Training Module

on Air Pollution Mitigation for Government Officials in Assam

Message by Hon’ble MP Shri Gaurav Gogoi

The issue of Air Pollution is complex, multi-sectoral, and needs to be addressed urgently. Multiple steps taken by the government like; the launch of the National Clean Air Programme (NCAP), the establishment of the Commission for Air Quality Management, and grants recommended by the Fifteenth Finance Commission, etc have, to an extent, taken the conversation out of Delhi-NCR. However, we need to focus more on issues like; the availability of actionable data for local actions, capacity building and sensitization, sustainable waste management, promotion of clean energy infrastructure, and implementation of programs and schemes addressing polluted air.

Assam has been experiencing an all-high particulate matter while Guwahati has one of the highest Black Carbon pollution levels in the world. With rapid urbanisation and rising population in the city since the last 12-15 years resulting in massive infrastructural growth, there is a possibility that they can hamper neighbouring cities due to the light nature of particulate matter and ability to float over long distances. Similar to the clean air initiatives for Delhi and adjoining areas, Greater Guwahati and nearby areas require an airshed approach in order to meet the target of reducing forty percent PM2.5 by 2026. And for airshed management to take shape into stringent implementation of actions, there is a need for appropriate capacity to advance and accelerate climate action in even sharper relief, further accentuated when seen in light of the pressing development needs. In this context, questions of capacity cannot be seen only as issues of domestic or local decision-making, but as the site of cooperation among officials at all levels, ranging from the state to the ward and panchayat. Any transformation requires a concerted effort, and even more so when it's more accurately recognised as a suite of interconnected transformations.

It is with the aforesaid views and beliefs that my office set itself upon a project to draft a Training Module with high-impact clean air strategies for various polluting sources and sectors for the sole purpose of enabling government officials to collectively engage in clean air initiatives and act as an agent of information on the characteristics of polluted air and measures to avoid, control and alter.

I am hopeful that the Compendium on Air Pollution serves its intended purpose and fellow Parliamentarians make maximum use of it and provide their thoughts for its continuous upgradation.

Yours Sincerely,

Shri Gaurav Gogoi, Hon’ble MP (LS) and Convener, PGCA

Acronyms

AAQ: Ambient Air Quality
ADMS: Advanced Distribution Management System
AEROMOD: American Environmental Protection Agency Regulatory Model
AIR: Air Information and Response
AOD: Aerosol Optical Depth
AQ: Air Quality
AQI: Air Quality Index
AQM: Air Quality Management
BEST: BrihanMumbai Electric Supply & Transport Undertaking
BMS: BrihanMumbai Municipal Corporation
BS: Bharat Stage
C&D: Construction and Demolition
CAA: Clean Air Asia
CAAP: Clean Air Action Planning
CAAQMS: Continuous Ambient Air Quality Monitoring Station
CAP: Comprehensive Action Plan
CEMS: Continuous Emission Monitoring System
CFC: Chlorofluorocarbon
CNG: Compressed Natural Gas
CO: Carbon Monoxide
CO2: Carbon Dioxide
COPD: Chronic Obstructive Pulmonary Disease
CPCB: Central Pollution Control Board
CSO: Civil Society Organisation
DoEF: Department of Environment and Forest
DG: Diesel Generator
DRS: Decision Review System
ECOSS: European Conference on Surface Science
EPIC: The Energy Policy Institute at the University of Chicago
ETS: Emission Trading System
EV: Electric Vehicle
GBD: Global Burden of Diseases
GDP: Gross Domestic Product
GHG: Green House Gas
GRAP: Graded Response Action Plan
GWP: Global warming potential
HAP: Hazardous Air Pollutant
HC: Hydrocarbon
ICS: Improved Cookstoves
IEC: Information Education Communication
IIT: Indian Institute of Technology
ITDP: Institute for Transport and Development
LEUD: Low Emissions Urban Development
LPG: Liquified Petroleum Gas
MoEFCC: Ministry of Environment Forest and Climate Change
MoHUA: Ministry of Housing and Urban Affairs
MSW: Municipal Solid Waste
NAAQS: National Ambient Air Quality Standards
NAC: Non-Attainment cities
NAMP: National Air Quality Monitoring Program
NAPCC: National Action Plan for Climate Change
NCAP: National Clean Air Program
NCR: National Capital Region
NGO: Non-Government Organisations
NH3: Ammonia
NMT: Non-motorized transport
NO: Nitric Oxide
NO2: Nitrogen Dioxide
NOX: Nitrogen Oxides
O3: Ozone
Pb: Lead
PCT: Pollution Control Technology
PM: Particulate Matter
PMUY: Prime Minister Ujjwala Yojana
PM KUSUM: Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
PNG: Piped Natural Gas
pH: Potential of Hydrogen
RDF: Refuse Derived Fuel
ROG: Reactive Organic Gas
SIPCOT: State Industries Promotion Corporation of Tamil Nadu Ltd.
SCF: Supercritical Fluid
SDG: Sustainable Development Goal
SO2: Sulfur Dioxide
SPCB: State Pollution Control Board
SPM: Suspended Particulate Matter
SWM: Solid Waste Management
TOD: Transit Oriented Development
TSDF: Treatment, Storage and Disposal Facilities
USD: U.S Dollar
USEPA: The United States Environmental Protection Agency
VOC: Volatile Organic Compounds
WHO: World Health Organisation
WWF: World Wide Fund
YCAN: Youth for Clean Air Network

