figure 11. Annual average of SO_2 in 106 Indian Cities 2008



[17] CAI-Asia, 2009. Ambient Air Quality Standards Summary for India; WHO. 2005. *Air Quality Guidelines Global Update 2005 – Particulate matter, ozone, nitrogen dioxide and sulphur dioxide*. http://www.euro.who.int/Document/E90038.pdf; Data collected from various sources.

A decreasing trend has been observed in SO_2 levels (Figure 12).[18]

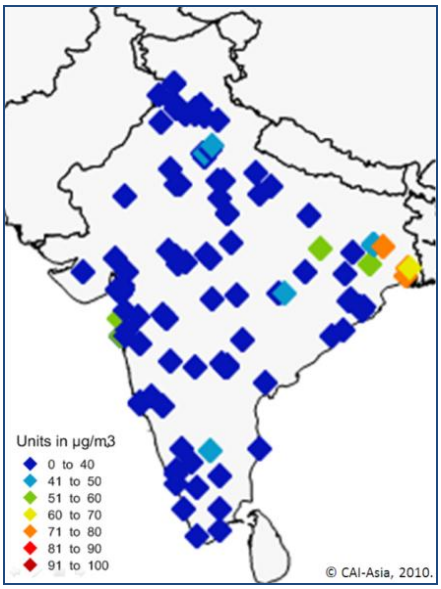
Figure 12. Average of Annual Average of SO_2 Concentrations in 106 Indian Cities 2008



c. Nitrogen dioxide Status and Trend

NO_2 levels at 81% of the monitoring stations in industrial areas and 70% of the monitoring stations in residential areas were found to be lower than the annual NAAQS and the WHO AQG (40µg/m^3) (Figure 13). During 2007, the highest concentration of NO_2 among all residential areas was observed at Town Hall, Delhi and from the industrial areas, at Bandhaghat, Howrah.

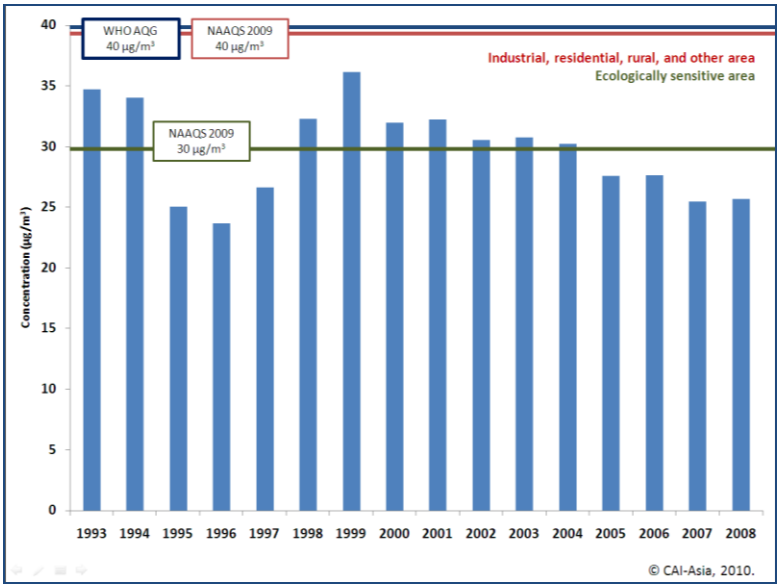
Figure 13. Annual average of NO_2 in 133 Indian Cities 2008



[18] 17

A decreasing trend has been observed in NO_2 levels (Figure 14).[19]

Figure 14. Average of Annual Average of NO_2 Concentrations in 133 Indian Cities 2008



c. Other Air Pollutants

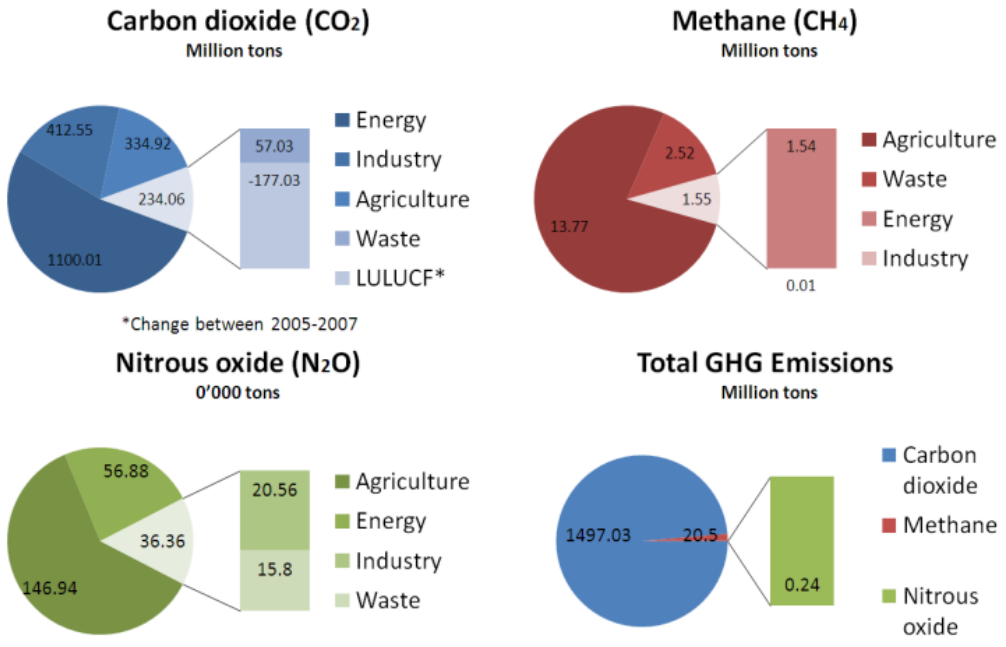
Based on the Greenhouse Inventory 2007, results showed that India is now the world's fifth-largest emitter of greenhouse gases, ranking behind China, the United States, the European Union, and Russia. Many claim that India's fast growing economy has driven up greenhouse gas emissions.

The Environment Minister Jairam Ramesh emphasized that India's emissions are still one-quarter of those of the top emitters, the United States and China. He further highlighted that in the same period, from 1994-2007, India reduced the emissions intensity of its economy by 30%.

India has announced plans to reduce emissions intensity by a further 20-25% between 2005 and 2020. The net GHG emissions from India, that is emissions with Land Use, Land-Use Change and Forestry (LULUCF), in 2007 were 1727.71 million tons of CO_2 equivalent (eq) of which CO_2 emissions were 1221.76 million tons; CH_4 emissions were 20.56 million tons; and nitrous oxide (N_2O) emissions were 0.24 million tons (Figure 15).[20]

[19] 17
[20] 16

Figure 15. Distribution of Greenhouse Gases from India



Source: Ministry of Environment and Forests, 2010. Greenhouse Gas Inventory 2007.

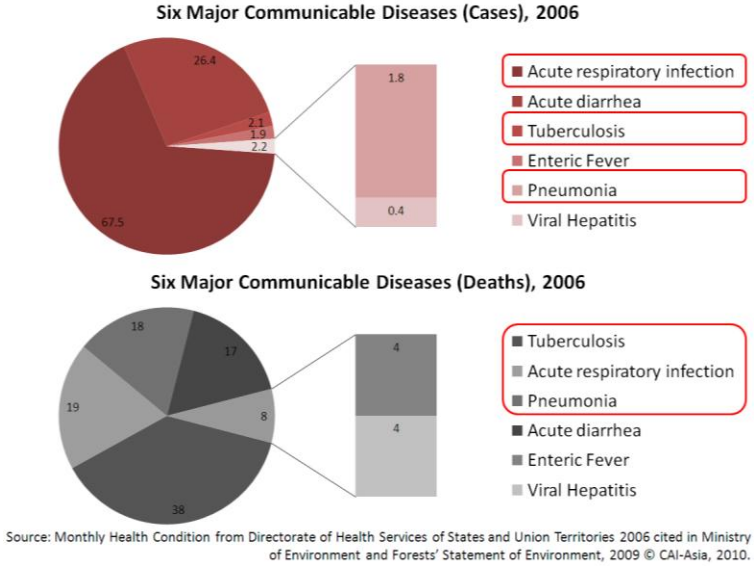
© CAI-Asia, 2010. Collected from various sources.

3. Impacts of Air Pollution and Climate Change

Impacts of air pollution and climate change on health, economy, and environment can result in major damages in both the national and local levels. Cities are most affected by the impacts of air pollution.

Health in India is deteriorating especially in metropolitan cities. Over 900 million urban people are affected with diseases and irritations linked with high levels of indoor and ambient harmful emissions. In Mumbai, the prevalence of both symptoms and signs of such diseases is around 22.2%. Among the six major communicable diseases, maximum cases (25,807,722) 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 16).[21]

Figure 16. Distribution of Cases and Deaths Related to Air Quality



Source: Monthly Health Condition from Directorate of Health Services of States and Union Territories 2006 cited in Ministry of Environment and Forests' Statement of Environment, 2009 © CAI-Asia, 2010.

A study conducted by All India Institute of Medical Sciences (AIIMS) and CPCB 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%), cough (28.8%), pharyngitis (16.8 %), dyspnea (16%) and nausea (10%). It has been estimated that the annual economic cost of damage to public health from increased air pollution, based on PM_{10} measurements for 50 cities with the total population of 110 million, reached 3 billion USD in 2004.

Aside from health-related concerns, Acid rain is a major problem in India where the use of sulfur-containing coal and oil—the primary sources of acidic emissions—is very high. Acid deposition levels were particularly high in areas of northeast India, which are near or downwind from major urban and industrial centers. The effects are already being felt in agriculture with yield reduction. Aside from agriculture, damaged buildings and materials hurt tourism as well. Several important temples and palaces in India have deteriorated because of air pollution especially due to acidic particulate matter.[22] Many claim that the Taj Mahal is turning yellow

[21] 16
[22] 16

due to Agra's air pollution especially particulate matter. Residents' claim that many initiatives have taken place to no avail due to the sheer number of commercial tourism buildings, population, energy use, and personal vehicles.[23]

Aside from effects on India alone, air pollution is a trans-boundary concern. An atmospheric phenomenon, known as Atmospheric Brown Cloud (ABC) or South Asia haze is responsible for hundreds of thousands of deaths a year from respiratory diseases. Aside from potential health impacts, it also has considerable effects on climate and agriculture causing erratic weather, flooding, drought, and low yield in Northern India. It is estimated to be a brownish cloud to be a 3 km thick blanket of pollution, which is composed of black carbon, organic carbon, sulfates, nitrates, mineral dust and fly ash. Anthropogenic sources are estimated to contribute approximately 75% to this haze due to the burning of fossil fuels and biomass in the countries of South Asia. [24] This problem has led to the Male declaration which requires the signatory South Asian counties National action plans to address air pollution.[25]

[23] Brij Khandelwal. 2009. *Taj Mahal remains at risk from air pollution.* http://www.thaindian.com/newsportal/enviornment/taj-mahal-remains-at-risk-from-air-pollution_100201020.html#ixzz0ySR5Sr4V
[24] Schwela, Dieter, Haq, Gary, Huizenga, Cornie, Han, Wha-Jin, Fabian Herbert, Ajero, May. 2006. *Urban Air Pollution in Asian Cities: Status, Challenges and Management*. United Kingdom
[25] UNEP. *Male Declaration.* http://www.rrcap.unep.org/male/baseline/ActnPlan/Pakistan/pakch_A.htm

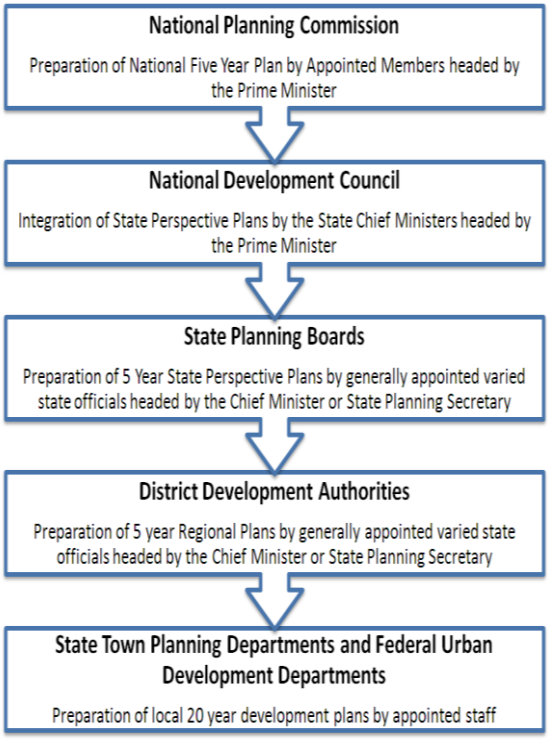
4. Policies and Measures on Air Pollution and Climate Change

A country's seriousness in implementing a policy to provide better air quality for its people may be judged on whether: (1) the policy and its implementation details are reflected in laws, regulations and plans; (2) enough resources are provided to implement it; and (3) the laws, regulations and plans are actually implemented.

4.2. General Environment Management

The Government of India is known as the Union government or Central government governing 28 states and 7 union territories (UTs) . The President of India is the Head of the State, elected indirectly by an electoral college for a five year term. The Prime Minister is the head of the government and exercises most executive powers. The Prime Minister is appointed by the President and, by convention, is the candidate supported by the party or political alliance holding the majority seats in the lower house of Parliament. The legislature of India is a bicameral Parliament, which consists of the upper house called the Rajya Sabha and the lower house called the Lok Sabha.[26] As a parliament, controlling and supervisory powers belong to the state government and central government. Entry 5 of the State list in the Seventh Schedule of the Constitution of India gives legislative power to the State with regards to municipal laws, establishments, constitution and powers of local governments. The Constitution does not confer any independent status or powers to local government bodies. Local government units known as Districts still their plans laid out by the State (Figure 17).

Figure 17. National, State, and District Levels Planning Levels



[26] Know India. http://india.gov.in/knowindia.php

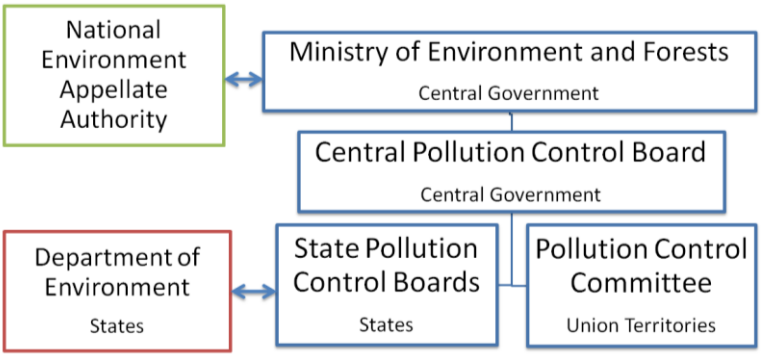
The Seventy-Fourth Constitutional Amendment Act (CAA) of 1992 provided a common framework for urban and rural local governance based on democratic self-government, decentralization and local empowerment. There are three types of Municipalities, i.e., Nagar Panchayats for areas in transition from a rural area to urban area, Municipal Councils for smaller urban areas and Municipal Corporation for large urban areas.

Aside from municipalities, Article 40 of the constitution directs the government to establish panchayats to serve as institutions of rural local self-government. Most states began implementing this Directive Principle along the lines of the recommendations of the government's Balwantrai Mehta Commission report. It considered as the first serious attempt to ensure stabilization of democratic local government through constitutional provisions.

The incorporation of the CAA in the existing Municipal Acts empowers local government to plan for programs related to air quality such as urban planning, town planning, land use regulation etc. Despite the responsibility of the district government for education, health, sanitation, safety, and maintaining roads and other public facilities, they still have limited authority. The frequent intervention and centralization on state government and lack of funds to support their projects has long troubled Indian local governance.[27]

The Ministry of Environment and Forests (MoEF) is the central ministry mandated with planning, promotion, co-ordination and overseeing the implementation of India's environmental and forestry policies and programs. The National Environment Appellate Authority (NEAA) is an independent body which adjudicates complaints by civil society regarding environmental clearances given by the MoEF. The National Green Tribunals will soon replace the NEAA. The CPCB is a specialized branch of the MoEF, it advises the Central Government on matters relating to pollution especially for nation-wide programs and also coordinates the activities of the State Boards with supporting them with technical and training assistance to carry out and sponsor investigations and research relating to control of pollution (Figure 18). [28]

Figure 18. National and State Environmental Management



[27] CPCB. 2008. *National Report of Ambient Air Quality Status*. http://www.cpcb.nic.in/upload/NewItems/NewItem_147_report-2008.pdf
UNESCAP, 1995. *Local Government in Asia and the Pacific: A Comparative Study*.
http://www.unescap.org/huset/lgstudy/country/india/india.html
[28] 9

The Air (Prevention and Control of Pollution) Act, 1981 empowers the CPCB to perform the functions of the SPCB for all UTs. The same act also provides that CPCB may delegate all or any of its powers and functions of a State Board in a UT under the said Acts to such person or body of persons as the Central Government may specify. For Delhi, the CPCB has delegated all its powers and functions as a State Board in respect of the UT of Delhi to a committee of officials as specified by the Central Government in March, 1991. This committee has been reconstituted on 14th June 2002 vide notification No. B-12015/7/92-AS. This provided the basis for the creation of PCCs for UTs.

Both Pollution Control Committees (PCCs) and SPCBs are entrusted in the state- and UT-level to plan a comprehensive program for prevention, control, or abatement of air pollution and to secure the execution thereof within their jurisdictions. They are tasked to advise the state government on any matter concerning prevention, control, and abatement of air pollution, collect and disseminate information related to air pollution, collaborate with CPCB in program 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.[29]

Municipal finance was left to the discretion of the respective state governments to specify by law matters relating to imposition of taxes. Municipal Revenues are basically from tax revenue, non-tax revenue, grants-in-aid, borrowings or loans. Meanwhile the major taxes levied by urban local government are the following tax on property including service levy for water supply, conservancy, drainage, lighting and garbage disposal; tax on entry of goods into a local area for consumption use of sale therein, popularly known as octroi; tax on professions; and tax on vehicles (other than motor vehicles).

In terms of the National budget for 2009-10, some claim that the funds for the environment, climate change and adaptive agriculture were not aptly allocated. The allocation for environment and forests is Rs 2,129 crore, just 0.2% of the total budget expenditure. Meanwhile, oil and gas companies are given more leeway to push through with their proposal of a national grid for liquefied gas from the Krishna-Godavari basin. Moreover, mineral companies, exploring oil and gas, have been given a seven-year tax holiday. The minimum alternative tax (mat), tax paid by profit-making companies enjoying tax holiday, has been increased from 10 %to 15 %. This would make producing renewable energy, a key strategy to cut green house gases, more expensive.[30]

4.3. Air Quality Management and Climate Change Mitigation

a. Laws, Regulations, and Action Plans

Air Quality Standards

India's first set of ambient air quality standards was adopted in 1982 under the Air (Prevention and Control of Pollution) Act, 1981. The act mandated the establishment of the central and state boards for the prevention and control of air pollution. It empowered the central board- the CPCB to create and enforce air quality

[29] UNESCAP, 1995. *Local Government in Asia and the Pacific: A Comparative Study*. http://www.unescap.org/huset/lgstudy/country/india/india.html

[30] Down to Earth, 2009. *How Green is the Budget*. http://www.indiaenvironmentportal.org.in/node/288710.

standards.[31] In 1994, the CPCB indentified the NAAQS for six major pollutants: SO_2, NO_X as NO_2, SPM, PM_{10}, Pb, and CO (Annex G). The limiting concentration values for various pollutants were determined considering an adequate margin of safety. The concentration values vary because the NAAQS is based on land-use, health effects, and emission control. If such studies were not available, the US EPA health criteria were used.[32] It set different standards for (i) industrial areas; (ii) residential, rural and other areas; and (iii) sensitive areas (Annex H).