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Acknowledgment

The Office of Shri Gaurav Gogoi, Hon'ble MP Kaliabor & Deputy Leader of Congress Parliamentary Party, Lok Sabha is grateful for the drafting of an informative Training Module, which not only guides office holders on fundamentals but also lays down a list of comprehensive roles and responsibilities to be adapted and practiced at their respective departments for robust implementation of Clean Air initiatives concerning the well-being of officials at the state, district and block levels. We express special gratitude to and acknowledge the contribution of Swaniti Initiative and Clean Air Asia for their guidance on the subject and support in developing the module. The committed core team at the Hon'ble MP's office: Ms Bedika Borah, Clean Air Associate, and at the PGCA Secretariat comprising, Mr Kumar Abhishek, Vertical Lead, Policy Engagement, Mr. Siddharth Srivastava, Assistant Manager, Ms Bhavayta Mahajan, Senior Associate and Ms Monal Singh, Associate - Clean Air. Ms Ureeda Rafiqi and Mr Sheikh Jahan Zaib, Clean Air Associates were instrumental in driving various components of the Training Module from designing the format to collating case studies. The Office of Shri Gaurav Gogoi appreciates and thanks each one of them for their services and timely support.

About the Toolkit

Air pollution is a major environmental issue that has become a significant public health concern worldwide, with high scope in Assam. The impact of air pollution on human health and the environment is well-documented, and government officials play a critical role in addressing this issue at the district and state levels. The Training Module on Air Pollution Mitigation for Government Officials in Assam is designed to equip district and state-level officials with the knowledge and strategies needed to understand and address air pollution effectively. This training module can be effective because it helps officials make informed decisions on policies, regulations, and other initiatives aimed at reducing air pollution.

The first section ‘Air Pollution: A Silent Killer’ provides an overview of air pollution from local to global level, its causes and its sources, and the impact of air pollution. The second section ‘Types of Air Pollution’ covers the criteria of air pollutants including their general characteristics, sources, and impacts on human health and the environment. The third section ‘Impacts of Air Pollution’ gives an insight into the impacts of air pollution on human health, ecosystems, and the economy. The fourth section ‘Urban Air Pollution’ traces evidence of air pollution in urban setups and its co-link with various government programs, monitoring frameworks, and inventory of data. It also highlights focus areas for Low Emissions Urban Development and sectoral interventions in Clean Air Action Planning. The fifth section ‘Regulations, Standards and Enforcement’ provides an understanding of the importance of stringent laws and regulations, and mainstreaming air quality for effective enforcement of them along with calling attention to government efforts for air pollution mitigation. The sixth section ‘Departmental Roles and Responsibilities/Role of Government Officials’ highlights the important roles of government officials in addressing air pollution and the different roles they can play in reducing air pollution. The seventh section ‘Air Quality Management’ outlines the various control measures that can be adopted for implementation to mitigate air pollution, including the Air Quality Management Framework. The eighth and final section ‘Case Studies’ presents case studies of successful air pollution mitigation initiatives from around the country, providing officials with practical examples of successful strategies that can be implemented in Assam.

The training module is designed to be interactive and engaging, with a range of learning activities, including case studies and mitigation strategies. The training manual shall support the officeholders by strengthening their knowledge of air quality management and enabling better decision-making on city/town development to help improve the air quality in Assam.

Section 1: Air Pollution: An Introduction

Pristine air is a mixture of various gasses such as oxygen, nitrogen, argon, carbon dioxide and small amounts of other gasses in a fixed proportion. When the composition of these gasses becomes altered through the addition of non-natural components it becomes polluted. Therefore, in simple terms air pollution is the contamination of the air we breathe with harmful substances.