The NAAQS 1994 was not sufficient in dealing with other pollutants such as hazardous air pollutants (HAPs) or distinction between pollutions such as PM_{10} and $PM_{2.5}$. The enforceability of the standards was compromised due to the land-use classification because demarcations are unclear in urban areas. Recent international and local scientific studies brought better understanding on the impacts of air pollution leading to the stringency of the standards (Annex I). The revised NAAQS has been notified under the Environment (Protection) Act, 1986 on 16 November 2009 through the Gazette of India, Extraordinary, Part II, Section 3, subsection (i) by MoEF. The NAAQS revised the standards for SO_2, NO_2, PM_{10}, CO, Pb and NH_3 and included standards for six additional pollutants—$PM_{2.5}$, O_3, benzene, benzo(a)pyrene, arsenic (As) and nickel (Ni). A major development in the 2009 NAAQS is that the MoEF placed uniform standards for residential and industrial areas (Table 2).[33]

Table 2. Revised National Ambient Air Quality Standards of India vs. WHO AQG

Pollutant ($\mu g/m^3$)	Time weighted average	Concentration in Ambient Air (µg/m3)		WHO AQG ($\mu g/m^3$)
		Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)	
SO_2	Annual*	50*	20*	-
	24-Hr**	80**	80**	20[a]
	1-Hr	-	-	200[a]
NO_2	Annual*	40*	30*	40[a]
	24-Hr**	80**	80**	-
PM_{10}	Annual*	60*	60*	20[a]
	24-Hr**	100**	100**	50[a]
$PM_{2.5}$	Annual*	40*	40*	10[a]
	24-Hr**	60**	60**	25[a]
O_3	8-Hr**	100**	100**	100[a]
	1-Hr*	180*	180*	-
Pb	Annual*	0.5*	0.5*	0.5[b]
	24-Hr**	1**	1**	-
CO	8-Hr**	2,000**	2,000**	10,000[b]
	1-Hr**	4,000**	4,000**	30,000[b]
Ammonia	Annual*	100*	100*	

[31] 9
[32] 9
[33] CAI-Asia, 2009. Ambient Air Quality Standards Summary for India; CPCB. 2008. *National Report of Ambient Air Quality Status*. http://www.cpcb.nic.in/upload/NewItems/NewItem_147_report-2008.pdf

	24-Hr**	400**	400**	
Benzene	Annual*	5*	5*	-[c]
Benzo(a)pyrene, particulate phase only, (ng/m^3)	Annual*	1*	1*	-[c]
Arsenic (ng/m^3)	Annual*	6*	6*	-[c]
Nickel (ng/m^3)	Annual*	20*	20*	-[c]

Guidelines refer to the safe level of a pollutant, for a given average time, to protect the public from acute health effects.

µg/m^3=micrograms per cubic meter

*Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

**24, 8 or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year, 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

[c]Unit risk available in WHO 2000.

Laws and Regulations

The main supportive laws and regulations and plans laid down by the national government on air quality, transport, energy, and climate change are summarized in the table below:

The Constitution of India enshrines environment protection as part of its directives in state policy.

Protection and improvement of environment and safeguarding of forests and wild life.

> **48A.** The State shall endeavour to protect and improve the environment and to safeguard the forests and wild life of the country.

The Government of India enacted the Air (Prevention and Control of Pollution) Act, 1981[34] to arrest the deterioration in air quality. The Act prescribes the various functions of the CPCB at the apex level and SPCB at the state level. Meanwhile, the Environment (Protection) Act, 1986[35] was created in order to prioritize environmental protection and degradation. The act highlights the responsibility of the Central government to control the sources and effects of pollution providing for both executive and legislative functions. This is augmented by the National Environment Policy, 2006[36] which built on the existing environmental policies to guide regulatory reform; programs and projects for environmental conservation; and review and enactment of legislations by Central, State and Local Government.

[34] Air (Prevention and Control of Pollution), 1981. http://www.envfor.nic.in/legis/air/air1.html

[35] Environment (Protection) Act, 1986. http://moef.nic.in/downloads/rules-and-regulations/eprotect_act_1986.pdf

[36] National Environment Policy, 2006.
http://megaevents.cleanairinitiative.org/sites/default/files/India%202006%20National%20Environment%20Policy.pdf

National Environmental Tribunal Act, 1995[37] was recently updated into the National Green Tribunal Bill, 2009[38] recently passed in Parliament. The bill provides the judicial function not afforded by the Environment (Protection) Act, 1986. It aims to set up environment courts in the country, replacing the National Environmental Appellate Authority (NEAA) in the settling of environment- and public health-related conflicts.

Aside from the NEAA, the India and the United began a [US-India] Green Partnership aimed at strengthening cooperation in clean energy, climate change, and food security. Among these initiatives is the creation of an Indian National Environmental Protection Authority (NEPA),[39] intended to enhance the authority of Indian environmental agencies, improve public information and transparency, and demonstrate progress in environmental compliance and enforcement.

For vehicles and motorization, the Motor Vehicles Bill, 1988 amended in 2007[40] regulates of transport and traffic systems in cities. The 2007 amendment set better regulation strategies with in urban territories. The Auto Fuel Policy, 2002[41] recognized the need for the quick adoption of emission norms and the updated information on air quality. The identified knowledge gaps in the area of air pollution SA led for studies to have been initiated in six major cities with the participation of oil companies, leading research institutes, CPCB, SPCBs, and MoEF. The National Urban Transport Policy, 2006[42] centralizes legislation concerning urban transport. It responded to the need for national planning with regards to sustainable city transport and integrated land use. The policy seeks to coordinate and hold accountable the several agencies and institutions related with urban transport as well as promote clean transport taking into account economic and social activities.

For energy, the Energy Conservation Bill, 2001 amended in 2010[43] centers on energy efficiency and conservation. The policy empowers the government to specify norms and standards of energy efficiency to be followed by different industries. The 2010 amendment expands the scope of energy conservation norms for buildings and tightens the applicability of energy efficiency norms for appliances and equipment. The Bill increases penalties for offences and provides for appeals to be heard by the Electricity Appellate Tribunal set up under the Electricity Bill, 2003. The Electricity Bill, 2003 amended in 2005[44] attempts to supply electricity to all areas including villages and hamlets through rural electricity infrastructure and electrification of households with emphasis on renewable energy. The 2005 amendment set the onus of rural electrification was solely on the State Government. It also clarifies the judicial aspect of the bill relating to the offenses and possible investigations and eventual punishments. The Integrated Energy Policy, 2006[45] creates a framework in order to meet the demand for energy for all sectors in India. It aims to encourage technology that it's not only energy efficient, economically viable, but also environmentally sustainable. This is supported by the

[37] National Environmental Tribunal Act, 1995. http://www.envfor.nic.in/legis/others/tribunal.html
[38] National Green Tribunal Bill, 2009. http://moef.nic.in/downloads/home/national-green-tribunal-bill-2009.pdf
[39] National Environmental Protection Authority Proposal Paper. 2009. http://moef.nic.in/downloads/home/NEPA-Discussion-Paper.pdf
[40] Motor Vehicle Amendment Bill 2007.
http://www.prsindia.org/uploads/media/1182409102/1182409102_THE_MOTOR_VEHICLES__AMENDMENT__BILL__2007.pdf
[41] Auto Fuel Policy, 2002. http://petroleum.nic.in/autoeng.pdf
[42] National Urban Transport Policy. 2006. http://www.urbanindia.nic.in/policies/TransportPolicy.pdf
[43] Energy Conservation Amendment Bill 2010.
http://www.prsindia.org/uploads/media/Energy/The%20Energy%20Conservation%20Amendment%20Bill%202010.pdf
[44] Electricity Act Amendment Bill, 2005.
http://www.prsindia.org/uploads/media/1167469188/1167469188_The_Electricity_Amendment_Bill_2005.pdf
[45] Integrated Energy Policy, 2006. Clean Air Mega Events, 2010. Link to document: http://megaevents.cleanairinitiative.org/node/272

National Tariff Policy, 2006[46] which encourages the use of renewable energy by the use of preferential tariffs with regards to conventional energy sources by distribution companies.

For climate change, the National Action Plan for Climate Change, 2009[47] seeks to strike a balance between the sustainable development and climate change adaption. It focuses on 8 missions (Annex E). States and UTs are encouraged to have their own plans. Delhi has formulated the Delhi Climate Change Agenda, 2010.[48] The climate change plan of Delhi proposes to cover all of the eight missions except on Sustainable Agriculture and Sustaining the Himalayan Ecosystem (Annex F).

b. Institutional Mandate

The Ministry of Environment and Forests (MoEF)[49] is the nodal agency for the planning, promotion, co-ordination and overseeing the implementation of India's environmental and forestry policies and programmes. Part of the MoEF, Central Pollution Control Board (CPCB)[50] serves field formation and technical assistance to the MoEF in the improvement of air quality and to prevent, control or abate air pollution in the country. In the state level, the State Pollution Control Board (SPCB) are entrusted to plan a comprehensive program for prevention, control, or abatement of air pollution and to secure the execution thereof within their states, while the Pollution Control Committees (PPC) serves in a similar capacity for all Union Territories. A hybrid of this would be the constitution of the Environment Pollution (Prevention and Control) Authority (EPCA) for NCR. The EPCA will take the necessary steps to ensure compliance with directions of different agencies. EPCA could take up matters on its own or receive complaints. It was also given extensive powers of search, entry, inspection, and seizure.[51] In order to aid in the judicial aspect of environmental management, the National Environment Appellate Authority (NEAA) addresses cases lodged by the civil society against the environmental clearances granted by the MoEF.[52] This will be replaced by the Green Tribunals to be established nationwide.

Ministry of Earth Sciences (MoES)[53] provides the nation with best possible services in forecasting the monsoons and other weather/climate parameters, ocean state, earthquakes, tsunamis and other phenomena related to earth systems through well integrated programs. They will provide air pollution forecasting for the Commonwealth Games. Indian Institute of Tropical Meteorology (IITM)[54] supports the MoES as the premiere research institute generating scientific knowledge in the field of meteorology and atmospheric sciences. It functions as a national centre for basic and applied research in monsoon meteorology. Aside from IITM, India Meteorological Department (IMD)[55] serves as the National Meteorological Service of the India under the MoES in all matters relating to meteorology, seismology, and allied subjects. National Environmental Engineering Institute (NEERI)[56] assists these agencies by contributing to research and innovations in environmental science and engineering to solve environmental problems

[46] National Tariff Policy, 2010. http://www.powermin.nic.in/whats_new/pdf/Tariff_Policy.pdf
[47] National Action Plan for Climate Change, 2009. http://megaevents.cleanairinitiative.org/node/273
[48] Delhi Climate Change Agenda, 2010. http://www.indiaenvironmentportal.org.in/files/climate-agenda.pdf
[49] MoEF. http://moef.nic.in
[50] CPCB. http://cpcb.nic.in
[51] EPCA. 1998. Ministry of Environment And Forests Order New Delhi, the 29th January 1998. http://hspcb.gov.in/Environment%20Protection%20Authority.pdf
[52] National Environment Appellate Authority Act. 1997. http://megaevents.cleanairinitiative.org/node/501
[53] MoES. http://www.dod.nic.in/
[54] IITM. http://www.tropmet.res.in/index.php
[55] IMD. http://www.imd.gov.in/
[56] NEERI. http://www.neeri.res.in/index.php

posed by industry, government and public. They will also monitor air pollutants for the Commonwealth Games.

Ministry of Health & Family Welfare (MoHFW- Department of Health)[57] and the National Institute of Occupational Health (NIOH)[58] identify and mitigate the public, occupational and environmental health problems in the country. ENVironmental Information System (ENVIS) Center[59] is engaged in collection, collation, storage, retrieval and dissemination of Indian Information related to Occupational-Environmental Health.

Ministry of Transport and Highways (MoRTH)[60] entrusted with the task of formulating and administering, in consultation with other institutions, policies for road transport, national highways and transport research with a view to increasing the mobility and efficiency of the road transport system in the country including public transport. Together with the Ministry of Urban Development (MoUD)[61] and the Ministry of Rural Development (MoRD),[62] both are responsible for is responsible for formulating policies and policies in coordination with the activities of various Ministries, State Governments and other nodal authorities for urban and rural development, respectively.

The three agencies correspond to the energy needs of India: Ministry of Coal (MoC),[63] Ministry of Petroleum and Natural Gas (MoPNG),[64] and the Ministry of New and Renewable Energy (MoNRE).[65] These Ministries are responsible for policies and strategies with respect to exploration and development of their respective fuels. Together with the Ministry of Power (MoP),[66] they are concerned with supplying the energy needs of India. MoP is responsible for the administration of the various electricity and energy acts. Along with these government agencies, The Energy and Resources Institute (TERI)[67] tackles energy security and the environmental issues associated with energy sources

c. Management of Specific Sector

Management of Mobile Sources

India's control of vehicular emissions is primarily accomplished through (i) establishment and enforcement of emission norms, (ii) inspection and maintenance systems (IMS), (iii) application of traffic and congestion management, (iv)accessible and comprehensive public transport, (v) use of cleaner fuels, and (vi) use of awareness programs. [68]

[57] MoHFW. http://mohfw.nic.in/
[58] NOIH. http://www.nioh.org/
[59] ENVIS Center. http://www.envisnioh.org/
[60] MoRTH. http://morth.nic.in
[61] MoUD. http://www.urbanindia.nic.in/
[62] MoRD. http://rural.nic.in/
[63] MoC. http://coal.nic.in
[64] MoPNG. http://petroleum.nic.in/
[65]MoNRE. http://www.mnre.gov.in/
[66] MoP. http://www.powermin.nic.in
[67] TERI. http://www.teriin.org/index.php
[68] ADB and CAI-Asia 2006. *Country Synthesis Report on Urban Air Quality Management India Discussion Draft.* http://cleanairinitiative.org/portal/node/4653; MoEF. 2009. *State of the Environment India 2009*. http://moef.nic.in/downloads/home/home-SoE-Report-2009.pdf; Schwela, Dieter, Haq, Gary, Huizenga, Cornie, Han, Wha-Jin, Fabian Herbert, Ajero, May. 2006. *Urban Air Pollution in Asian Cities: Status, Challenges and Management*. United Kingdom

Establishment and Enforcement of Emission Norms. First stage emission norms were established in 1991 for petrol vehicle and in 1992 for diesel vehicles. In 2000, India began a systematic adoption of cleaner fuels. They instituted the 'Bharat 2000' which set Bharat Stage emissions standards in stages comparable with European emission standards (Table 3).

Table 3. Emission standards for New Vehicles (light duty) in India

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
India*	EURO I						EURO II					EURO III
India**	EURO I	EURO II					EURO III					EURO IV

*Nation-wide

**New Delhi and other cities; Euro II introduced in Chennai, Kolkota, and Mumbai in 2001; Euro II in Ahmedabad, Bangalore, Hyderabad, Khampur, and Pune in 2003; Euro III was made applicable for the four megacities- Mumbai, Kolkata, Chennai, New Delhi—and the large cities of Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, and Agra; Euro IV was introduced in 2010 for 13 cities including the 4 mega cities.

Inspection and Maintenance System (IMS). IMS is implemented through the Pollution under Control (PUC) system. PUC system issues certificates for adherence to idling emission norms every 3-6 months. It identifies vehicles having mass emissions and requires maintenance. In-use vehicles are tracked especially because of abundance of released emission. Regional Transport offices' main job is to register vehicles and issue driving licenses but they also assist PUC testing work. The majority of the tests are conducted by authorized privately owned stations located mostly at gas stations. Few mobile stations are also available to conduct PUC testing and certification. Measures to upgrade non-compliant vehicles with more fuel and energy efficient technology are implemented sparingly. There exists no regulatory provision that calls for more fuel and and energy efficient technology. The PUC merely requires the non-compliant vehicle to resubmitted for testing after carrying out necessary repairs.

Application of Traffic and Congestion Management. Temporal and spatial restrictions have been imposed on vehicles contributing to congestion. In Delhi, goods vehicles are restricted during day time since 1999 and the left lane of the roads has been made exclusive for Heavy Motor Vehicles (HMV). Traffic signal clocks have been installed in important red lights in cities including Delhi, Mumbai, Pune, and Hyderabad to enable drivers to switch off their engines. Several major cities are also constructing several flyovers and subways and closing T-junctions for better traffic flow.

Economic disincentives are also in place to discourage personal and/or old vehicles. In addition to various taxes related to motor vehicle procurement and operations, the Government of Tamil Nadu introduced an additional Green Tax on all classes of old motor vehicles to discourage the use of old vehicles since 2003. The tax payments are levied for motorcycles (Rs500 for 5 years), other motor vehicle types (Rs1,000 for 5 years), and for motor vehicles with longer than 7 years of registration (Rs500 per annum). A Congestion Tax in Delhi is also proposed to deal with foreseen traffic problems with the Commonwealth games.

Accessible and Comprehensive Public Transport. Commuters are shown to be most at risk with PM pollution. Public transport measures have focused on immediate transport. The Supreme Court called for the phasing out of pre-1990 auto-rickshaws and to be replaced by post-1990 rickshaws required to run on clean fuels. The clean fuel available for that time was mainly compressed natural gas (CNG).

Aside from auto-rickshaws, proposals for Bus Rapid Transit System (BRTS) have been approved for Ahmedabad, Bhopal, Indore, Jaipur, Pune, Rajkot, Vijayawada and Visakhapatnam under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) covering a total length of more than 310 kms. They are also expected to switch CNG instead of diesel. Currently, all city buses were converted to the CNG mode in Delhi and buses older than 8 years are phased out. CNG has been introduced in 61 cities including Vijaywada, Hyderabad, Mumbai, Navi Mumbai, Thane, Pune-Pimpri-Chinchwad, Ankleshwar, Vadodra, Surat, Kanpur, Bareli, Agra, Lucknow, Faridabad, Noida, etc. The total number of CNG vehicles in the country is over 3.54 Lakh, as per the industry estimates.

Aside from buses, Metro Rail system has been introduced in Delhi and has been operational for several years in Kolkata. Both Mumbai and Chennai have just commenced the initial working stages. Maharashtra has also developed a master plan for the Mumbai Metro with implementation in three phases over nine corridors. Other states like Karnataka are in the initial phase of implementing Mass Rapid Transit System (MRTS). Metro Rail Project for Shahdara-Rithala Section in Delhi has been completed and commissioned from December 2003.

Use of Cleaner Fuels. Fuel quality specifications are established by the Bureau of Indian Standards (BIS) for gasoline and diesel. Given the increased usage of diesel in India, it becomes necessary to reduce its sulfur content. In a recent directive by the Supreme Court, the Ministry of Petroleum and Natural Gas (MoPNG) is to supply diesel with 0.05% m/m sulfur to the National Capital Territory (NCT) by 31 December 2000 and the entire National Capital Region (NCR)[69] from 30 June 2001 (Table 4).

Table 4. Current and Proposed Sulfur Levels in Diesel in India

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
India*	5000					2500				500					350
India**	5000					2500	500			350					50

*Nation-wide

**Metropolitan

Liquefied petroleum gas (LPG) driven vehicles has been introduced in more than 153 cities and towns in Varanasi, Bangalore, Delhi, etc. at 498 dispensing stations as of 2009. For gasoline, lead was phased out in the entire country since 2000. Similarly, the benzene content was reduced; and by 2001, gasoline with 1% benzene was supplied to the whole of NCR. Other efforts include Petrol vehicles are running on ethanol

[69] Delhi is known officially as the National Capital Territory of Delhi (NCT) as the capital of Inida. NCT along with the urban areas of Noida, Gurgaon, Greater Noida, Faridabad and Ghaziabad from neighboring states of Haryana, Uttar Pradesh and Rajasthan are part of the National Capital Region (NCR).

blended (5%) petrol in states of Maharashtra, Andhra Pradesh, Goa, Gujarat, Haryana, Karnataka, Tamil Nadu, Uttar Pradesh, Daman & Diu and UT of Dadar & Nagar Haveli, Chandigarh and Pondicherry.

Use of Awareness Programs. Aside from these efforts, ambient air quality data as well as articles related to vehicular emissions are disseminated through print and online media to generate public awareness of the importance of air quality. Civic society is also encouraged by the government to conduct mass awareness campaigns.

Management of Stationary Sources

Stationary sources of pollution are primarily from industries and power generation. India's control of stationary sources of emissions is accomplished through the (i) establishment and enforcement of emission norms, (ii) use of planning and evaluation tools, (iii) application of zoning management, (iv) use of cleaner fuels, (v) energy efficient and conservative reforms and (v) use of renewable energy.