The introduction of chemicals, particulate matter, or biological materials into the atmosphere causes harm or discomfort to humans and other living organisms or damages the natural environment. Natural phenomena such as volcanoes, windstorms, the decomposition of plants and animals, and even the aerosols emitted by the ocean pollute the air. However, the pollutants usually referred to when talking about air pollution are those generated as a result of human activity, such as driving motor vehicles, burning of coal, oil, and other fossil fuels, manufacturing chemicals, etc. These activities produce polluting emissions into the air causing damage to human health and the environment. Air Pollution occurs both indoors and outdoors. Indoor air pollution is caused mainly by the household burning of solid fuels such as wood, dung, agricultural residues, coal, and charcoal for cooking and heating. Outdoor air pollution, also called ambient air pollution, is mainly caused due to emissions from human activities such as the use of motor vehicles, and natural sources such as dust storms. Air pollutants can be in the form of solid particles, liquid droplets, or gasses, which can be classified as either primary or secondary. For regulatory purposes, air pollutants have also been further classified as criteria pollutants and Hazardous Air Pollutants.

1.1. How Severely Air Pollution Affects Us From the Local to the Global Level?

Apart from the physical state of pollutants (such as gaseous or particulate matter), it is important to consider the geographical location and distribution of the emission sources. Air pollution can occur at the household, urban, peri-urban, regional, and global scale. Moderately long-lived gasses contribute to urban and regional air pollution, such as smog over a city or acid rain impact over a region. Long-lived pollutants such as GHG contribute to global heating and represent global-scale air pollution.

On a global scale, indoor air pollution is responsible for the premature death of 3.8 million people due to exposure to household air pollution from inefficient cooking practices using polluting stoves together with solid fuels and kerosene. Around 3 billion people worldwide cook using polluting open fires or simple stoves fuelled by kerosene, biomass (wood, animal dung, and crop waste), and coal.

1.1.1. Household Air Pollution

Household air pollution is generated by the use of inefficient and polluting fuels and technologies in and around the home that contain a range of health-damaging pollutants, including small particles that penetrate deep into the lungs and enter the bloodstream. In urban areas, indoor air pollution is often associated with high population density, industrial activities, and traffic congestion. Indoor air pollution in rural areas is primarily influenced by agricultural practices, biomass fuel usage, and limited access to modern energy sources.

At the household level Indoor air pollutants can be grouped into four categories:

1. Combustion contaminants comprise a large group of gaseous and particulate pollutants that may be emitted from all types of combustion.
2. Volatile organic compounds (VOC) may be emitted to indoor air from many sources. These include building materials, household products, and paints, or from contaminated soil.
3. Biological agents include mildew, molds, fungi, or bacteria. Furthermore, biological allergens such as dust mites may cause an allergic reaction in vulnerable people.
4. Other contaminants are specific groups of chemicals such as pesticides or asbestos.

1.1.2. Urban Pollution

Over the last five decades, there has been unprecedented growth in Indian cities with the urban population growing nearly fivefold from 60 million in 1947 to around 400 million people today. There are currently three Indian megacities with a population of more than 10 million people (Mumbai, New Delhi, and Kolkata). As Indian cities are increasing in size and population, there is a steady demand for motorised vehicles, which places pressure on the city's infrastructure and environment, including poor urban air quality. Urban air pollution not only has immediate localised impacts on human health and well-being but also contributes to regional and global air pollution. For example, regional acidification is increasingly experienced in East Asia and Southeast Asia. The use of fossil fuels in the industrial and transport sectors, not only contributes to climate change but also the haze in South Asia known as the 'Atmospheric Brown Cloud', which is a mass of ash, acids, aerosols, and other particulates.

1.1.3. Peri-Urban and Rural Pollution

It is often assumed that ambient air quality in rural areas is better than that in towns and cities. While this may be true for some primary gaseous air pollutants emitted directly from urban sources, it is not necessarily true for PM2.5. For ground level O3 (a secondary air pollutant that is formed in the atmosphere through photochemical reactions) the levels are often lower in urban areas than in suburban areas and the surrounding countryside.

The burning of agricultural crop residue to clear fields is a major contributor to air pollution. When rice farmers in north-western India burn their fields, PM2.5 concentrations in the highly populated city of New Delhi spike to about 20 times beyond the World Health Organisation's (WHO) air quality guidelines. Emissions from burning agricultural residue and household waste and mining in the countryside is still not considered as an issue of priority in large parts of the country. Living in areas where crop burning is common is associated with a three-fold higher risk of acute respiratory infection with children being particularly susceptible to the health effects of crop burning.

1.1.4. Regional and Transboundary Pollution

The transboundary movement of air pollution across borders may cause adverse effects in countries other than the country of origin. Regional and transboundary air pollution has been a topic of scientific research for several decades but with advanced monitoring and modelling technology there is more evidence that pollution emitted in one part of the world can create adverse effects in other parts.