Establishment and Enforcement of Emission Norms. CPCB laid down the standards for polluting emissions notified by the MoEF under the Environment Protection Act (1986). The act mandates that polluting industries submit an environmental statement known as an environmental audit to the concerned SPCBs. Compliance with industrial emission norms with respective air standards is continuously assessed and monitored in 17 categories of highly polluting medium- and large-scale industries (Annex J). The CPCB intends to develop Minimum National Standards (MINAS) for all types of industries with regards to their emissions. The Charter on Corporate Responsibility for Environmental Protection (CREP) is the proposed model for evolving industry specific standards specifying limits of pollutants for environmental protection. 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. MoEF has also taken up carrying capacity-based regional planning studies in certain selected areas of the country including the NCR. Aside from these efforts, action plans are being prepared and implemented for the 24 critically-polluted areas.[70]

Use of Planning and Evaluation Tools. Environment Impact Assessment (EIA) is an important instrument directed by the *Environment Protection Act, 1986.* MoEF has recently introduced thresholds for 32 types of development projects for screening and categorization, emphasized scoping and public consultation, and decentralized the decision-making process. The procedure for examining the impact of different activities includes the preparation of an EIA report, holding a public hearing, and examination by duly constituted appraisal committees at the state and center levels. Environmental clearance is made compulsory for 29 categories of development projects involving civil society participation as an important component of the EIA process. To facilitate conduct of EIA studies, MoEF has piloted Environmental Information Centre (EIC) on the model of public-private partnership.

Application of Zoning Management. Spatial Environmental Planning Cell (SEPC) of CPCB supports the Zoning Atlas project targeted to provide siting-related advice at district level to the departments of industries in the

[70] The Central Pollution Control Board in consultation with State Pollution Control Boards has identified 24 areas in the country as critically polluted areas. These are: Bhadravati (Karnataka), Chembur (Maharashtra), Digboi (Assam), Govindgarh (Punjab), Greater Cochin (Kerala), Kala-Amb (Himachal Pradesh), Parwanoo (Himachal Pradesh), Korba (Madhya Pradesh), Manali (Tamil Nadu), North Arcot (Tamil Nadu), Pali (Rajasthan), Talcher (Orissa), Vapi (Gujarat), Visakhapatnam (Andhra Pradesh), Dhanbad (Bihar), Durgapur (West Bengal), Howrah (West Bengal), Jodhpur (Rajasthan), Nagda- Ratlam (Madhya Pradesh), Najafgarh Drain (Delhi), Patancheru Bollaram (Andhra Pradesh), Singrauli (Uttar Pradesh), Ankleshwar (Gujarat), Tarapur (Maharashtra)

States through SPCBs. Under this project, tools like a geographic information system (GIS) are used to measure for air pollution potential which is considered as one of the decision variables in recommending siting of industries. Preparation of Zoning Atlas for setting up industries will be based on environmental and health considerations in various districts of the country. The MoEF has made it mandatory for thermal power plants located more than 1,000 km from the coal pit-head. Courts ordered that the polluting industries and industries operating in non-conforming areas be either closed or shifted to other areas.

Energy Efficient and Conservative Reforms. India has made significant advances in energy efficiency and conservation. A Bureau of Energy Efficiency (BEE) operationalizes conservation measures such as energy standards, replacement of inefficient equipment, fuel-efficient practices, labeling of equipment/appliances, building energy codes, and energy audits. New Indian plants are among those with the lowest power consumption internationally. Industries are encouraged to use cleaner and low-waste or no-waste technologies to reduce waste generation and the emission of pollutant.

Use of Cleaner Fuels. MoEF has made it mandatory for thermal power plants located in urban, ecologically-sensitive or critically polluted areas, to use beneficiated/blended coal containing ash no more than 34% effective 2002. Petroleum Conservation Research Association (PCRA) has been established to increase awareness and develop fuel-efficient equipment. Coal is, and will remain, the mainstay of commercial energy production in India in the near future despite its polluting nature. To ensure more efficient use of coal, the following measures have been taken: coal use rationalization, private sector participation, reformed pricing, technology upgrades, and coal-bed methane recovery. Coal based Power plants located beyond 1,000 kms from the pit-head are required to use low ash content coal. Gas is the preferred substitute for coal and oil. In the residential sector, gas has replaced coal and kerosene, while CNG is an alternative to petrol and diesel in transport.

Renewable Energy. India's renewable energy program focuses on maximizing different sources of energy. At present, about 25% of the total installed capacity is accounted for by hydroelectricity with great potential from North-East India. Meanwhile Solar Photovoltaic (SPV) systems have been put to a variety of uses in rural electrification, railway signaling, microwave repeaters, power to border outposts and TV transmission and reception. So far, 9,20,000 SPV systems, with an aggregate capacity of 82 Megawattpeak (MWp), have been installed in the country. India is also among the five leading nations in wind power generation. The installed capacity is 1,507 MW, and generators of capacity 250-600 Kilowatt (KW) are manufactured in India. Around 95% of installed wind power capacity is from the private sector. Biomass power generation plants of a total capacity of about 358 Megawatt (MW) have been installed and gasification systems of a total capacity of 42.8 MW have been set up for decentralized energy application. In rural areas, over 3.2 million biogas plants and 33 million improved stoves have been installed. Projects with an aggregate capacity of about 15 MW have been completed using energy recovered from urban, municipal and industrial waste.

Management of Area Sources

Efforts are being made to target non-point sources of air pollution. The open incineration of dry leaves, old tires, plastics, and garbage is prohibited in metropolitan areas. The Department of Science, Technology & Environment, the Government of Punjab sought to address this program by the promotion of agronomic practices for agricultural waste by various methods of composting.

There is also an encouraging trend toward use of cleaner fuel such as LPG for domestic cooking fuel. As a control measure to reduce air pollution, massive afforestation, greenery programs, green barriers and green buffers are being promoted in several areas. They have also under taken the standardization of fuel-efficient technologies and practices which will help in reducing NO_2 emissions. [71]

[71] 2

5. Stakeholders

Stakeholders play important roles in air quality management; these include government agencies, non-government organizations, academe, development agencies & foundations, and the private sector. This Chapter takes a look at whether stakeholders actively participate in air quality management in India.

The two main development agencies working in India are the Asian Development Bank (ADB) and the World Bank (WB). ADB's RETA 6159 is the first technical assistance (TA) designed and implemented in support of the South Asian Subregional Economic Cooperation (SASEC) Environment Working Group (EWG). The TA constitutes ADB's first effort to tackle Air Quality Management (AQM) at South Asia. One of their objectives was to create Indian Association for Air Pollution Control (IAAPC), a local area network for air quality management and to raise the importance of AQM at different levels. They were able to establish an air quality group consisting of a cross section of stakeholders from concerned agencies and individuals.[72] IAAPC provides a formal structure for networking on air quality management issues e.g. the Delhi chapter met to discuss air quality management during the Commonwealth Games.[73] Aside from this ADB assists India in several development projects relating to infrastructure, energy, and food security. WB also works extensively in India by working in the development of infrastructure for transport and energy. WB agreed to extend $1.195 billion to the India Infrastructure Finance Company Limited (IIFCL) to help finance private-public partnerships in infrastructure, especially in the roads, power and ports sectors. [74]

The MoEF is the nodal agency for planning, promotion and coordination of environmental activities in India. They are responsible for AQM through various measures such as policy and program formation, EIA of development projects, promotion of clean technologies and public awareness. The Ministry has established the ENVIS Center with a network of Distributed Information Centers (DICs) on specific subject areas. The CPCB has been designated as the DIC for Air Quality. Aside from information dissemination, a formal network of the Pollution Control Boards is needed to gather relevant data/information from the concerned agencies on a regular basis.

The CPCB along with the SPCBs and PCCs are mandated to implement the *Air (Prevention and Control of pollution) Act, 1981* have established an informal network of stakeholders consisting of experts and representatives to deal with specific issues such as ambient air quality and emission standards. CPCP also provides technical inputs to MOEF and assists in enforcement of air quality related policies and programs. In the state-level, CPCB holds periodic meetings with the chairmen and Member Secretaries of the SPCBs. In these interaction meetings, various issues including air quality monitoring and air pollution control measures are discussed along with possible initiatives. The Central Labour Institute (CLI), the Industrial Toxicology Research Centre (ITRC) and the NIOH are among the important agencies in the country which are in a position to provide technical support and networking.

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[72] ADB. 2004. *RETA 6159: Technical Assistance to the South Asian Subregional Economic Cooperation (SASEC) Countries for Regional Air Quality Management Technical Report.* http://www.adb.org/Documents/TACRs/REG/37014-REG-TACR.pdf

[73] Indian Association for Air Pollution Control Delhi Chapter. 2009. Brain Storming Workshop on Management of Air Quality During Common Wealth Games-2010. http://www.cleanairnet.org/caiasia/1412/articles-73500_resource_1.pdf

[74] WB. 2010. *India Country Overview April 2010.* http://www.worldbank.org.in/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/INDIAEXTN/0,,contentMDK:20195738~pagePK:141137~piPK:141127~theSitePK:295584,00.html

In recent years, the judiciary has been playing an important role in promoting AQM initiatives (such as in the city of Delhi) through judicial interventions on public grievances through Public Interest Litigations (PILs)/writ petitions on air pollution. Technical aspects can impede the case from moving forward if there is a lack of understanding from the judiciary. In order to mitigate this problem, complaints linked to the environment are adjudicated by the NEAA but soon they will be under the jurisdiction of the National Green Tribunals.