Pollutants with a potential for regional and intercontinental transport include particulate matter, acidifying substances such as SO2, CO, O3 and its precursors such as VOC and NOX; heavy metals (mercury); and persistent organic pollutants.

1.2. Causes of Air Pollution

Although the causes and sources of air pollution are related topics and appear to be of the same context, the fact is that both discuss very different aspects of air pollution. The causes of air pollution are defined as the driving forces of air pollution as described below:

Population Growth and Urbanisation: As the population grows, demand for transport, energy, housing, and environmental services also increases, which creates pressure on the environment in the form of emissions of air pollutants. Over the past decades, the urban population has grown more rapidly than the rural population. This is true as cities and towns become the engine of economic development in many countries. As cities expand to their hinterlands, so does the distance from home to work in the city centers which further raises the need for energy and transport, creating more burden on the environment.

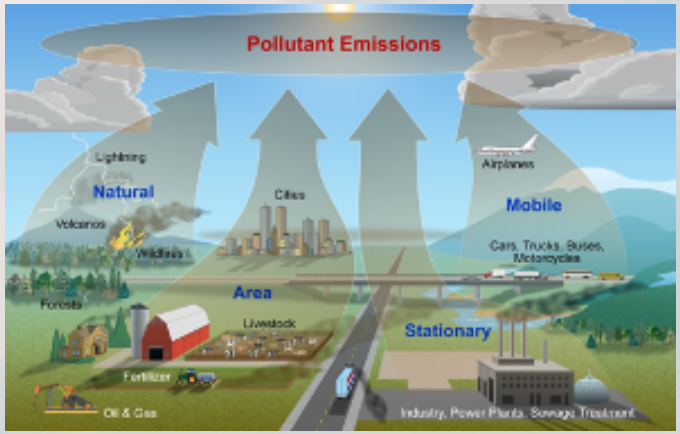
Economic Development: Many countries have experienced economic development and higher standards of living over the past decades. Conventional wisdom relates economic growth to increased air pollution; however, this is not the case for all countries. Some developed countries reported that their nation's air pollution had declined even without limiting their economic growth as a result of tightened environmental controls. On the other hand, in many developing countries that undergo economic and industrial development, and motorisation, the demand for fossil fuels tends to increase. Thus, increasing levels of air pollution occur in the absence of effective policies that could have helped in controlling the amount of emissions generated.

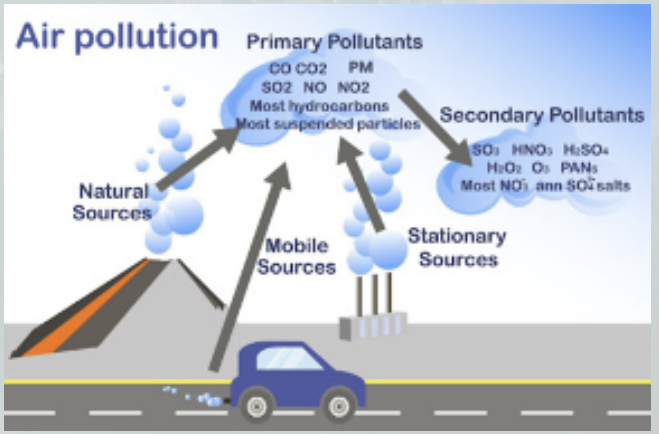
Motorisation: The number of motor vehicles on the road has been growing at a considerable pace, which is primarily influenced by increasing affluence and population growth. Although this is not necessarily true for all countries, especially in countries with active controls that limit the number of vehicles, and promote public transport options, and non-motorized forms of transport such as cycling and walking. As cities grow and sprawl, the number of trips made by public transport becomes limited and two-wheelers play an important role as an alternative mode of transport, further aggravating traffic congestion and resulting in increased traffic emissions.

Reliance on Fossil Fuels as Sources of Energy: Fossil fuels such as coal, oil, and natural gasses currently provide the majority of all the energy consumed worldwide since it is relatively cheap and it is the only viable solution to meeting the increasing demand in the next two decades even with aggressive development and deployment of new renewable and nuclear technologies. Coal remains the dominant source of the power sector but higher fossil-fuel prices in the future and increasing concerns over energy security and climate change are expected to boost the share of renewable-based power generation. The continuation of current trends would have dire consequences for climate change and also exacerbate air pollution, particularly in developing countries.