Local governance in the form of Urban Development Agencies have been taking a proactive role in recent times. For instance, in Ahmedabad, the civic authorities including the Municipal Corporation and State Transport Department have taken initiatives for air pollution control and networking with the NGOs and citizen groups. Among the research organizations, NEERI and its regional centres have been actively involved in generation of air quality monitoring data in different parts of the country under NAMP coordinated by CPCB along with SPCBs. [75] The Association of Local Governance of India (ALGI) in New Delhi was launched in 2006 which covers all the 28 states and seven UTs of India. It is run by a National Council which seeks to push the objectives of interests of local governments and the decentralization process in India. As of now, the Association is focused on networking, local policy research, and development planning. AQM should be ideally inputted in these plans. [76]

Aside from the government, the private sector is also an important stakeholder. The Confederation of Indian Industry (CII), the Federation of Industries and Commerce of India (FICCI), the Associated Chambers of Commerce and Industry of India (ASSOCHAM), the Indian Chemical Manufacturers Association (ICMA), and the Indian Chamber of Commerce (ICC) represent a large section of the industrial community in India. These organizations recognized the need for environmental protection and sought to address issues relating to air pollution control. Measures include the organization of workshops, training courses and interaction meetings, assistance to industry members for adoption of clean technologies and ISO14001 certification, set up of Environmental Committees. For instance, the FICCI has constituted an Environmental Committee consisting of industry members and independent experts. Similar initiatives are happing in Transport. The Society of Indian Automobile Manufactures (SIAM) has been actively involved creating a network among the automobile industries and a linkage with the regulatory agencies. Subsequently, several organizations, including industry and automobile sectors whose activities have a bearing on the air quality, have designated personnel within the respective organizations for ensuring compliance of the air quality standards.[77]

Research institutes have also taken an interest in air quality. The Indian Institutes of Technology in Delhi, Kanpur and Mumbai have taken special interest in research and educational activities on air quality issues. Some of the other educational institutions (such as, Pune University) are also taking active role in air quality issues. The professional organizations notably, the Indian National Science Academy (INSA), the Indian Institute of Chemical Engineers (IICHE) and the Indian Institute of Engineers (IIE) have organized conferences on air quality issues which helped in creation of awareness and networking. Several citizen groups such as the Centre for Science and Environment (CSE), TERI in New Delhi and Society for Clean Environment

[75] ADB. 2004. *RETA 6159: Technical Assistance to the South Asian Subregional Economic Cooperation (SASEC) Countries for Regional Air Quality Management Final Report.* http://www.cleanairnet.org/caiasia/1412/articles-70581_v17a.pdf
[76] 75
[77] 72

(SOCLEEN) in Mumbai formed an informal group on air quality issues. However, academic and research institutions, as well as the professional societies are not provided with necessary financial assistance and opportunities to participate in the decision making process. [78]

[78] 29

6. Conclusions

Air pollution levels in India have been showing a decreasing trend. Despite this, PM_{10} [RSPM] levels are still non-compliant with annual NAAQS and WHO AQG. SO_2 levels are compliant with the annual NAAQS while NO_2 levels are mostly compliant NAAQS and WHO AQG. There is not enough data to assess a trend for $PM_{2.5}$ and O_3. For GHG, levels remain high especially CO_2.

India has strong legislative measures in place to support their air quality management system. Most concerns are with the implementation by the central and local government. States have a certain level of autonomy and funding they are able to develop their own air quality plans and programs which can include more participation from various districts, agencies and departments are active in air quality management. Financial incapacity and inadequate manpower are among the hurdles faced by these agencies. Proper air quality management measures are retarded by the lack of a concerted effort, transparency, and networking.

References

ADB and CAI-Asia 2006. *Country Synthesis Report on Urban Air Quality Management India Discussion Draft.* http://cleanairinitiative.org/portal/node/4653

ADB. 2004. *RETA 6159: Technical Assistance to the South Asian Subregional Economic Cooperation (SASEC) Countries for Regional Air Quality Management Technical Report.* http://www.adb.org/Documents/TACRs/REG/37014-REG-TACR.pdf

ADB. 2004. *RETA 6159: Technical Assistance to the South Asian Subregional Economic Cooperation (SASEC) Countries for Regional Air Quality Management Final Report.* http://www.cleanairnet.org/caiasia/1412/articles-70581_v17a.pdf

Cooperation (SASEC) Countries for Regional Air Quality Management Final Report. http://www.cleanairnet.org/caiasia/1412/articles-70581_v17a.pdf

Air (Prevention and Control of Pollution), 1981. http://www.envfor.nic.in/legis/air/air1.html

Auto Fuel Policy, 2002. http://petroleum.nic.in/autoeng.pdf

Brij Khandelwal. 2009. *Taj Mahal remains at risk from air pollution.* http://www.thaindian.com/newsportal/enviornment/taj-mahal-remains-at-risk-from-air-pollution_100201020.html#ixzz0ySR5Sr4V

CAI-Asia, 2009. Ambient Air Quality Standards Summary for India.

Clean Air Mega Events Website, http://megaevents.cleanairinitiative.org/delhicwg2010.

CPCB. 17 Categories of the Major Polluting Industries. http://www.cpcb.nic.in/faq2.php

CPCB. 2010. *Air quality monitoring, emission inventory and source apportionment study for Indian cities.* http://moef.nic.in/downloads/public-information/Rpt-air-monitoring-17-01-2011.pdf

CPCB. 2008. *National Report of Ambient Air Quality Status*. http://www.cpcb.nic.in/upload/NewItems/NewItem_147_report-2008.pdf

CPCB. Air Quality Data. http://cpcb.nic.in/Air_Quality_Major_Cities.php

CPCB. Air Quality Data. http://www.cpcb.nic.in/Data-2006_air.php

CPCB. Environmental Data Bank. http://cpcbedb.nic.in/

CPCB. http://cpcb.nic.in

CPCB. Real Time Air Quality Data. http://164.100.43.188/cpcbnew/movie.html

CPCB. Source Apportionment Studies. http://cpcb.nic.in/Source_Apportionment_Studies.php

Delhi Climate Change Agenda, 2010. http://www.indiaenvironmentportal.org.in/files/climate-agenda.pdf

Department of Environment, Government of NCT, Delhi, 2010. http://www.delhi.gov.in/wps/wcm/connect/environment/Environment/Home/Achievements/Climate+Change+Agenda+for+Delhi+2009-12

Down to Earth, 2009. *How Green is the Budget*. http://www.indiaenvironmentportal.org.in/node/288710.

During Common Wealth Games-2010. http://www.cleanairnet.org/caiasia/1412/articles-73500_resource_1.pdf

Electricity Act Amendment Bill, 2005. http://www.prsindia.org/uploads/media/1167469188/1167469188_The_Electricity_Amendment_Bill_2005.pdf

Energy Conservation Amendment Bill 2010. http://www.prsindia.org/uploads/media/Energy/The%20Energy%20Conservation%20Amendment%20Bill%202010.pdf

Environment (Protection) Act, 1986. http://moef.nic.in/downloads/rules-and-regulations/eprotect_act_1986.pdf

ENVIS Center. http://www.envisnioh.org/

EPCA. 1998. Ministry of Environment And Forests Order New Delhi, the 29th January 1998. http://hspcb.gov.in/Environment%20Protection%20Authority.pdf

EPCA. http://hspcb.gov.in/Environment%20Protection%20Authority.pdf

IITM. http://www.tropmet.res.in/index.php
IMD. http://www.imd.gov.in/
Indian Association for Air Pollution Control Delhi Chapter. 2009. Brain Storming Workshop on Management of Air Quality
Integrated Energy Policy, 2006. Clean Air Mega Events, 2010. Link to document: http://megaevents.cleanairinitiative.org/node/272
Know India. http://india.gov.in/knowindia.php
MoC. http://coal.nic.in
MoEF. 2009. India and Climate Change. http://moef.nic.in/downloads/public-information/presnt_CC.pdf
MoEF. 2009. *State of the Environment India 2009*. http://moef.nic.in/downloads/home/home-SoE-Report-2009.pdf
MoEF. 2010. *India: Greenhouse Gas Emissions 2007*. http://moef.nic.in/downloads/public-information/Report_INCCA.pdf
MoEF. http://moef.nic.in
MoES. http://www.dod.nic.in/
MoHFW. http://mohfw.nic.in/
MoNRE. http://www.mnre.gov.in/
MoP. http://www.powermin.nic.in
MoPNG. http://petroleum.nic.in/
MoRD. http://rural.nic.in/
MoRTH. http://morth.nic.in
Motor Vehicle Amendment Bill 2007. http://www.prsindia.org/uploads/media/1182409102/1182409102_THE_MOTOR_VEHICLES__AMENDMENT__BILL__2007.pdf
MoUD. http://www.urbanindia.nic.in/
National Action Plan for Climate Change, 2009. http://megaevents.cleanairinitiative.org/node/273
National Environment Appellate Authority Act. 1997. http://megaevents.cleanairinitiative.org/node/501
National Environment Policy, 2006. http://megaevents.cleanairinitiative.org/sites/default/files/India%202006%20National%20Environment%20Policy.pdf
National Environmental Protection Authority Proposal Paper. 2009. http://moef.nic.in/downloads/home/NEPA-Discussion-Paper.pdf
National Environmental Tribunal Act, 1995. http://www.envfor.nic.in/legis/others/tribunal.html
National Green Tribunal Bill, 2009. http://moef.nic.in/downloads/home/national-green-tribunal-bill-2009.pdf
National Tariff Policy, 2010. http://www.powermin.nic.in/whats_new/pdf/Tariff_Policy.pdf
National Urban Transport Policy. 2006. http://www.urbanindia.nic.in/policies/TransportPolicy.pdf
NEAA. http://megaevents.cleanairinitiative.org/node/501CREP. http://www.cpcb.nic.in/crep.php
NEERI. http://www.neeri.res.in/index.php
NOIH. http://www.nioh.org/
Schwela, Dieter, Haq, Gary, Huizenga, Cornie, Han, Wha-Jin, Fabian Herbert, Ajero, May. 2006. *Urban Air Pollution in Asian Cities: Status, Challenges and Management*. United Kingdom
TERI. http://www.teriin.org/index.php
UNESCAP, 1995. *Local Government in Asia and the Pacific: A Comparative Study*. http://www.unescap.org/huset/lgstudy/country/india/india.html
US EPA. India IES Emission Inventory. http://www.epa.gov/ies/pdf/india/ies_emission_inven.pdf
US EPA. India Source Apportionment documents. http://www.epa.gov/ies/india/apportionment_documents.html

WB. 2010. *India Country Overview April 2010.*
http://www.worldbank.org.in/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/INDIAEXTN/0,,contentMDK:20195738~pagePK:141137~piPK:141127~theSitePK:295584,00.html
WHO. 2005. *Air Quality Guidelines Global Update 2005 – Particulate matter, ozone, nitrogen dioxide and sulphur dioxide*. http://www.euro.who.int/Document/E90038.pdf

ANNEXES

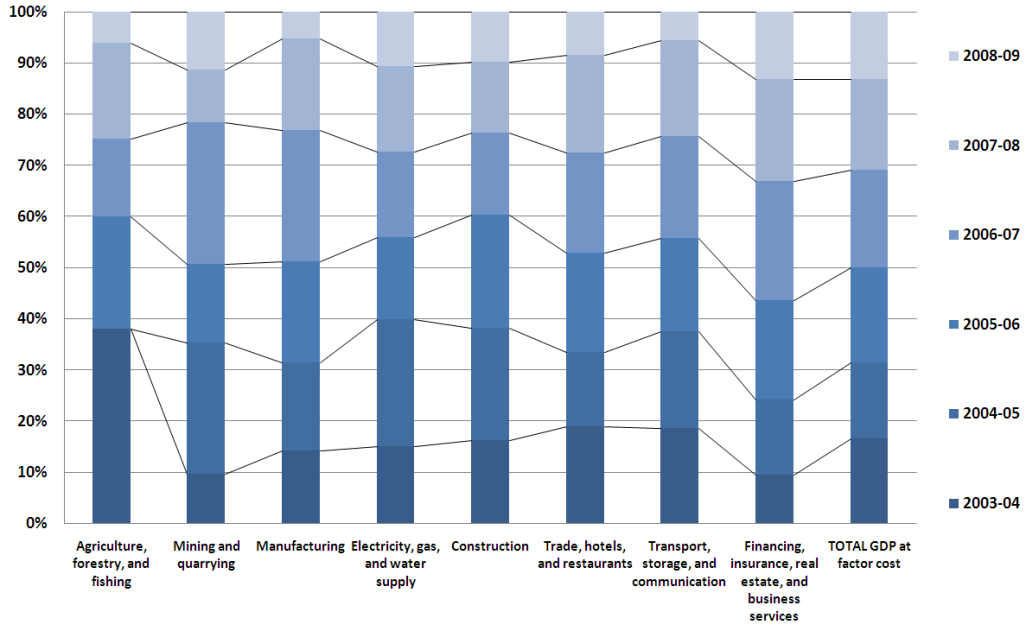
Annex A List of Most Populous Cities in India[79]

Rank	City	Population (est. 2010)	Population (2001)	State/UT
1	Mumbai	13,830,884	11,978,450	Maharashtra
2	Delhi	12,565,901	9,879,172	Delhi
3	Bangalore	5,438,065	4,301,326	Karnataka
4	Kolkata	5,138,208	4,572,876	West Bengal
5	Chennai	4,616,639	4,343,645	Tamil Nadu
6	Hyderabad	4,068,611	3,637,483	Andhra Pradesh
7	Ahmedabad	3,959,432	3,520,085	Gujarat
8	Pune	3,446,330	2,538,473	Maharashtra
9	Surat	3,344,135	2,433,835	Gujarat
10	Kanpur	3,221,435	2,551,337	Uttar Pradesh
11	Jaipur	3,210,570	2,322,575	Rajasthan
12	Lucknow	2,750,447	2,185,927	Uttar Pradesh
13	Nagpur	2,447,063	2,052,066	Maharashtra
14	Patna	1,875,572	1,366,444	Bihar
15	Indore	1,854,930	1,474,968	Madhya Pradesh
16	Thane	1,807,616	1,262,551	Maharashtra
17	Bhopal	1,792,203	1,437,354	Madhya Pradesh
18	Ludhiana	1,740,247	1,398,467	Punjab
19	Agra	1,686,976	1,275,134	Uttar Pradesh
20	Pimpri-Chinchwad	1,637,905	1,012,472	Maharashtra
21	Nashik	1,585,444	1,077,236	Maharashtra
22	Vadodara	1,539,428	1,306,227	Gujarat
23	Faridabad	1,521,605	1,055,938	Haryana
24	Ghaziabad	1,505,958	968,256	Uttar Pradesh
25	Rajkot	1,456,181	967,476	Gujarat
26	Meerut	1,404,723	1,068,772	Uttar Pradesh
27	Kalyan-Dombivali	1,342,842	1,193,512	Maharashtra
28	Navi Mumbai	1,268,784	704,002	Maharashtra
29	Amritsar	1,224,616	966,862	Punjab
30	Varanasi	1,211,891	1,091,918	Uttar Pradesh
31	Aurangabad	1,208,285	873,311	Maharashtra
32	Solapur	1,163,734	872,478	Maharashtra
33	Allahabad	1,142,722	975,393	Uttar Pradesh
34	Jabalpur	1,082,794	932,484	Madhya Pradesh

[79] Data from Wikipedia and India Census 2001

35	Srinagar	1,081,562	898,440	Jammu and Kashmir
36	Ranchi	1,073,466	847,093	Jharkhand
37	Visakhapatnam	1,065,395	982,904	Andhra Pradesh
38	Chandigarh	1,064,711	808,515	Chandigarh
39	Mysore	1,042,354	755,379	Karnataka
40	Howrah	1,034,982	1,007,532	West Bengal
41	Jodhpur	1,026,140	851,051	Rajasthan
42	Guwahati	1,022,606	809,895	Assam
43	Coimbatore	1,016,348	930,882	Tamil Nadu
44	Vijayawada	985,733	851,282	Andhra Pradesh
45	Mira-Bhayandar	985,072	520,388	Maharashtra
46	Gwalior	943,725	827,026	Madhya Pradesh
47	Hubballi-Dharwad	904,916	786,195	Karnataka
48	Bhubaneswar	904,225	648,032	Orissa
49	Jalandhar	903,491	706,043	Punjab
50	Salem	895,388	696,760	Tamil Nadu

Annex B Rate of growth at Factor Cost 1999-2000 prices[80]



*** Trade, hotels & restaurants, transport & communication (together) grew at 9 per cent, 2008-09**

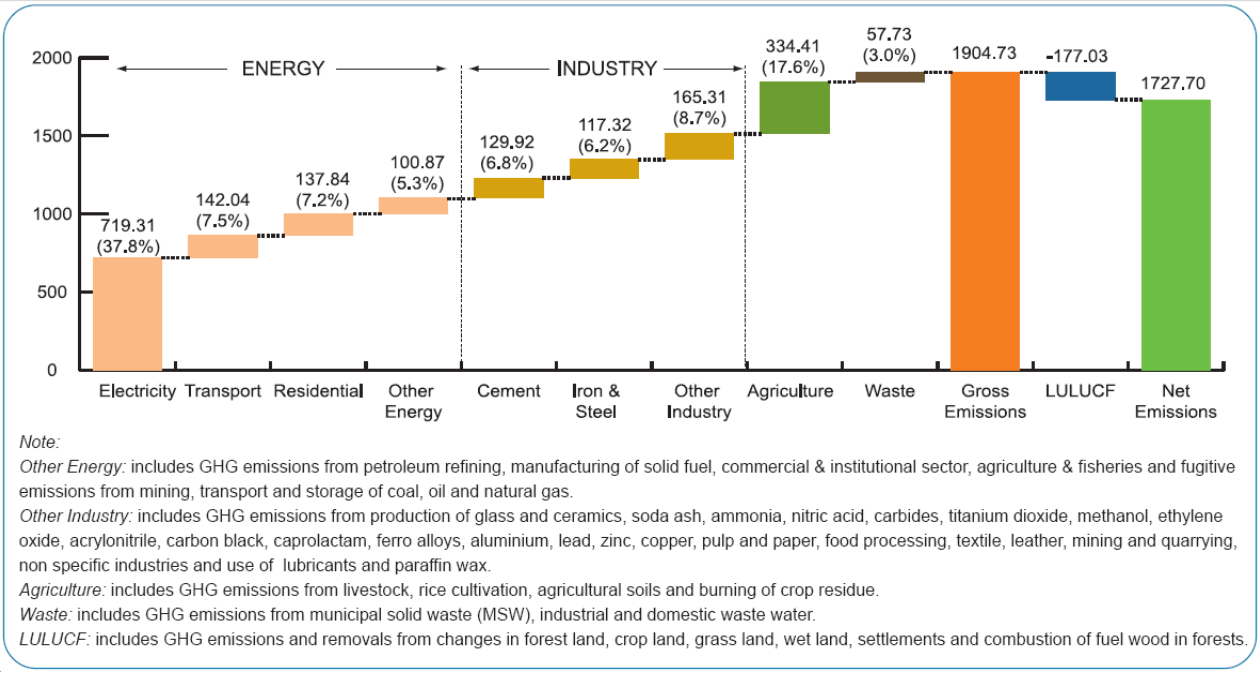
Source: Ministry of Environment and Forests' Statement of Environment, 2009 as taken from Economical Survey of India, 2007-2008, Ministry of Finance

© CAI-Asia, 2010.

[80] 2

Annex C Greenhouse Gas (GHG) Inventory Key Results[81]

GHG Emissions by Sector in 2007 (million tons of CO_2 eq)



Note:
Other Energy: includes GHG emissions from petroleum refining, manufacturing of solid fuel, commercial & institutional sector, agriculture & fisheries and fugitive emissions from mining, transport and storage of coal, oil and natural gas.
Other Industry: includes GHG emissions from production of glass and ceramics, soda ash, ammonia, nitric acid, carbides, titanium dioxide, methanol, ethylene oxide, acrylonitrile, carbon black, caprolactam, ferro alloys, aluminium, lead, zinc, copper, pulp and paper, food processing, textile, leather, mining and quarrying, non specific industries and use of lubricants and paraffin wax.
Agriculture: includes GHG emissions from livestock, rice cultivation, agricultural soils and burning of crop residue.
Waste: includes GHG emissions from municipal solid waste (MSW), industrial and domestic waste water.
LULUCF: includes GHG emissions and removals from changes in forest land, crop land, grass land, wet land, settlements and combustion of fuel wood in forests.

*Figures on top indicate the emissions by sectors and in brackets indicate % of emission of the category with respect to the net CO_2 equivalent emissions.