1.3. Sources of Air Pollution

The sources of air pollution are the various locations or activities responsible for the release of pollutants in the atmosphere. These sources can be classified into various categories. Natural sources include volcanoes that have spewed particulate matter and gasses into our atmosphere, lightning strikes that have caused forest fires, with their resulting contribution of gasses and particles, vegetation contributing to large amounts of pollen and spores to the atmosphere, organic matter in swamps that decay and windstorms that whip up dust. Anthropogenic sources are categorised in two ways- stationary and mobile sources. Stationary sources consist of non-moving sources such as power plants, manufacturing facilities, oil refineries, chemical plants, waste incinerators, furnaces, etc. Stationary sources are classified further into either point source or area source. Large, stationary sources of emissions that have specific locations and release pollutants in quantities above an emission threshold are considered point sources. For example, coal and oil-fired power plant facilities. An area source refers to a series of small sources that together can affect air quality in a region. For example, dry cleaners, vehicle refinishing, gasoline dispensing facilities, and residential heating collectively emit pollutants from these sources along with forest fires and open burning of waste. Mobile sources of air pollution include a wide variety of vehicles, engines, and equipment that generate air pollution and that move, or can be moved from place to place., classified as either on-road or non-road sources. On-road sources include vehicles and non-road sources include gasoline and diesel-powered engines and equipment used for construction, agriculture, transportation, recreation, and many other purposes.





Based on the source of its origin, air pollutants have been classified into primary and secondary pollutants. Primary pollutants (Sulphur dioxide, Hydrogen Sulphide, Volatile organic compounds, Nitrogen oxides, Ammonia, Hydrochloric acid, Hydrogen fluoride) are emitted directly into the atmosphere from the pollution source while secondary pollutants (Sulphur trioxide, Sulphuric acid, Ozone, Ketones, aldehydes, acids, Nitrogen dioxide) are produced when primary pollutants interact with other substances in the air.

1.4. Criteria Air Pollutants

The criteria air pollutants include particle pollution, ground-level ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead. These pollutants can harm your health and the environment, and cause property damage. Of the six pollutants, particle pollution and ground-level ozone are the most widespread health threats. The Environmental Protection Agency calls these pollutants "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels.

Particulate Matter (PM) is a common proxy indicator for air pollution as it affects more people than any other pollutant. Airborne PM is a complex mixture of particles with components having diverse chemical and physical characteristics, generally classified by their aerodynamic diameters since size is a critical determinant of site of deposition within the respiratory tract. PM10 includes inhalable particles (PM4.0), which can enter the thoracic region. Fine particles (PM2.5) penetrate deep into the lung and into the air sacs, and can damage cells in the airways and affect the lung causing exacerbation of asthma, chronic obstructive pulmonary disease, cardiovascular impacts and circulatory system. The major components of PM are sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air.

Sulfur Dioxide (SO2) is an acidic and colourless gas with a pungent, suffocating odour and is corrosive to organic materials. The principal source is the combustion of sulfur-containing fossil fuels used in industries, power stations and domestic heating. SO2 emissions from large industries and power stations with tall stakes and located in sub-urban areas may still affect air quality in both rural and urban areas. SO2 is considered more harmful when particles and other pollution concentrations are high.

Nitrogen Oxides (NOX) are oxidised in the atmosphere to the secondary pollutant NO2 which is the major form of NOX in the atmosphere. The principal source of NOX is road traffic, power stations, heating plants and industrial processes. NOX emissions can be reduced by optimisation of the combustion process (e.g. low NOX burners in power plants).

Ozone or O3 is the main component of the photochemical smog. Tropospheric or ground-level O3 is the toxic pollutant which we breathe in contrast to stratospheric O3, which protects the earth from harmful ultraviolet radiation. Ground-level O3 is a secondary pollutant because it is not directly emitted from sources but rather, produced when the primary pollutants react in presence of sunlight. Once formed, O is destroyed by NO which is high at traffic sites, and therefore O3 is normally higher at a distance from busy traffic areas such as rural suburbs.

Carbon Monoxide or CO is a toxic gas which is produced as a result of incomplete combustion. Once emitted, it can remain in the atmosphere for a few months and is eventually oxidised to CO2. Exposure to high CO levels is lethal. In urban areas, CO is produced almost entirely (~90%) from road traffic emissions. CO from open fires may be significant in local areas. The emissions can be reduced by optimising the combustion conditions to burn more completely, but with the risk of increasing the formation of NOX. Most effective reductions are achieved by catalytic converters which oxidise CO to CO2.

Lead (Pb) is a toxic heavy metal that normally exists as fine particles in the air. It is a neurotoxin or nerve poison and could reduce the intelligence level and brain function of children. Sources of lead pollution include mining, smelting, manufacturing and recycling activities, and, in some countries, the continued use of leaded paint, leaded gasoline, and leaded aviation fuel. More than three quarters of global lead consumption is for the manufacture of lead-acid batteries for motor vehicles.

Section 2: Impacts of Air Pollution

The impact of air pollution has a range of direct and indirect effects on human health, ecosystems, vegetation, and material assets. The severity of impact is dependent upon the concentration and mixture of the pollutants, the duration of exposure, and the susceptibility of the sensitive receptor. The spatial scale of air pollution impacts ranges from the street level to urban, peri-urban and regional and global. The time-scale of effects also varies ranging from hours to years.

The Air Quality Index (AQI) works as a yardstick from 0 to 500 comparing the levels of air pollution and health concerns associated with it. For each pollutant, an AQI value of 100 generally corresponds to an ambient air concentration that equals the level of the short-term national ambient air quality standard for protection of public health. AQI values at or below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is unhealthy, at first for certain sensitive groups of people, then for everyone as AQI values get higher. The AQI is divided into six categories. Each category corresponds to a different level of health concern with a specific color making it easy for people to quickly determine whether air quality is reaching unhealthy levels in their communities.

Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 TO 50	Air quality is satisfactory, and air pollution poses little or no risk
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may expertise health effects. The general public is less likely to be affected
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects
Purple	Very Unhealthy	201 to 300	Health Alert: The risk of health effects is increased for everywhere
Maroon	Hazardous	301 and Higher	Health warning of emergency conditions: everyone is likely to be affected

Table: Air Quality Index

2.1. Impacts on Human Health

A healthy adult human breathes about 16 kilograms of air every day and ambient air pollution has significant impacts on human health. Many air pollutants have been classified as carcinogenic, and cause a variety of respiratory, cardiovascular diseases, and physiological disorders in humans. Air pollution can affect our health in many ways both acute (short-term) and chronic (long-term) effects. Acute effects are usually immediate and often reversible when exposure to the pollutant ends. Some acute health effects include eye irritation, headaches, nausea, and upper respiratory infections such as bronchitis and pneumonia. Chronic effects are usually not immediate and tend not to be reversible when exposure to the pollutant ends. Some chronic health effects include decreased lung capacity, heart disease, lung cancer, and even damage to the brain, nerves, liver or kidneys resulting from long-term exposure to toxic air pollutants. Young children and elderly people often suffer more from the effects of air pollution. People with health problems such as asthma, heart, and lung disease are also more vulnerable. The extent to which an individual is harmed by air pollution usually depends on the total exposure to the damaging chemicals, i.e. the duration of exposure and the concentration of the chemicals must be taken into account.

The greatest impacts on human health tend to be focused on the effects of criteria pollutants such as PM2.5, O3, NO2 and SO2 as well as toxic air pollutants, secondary pollutants, volatile organic compounds, and heavy metals. In Indian cities, poor air quality is emerging as a serious concern because of its impact on human health. Long-term exposure to air pollution has shown that people living in more polluted locations die prematurely. The World Health Organisation estimates 4.2 million premature deaths globally linked to ambient air pollution, mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children. Indian Council of Medical Research study showed that 1.7 million deaths in India were attributable to air pollution in 2019, which was 18% of the total deaths in the country. The study revealed that household air pollution is decreasing in India resulting in a 64% reduction in the death rate attributable to it from 1990 to 2019, whereas the death rate from outdoor ambient air pollution has increased during this period by 115%. Findings by the Lancet in 2021 revealed that the majority of these deaths were from ambient particulate matter pollution accounting for 0·98 million deaths.

2.2. Impact on Ecosystems

Air pollutants may cause harm to water bodies, aquatic life, and vegetation. The greenhouse effect is being increased by the release of certain gasses into the atmosphere that cause the earth's temperature to rise, also called global warming. Carbon dioxide, methane, particulate matter (especially black carbon or soot), nitrous oxide, fluorinated compounds, and ozone are some of the compounds contributing to global warming. They are combinedly released from the combustion of fossil fuels in electric power generation, motor vehicles, and industries; agricultural activities and landfills; biomass burning; nitrogen fertilisers; sewage; medical applications; refrigeration and air conditioning; solvents; degreasing and cleaning agents; insulation; refrigerating units; and fire extinguishers. Continued emissions of greenhouse gasses could lead to more extreme weather events such as drought and floods, threaten coastal resources and wetlands by raising the sea level as a result of increased polar ice cap melting, and increase the risk of certain diseases by producing new breeding sites for pests and pathogens. Agricultural regions and woodlands are also susceptible to changes in climate that could result in increased insect populations and plant disease. This degradation of natural ecosystems could lead to reduced biological diversity. Chemicals released by human activities destroy ozone in the stratosphere that protects the Earth from harmful ultraviolet radiation from the sun.