Key Findings:

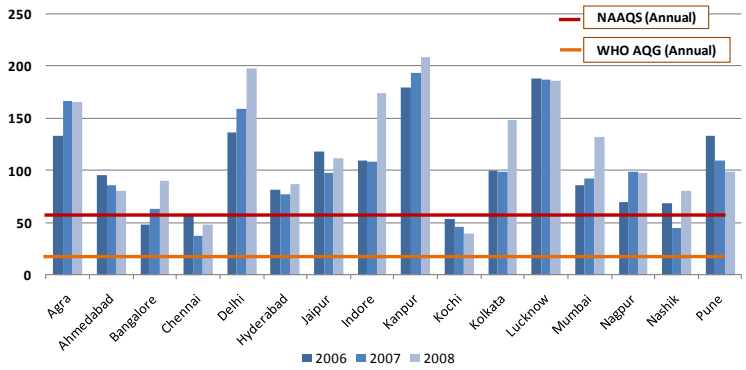
- The net Greenhouse Gas (GHG) emissions from India, that is emissions with Land Use, Land-Use Change and Forestry (LULUCF), in 2007 were 1727.71 million tons of CO2 equivalent (eq) of which CO2 emissions were 1221.76 million tons; CH4 emissions were 20.56 million tons; and N2O emissions were 0.24 million tons.
- GHG emissions from Energy, Industry, Agriculture, and Waste sectors constituted 58%, 22%, 17% and 3% of the net CO2 eq emissions respectively.
- Energy sector emitted 1100.06 million tons of CO2 eq, of which 719.31 million tons of CO2 eq were emitted from electricity generation and 142.04 million tons of CO2 eq from the transport sector.
- Industry sector emitted 412.55 million tons of CO2 eq.
- LULUCF sector was a net sink. It sequestered 177.03 million tons of CO2.
- India's per capita CO2 eq emissions including LULUCF were 1.5 tons/capita in 2007.

[81] MoEF. 2010. *India: Greenhouse Gas Emissions 2007*. http://moef.nic.in/downloads/public-information/Report_INCCA.pdf

Annex D Air Quality Status and Trends for Recent Years in Selected Indian Cities[82]

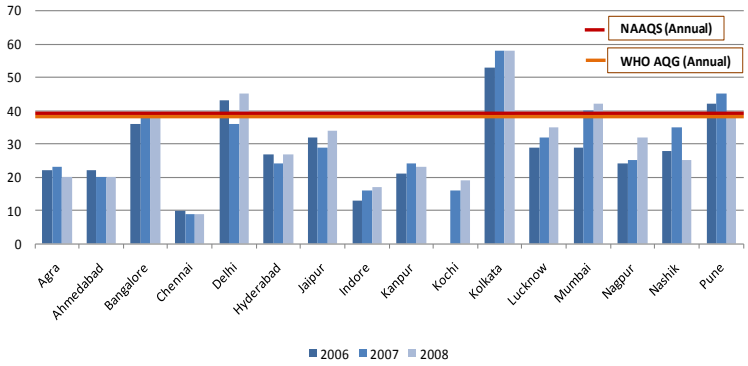
Particulate Matter $(PM)_{10}$ Status in India

Annual average PM_{10} in 16 Metro Cities (Residential areas) – 2006 to 2008 data



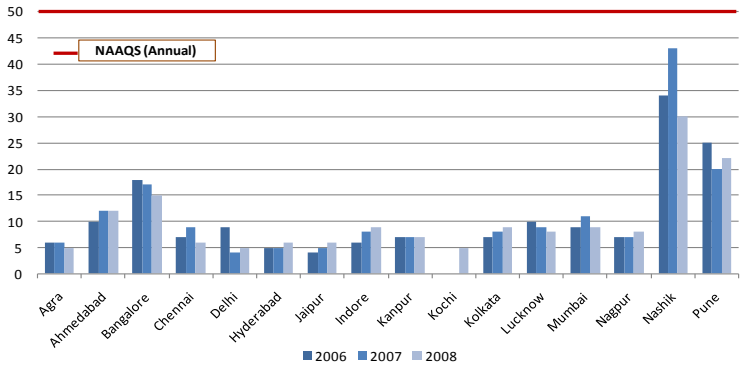
Sulfur dioxide (SO_2) Status in India

Annual average SO_2 in 16 Metro Cities (Residential areas) – 2006 to 2008 data



Nitrogen dioxide (NO_2) Status in India

Annual average NO_2 in 16 Metro Cities (Residential areas) – 2006 to 2008 data



[82] 9

Annex E Eight Missions of the National Action Plan on Climate Change[83]

Mission	Objective	Responsible Entity
National Solar Mission	• 20,000 MW of solar power by 2020	Ministry of New & Renewable Energy
National Mission for Enhanced Energy Efficiency	• 10,000 MW of EE savings by 2020	Ministry of Power
National Mission for Sustainable Habitat	• EE in residential and commercial buildings, public transport, Solid waste management	Ministry of Urban Development
National Water Mission	• Water conservation, river basin management	Ministry of Water Resources
National Mission for Sustaining the Himalayan Ecosystem	• Conservation and adaptation practices, glacial monitoring	Ministry of Science & Technology
National Mission for a Green India	• 6 mn hectares of afforestation over degraded forest lands by the end of 12th Plan	Ministry of Environment & Forests
National Mission for Sustainable Agriculture	• Drought proofing, risk management, agricultural research	Ministry of Agriculture
National Mission on Strategic Knowledge for Climate Change	• Vulnerability assessment, Research & observation, data management	Ministry of Science & Technology

Missions focused on 'Mitigation' Missions focused on 'Adaptation'

Annex F Delhi Climate Change Agenda[84]

1. The Climate Change Agenda for Delhi 2009-12 by the Government of NCT of Delhi put forth several action items that the Government intends to undertake in the coming years.
2. 65 Agenda Points for action on various sectors identified.
3. Mandatory Energy Conservation Building Code adoption in Government buildings and in all new construction projects applied for Environmental Clearance.
4. Delhi Cabinet has decided to upgrade energy efficiency of existing Government Buildings through retrofitting to be carried out by energy service companies in a performance contracting mode.
5. The objective is to ensure that Government Buildings can achieve at least rating of one star from BEE under their office building labeling programme.

[83] MoEF. 2009. India and Climate Change. http://moef.nic.in/downloads/public-information/presnt_CC.pdf
[84] Department of Environment, Government of NCT, Delhi, 2010.
http://www.delhi.gov.in/wps/wcm/connect/environment/Environment/Home/Achievements/Climate+Change+Agenda+for+Delhi+2009-12

Annex G Previous National Ambient Air Quality Standards of India[85]

Pollutant (µg/m3)	Time Weighted Average	Concentration in ambient air (µg/m3)		
		Industrial Area	Residential, Rural & other areas	Sensitive Area
SO_2	Annual Average* 24 hours**	80 120	60 80	15 30
NO_2	Annual Average* 24 hours**	80 120	60 80	15 30
SPM	Annual Average** 24 hours*	360 500	140 200	70 100
RSPM (PM_{10})	Annual average** 24 hours*	120 150	60 100	50 75
Pb	Annual Average** 24 hours*	1.0 1.5	0.75 1.00	0.50 0.75
CO	8 hours 1 hour	5000 10000	2000 4000	1000 2000

Guidelines refer to the safe level of a pollutant, for a given average time, to protect the public from acute health effects.

µg/m^3=micrograms per cubic meter

*Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/8 hourly values should be met 98% of the time in a year. However 2% of the time, it may exceed but not on two consecutive days.

Note: The levels of air quality necessary with an adequate margin of safety, to protect the public health, vegetation and property.

[85] 9

Annex H Guidelines for Declaring Sensitive Areas by Central Pollution Control Board (CPCB)[86]

1. 10 kms [kilometers] all around the periphery of health resorts that are notified by State Pollution Control Boards (SPCB) in consultation with department of public health of the concerned state.
2. 10 kms all around the periphery of biosphere reserves, sanctuaries and national parks that are notified by Ministry of Environment and Forest or concerned states.
3. 5 kms all around the periphery of an archeological monument declared to be of national importance or otherwise that are notified by Archeological Survey of India (ASI) in consultation with State Pollution Control Boards.
4. Areas which are delicate or sensitive to air pollution in terms of important agricultural/horticultural crops grown in that area and accordingly notified by State Pollution Control Boards in consultation with department of agriculture/horticulture of concerned state.
5. 5 kms around the periphery of centers of tourism and/or pilgrim due to their religious, historical, scenic or other attractions, that are notified by department of tourism of the concerned state in consultation with State Pollution Control Boards.

Annex I Review of National Ambient Air Quality Standards[87]

The review of ambient air quality standards project was awarded to Indian Institute of Technology Kanpur (IIT-Kanpur) in 2003. The steering committee was composed of academicians, consultants, non-government organizations (NGOs), doctors, National Environmental Engineering Research Institute (NEERI), National Institute of Occupational Health (NIOH), Indian Meteorological Department (IMD), industry associations, SPCBs, Ministry of Environment and Forests (MoEF), CPCB, and other stakeholders to provide guidance on the review of NAAQS.[88]

In reviewing the 1994 NAAQS, the following items were considered:

- general description of the pollutant
- dose-response relationship based health risk evaluation developed by international and local organizations
- current air quality levels
- current NAAQS
- associated risk with revised standards
- pollutants having long-term effects should also have 24-hour standards along with the annual standard
- cost of implementation of the standards
- implication to development projects
- protection of human health

[86] 16
[87] 9
[88] CAI-Asia, 2009. Ambient Air Quality Standards Summary for India; CPCB. 2008. *National Report of Ambient Air Quality Status*. http://www.cpcb.nic.in/upload/NewItems/NewItem_147_report-2008.pdf

Annex J 17 Categories of Highly Polluting Medium- and Large-scale Industries[89]

Category	Pollution
1. Aluminum Smelter	Pot room secondary emission
2. Caustic Soda	
3. Cement	PM emission
4. Copper Smelter	SO_2 emission
5. Distilleries	
6. Dyes & Dye Intermediates	Incinerator performance, fugitive emission, Volatile organic compounds (VOC)
7. Fertilizer	
8. Integrated Iron & Steel	Coke oven plants toxic gas emissions
9. Tanneries	Heavy metals
10. Pesticides	Incinerator performance, fugitive emission, VOC
11. Petrochemicals	VOC
12. Drugs & Pharmaceuticals	VOC
13. Pulp & Paper	Odor issues
14. Oil Refineries	VOC
15. Sugar	SO_2 emission
16. Thermal Power Plants	High ash, SO_2 emission, PM emission
17. Zinc Smelter	SO_2 emission

[89] CPCB. 17 Categories of the Major Polluting Industries. http://www.cpcb.nic.in/faq2.php

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