2.3. Impacts on the Economy

Adverse health impacts of air pollution affect a country's economy through a decline in productive days, revenues, and increased medical expenses. For example, despite overall improvements in air quality in China, illnesses resulting from O3 and PM exposure in China is estimated to have cost USD 112 billion. Similarly, Indian Council of Medical Research study showed that India's economic loss due to lost output from premature deaths and morbidity from air pollution was 1.4% of the GDP in India in 2019, equivalent to INR 260,000 crores (US$ 36.8 billion), and the economic loss was higher in the northern and central India states, with the highest in Uttar Pradesh (2.2% of GDP) and Bihar (2% of GDP).

The costs of outdoor air pollution can be divided into costs to the economy (market) and welfare (non-market) costs. Market costs are those that are associated with biophysical impacts that directly affect economic activity as measured in the national accounts GDP. For example, lower crop yields. Non-market costs include the monetised welfare costs of mortality (premature deaths), and of the disutility of illness (e.g. pain and suffering). Market costs show the need to address air pollution policies in order to avoid negative effects on the economy and non-market costs show the potential social benefits of air pollution control policies. When proposing control measures or policies and regulations to address air pollution, decision-makers usually consider the economic costs of control measures.

Section 3: Urban Air Pollution

Since the last few decades, there has been significant degradation of air quality in most of the Indian cities as they are in the grip of serious air pollution issues with the air quality above the standards provided by CPCB and WHO. Indian cities have high annual mean concentrations of PM 2.5 which exceed the 40μg/m3 limit set by the National Ambient Air Quality Standards. Urban air pollutants comprise vehicular emissions, industrial emissions, and emissions due to developmental activities causing several ill effects on human health and the environment. By 2025, the Asian region is projected to account for 40% of the total increase in world energy consumption. Increased emissions in terms of air pollution and global greenhouse gasses are therefore going to be a significant feature of growing Asian Cities. It is estimated that 98% of the Asian cities are currently at risk from the health impacts of exposure to PM2.5. When annual levels of PM10 were measured, it was found that 7 out of 10 cities in developing Asian countries have unhealthy levels of air pollution. Global data for aerosol optical depth collected for 189 megacities to evaluate the air quality status revealed that Indian subcontinent cities, Middle East, and North China are the most polluted cities due to their largest population growth leading to more anthropogenic emissions. 39 Indian cities were featured on the list of world's 50 most polluted cities, stated in the fifth World Air Quality Report prepared by IQAir based on the annual average level of pollutant PM2.5 in air for 7,323 cities and 131 countries in the year 2022. With its burgeoning population and widespread poverty, India faces enormous demands for transportation and energy usage that contribute to large amounts of pollutants in the atmosphere acting as a threat to delivering on the SDG vision of a better world.

3.1. Focus Areas for Low Emissions Urban Development (LEUD)

Cities are complex and dynamic entities. A study published by Clean Air Asia in 2018 of 889 Asian cities, revealed that 98 percent of these cities have unhealthy air pollution levels and only 32 cities meet the PM10 annual average as set by WHO Guidelines. There is no universal solution that can be applied to every city in any country. Energy needs, rising traffic and unplanned growth characterise many cities that are growing fast with rising populations. By adopting a LEUD approach to development in Indian cities we can encourage the development of urban spaces that can deliver benefits to both residents and the natural environment to integrate the importance of air quality in city development. The thematic focus areas for investment in LEUD may slightly differ from those of green urban development. However overall, they remain similar because the mitigation activities housed within the city for reducing GHGs and leading to a green city are similar to those that are required for reducing air pollution by low emissions urban development:

Low-Emissions Mobility: Low emissions mobility supports reduced reliance on petroleum-based modes of transport and increased emphasis on non-motorised transport that is accessible, safe, environment-friendly, and affordable. For the LEUD model to succeed there is a need for a well-integrated Transit Oriented Development that reduces the need for travel by private motorised modes. Enhancing urban areas through good design that creates spaces that are accessible, walkable, and serviced by efficient public transport helps reduce air pollution and improve living conditions

Green and Clean Industry: The concept of Green and Clean Industry takes 'circular economy' into consideration, an approach where implementation requires both government involvement and effective institutional arrangements to enable regulation, coordination, and incentives for adoption. Additionally, the clean industry depends on energy choices in the production process as well as the technology used.

Energy-Efficient Building: Buildings that consider both the energy required to extract, process, transport, and install building materials as well as the energy to operate services such as heating, cooling, and powering equipment are considered energy efficient. The source of this energy is also important along with building design standards that are expected to consider solar access; water capture, treatment, and reuse; improving operating efficiency; reliance on clean energy sources; and the use of alternative energy sources.

City Greening: The provision for green and open space helps to reduce the impact of heat island effect, improve air quality, improve the quality of water runoff through filtration, function as natural buffers to natural hazards, and increase urban biodiversity. It also provides the opportunity to increase food security in urban areas through urban farming and simultaneously increasing public open space for recreation.

Resilient Infrastructure: A network of multifunctional natural and semi-natural areas, features, and green spaces can be considered green infrastructure. They must address issues (like drainage) that traditionally have been addressed through hard engineering solutions, and consider natural processes like sustainable drainage systems. This response may be integrated into open space networks including walkways and bikeways. Resilient infrastructure refers to the ability of infrastructure to withstand extreme weather events or natural disasters and the impact of climate change.

Waste Management: Cities with efficient waste management systems including segregation, collection, transportation, disposal, storage and treatment of waste generated is crucial to ensure good public health. Recycling can reuse up to 75% of household waste. Campaigns on waste-to-compost like “Compost Banao, Compost Apnao” under Swachh Bharat Mission -(Urban) encourage people to convert their kitchen waste into compost for use as fertilizer and to reduce the amount of waste going to landfill sites.

Clean Cooking: Clean cooking ensures access to affordable, reliable, sustainable, and modern energy for cooking. Clean cooking initiatives and programs by the government to promote clean fuel, biogas, improved cookstoves, LPG, piped natural gas—for meeting the demand for cooking energy in urban India need to focus on more than one cooking fuel and technology combinations that also resemble the existing cooking practices.

Civic Engagement: Civic Engagement means active engagement of the public in the process of achieving low emissions urban development. This can be facilitated by making information accessible to the public to enable citizens to operate more effectively by encouraging more citizen participation; and making the government more accountable, transparent, and effective by supporting enforcement of regulation.

Green Urban Development: Green Development is best understood within the frame of a city’s actions and how these actions contribute to a city or urban area advancing as green and sustainable; its correlation with hinterlands and wider systems; and the resultant benefits derived by both the environment and residents. Funding, governance, sectoral policies, planning and demographic distribution are the five key elements in an Urban Operation Model in India.

3.2. Sectoral Interventions in Clean Air Action Planning

Clean Air Action Planning (CAAP) requires strategic interventions and control measures for identified sources at a city level. In order to identify priority pollutants, one needs to look at those that exceed national air quality standards and those that are major health risks. WHO guidelines and future trends are other issues that can be taken into consideration while identifying which pollutants to address. Along with pollutants, dominant pollution sources, possibly identified through an emissions inventory, need to also be considered.

Once the goals and targets of CAAP are set and the priority pollutants and pollution sources identified, the first step is selecting control measures that need to be included in the CAAP for transport, industry, small-medium enterprise, open burning (of municipal solid waste and agricultural residues) and household air pollution (from cooking and heating). For each of these sectoral categories, there are recommendations on the implementation time scale from short-term (3-5 years), medium-term (6-10 years), and long-term (11-20 years).

3.3. Urban Air Data

Urbanisation has resulted in rapid population and changes in land use and transportation modes, significantly increasing energy consumption and the massive emission of air pollutants, thereby exacerbating the current state of air pollution. The main factor is the different patterns of urban planning or development, thereby influencing the dispersion and accumulation of different air pollution sources in different ventilation environments. On the other hand, urban spatial patterns and land use types can also have a relatively significant impact. Therefore, collecting and monitoring data on air pollution (by type), the location of specific air quality problems and main polluting sources, the concentration of respiratory diseases, distribution of citizens' complaints, etc are all relevant information that can be plotted. These data can provide opportunities to the concerned authorities to assess the risks and the effectiveness of pollution control measures over time, identify pollution hotspots, and take measures to protect public health. Identification of specific pollution sources through the data is crucial for targeted interventions, setting standards, and implementing measures to limit emissions. Data-driven information can also be used to educate the public about the risks of poor air quality, encourage individual actions, and make international comparisons, enabling countries to learn from each other's experiences and adopt best practices for pollution control.

3.3.1. Monitoring the Pollution

Monitoring air quality provides the necessary baseline information to identify which pollutants are of major concern and are principal sources of pollution. Continuous monitoring is necessary to clarify air quality issues in greater depth and certainty with sound methodology and documentation of the process and results. The technology chosen must be appropriate in terms of the technical capability of the users and the availability of the resources to operate and maintain the technology.

Urban Air Quality can be measured through Passive Samplers; Active Samplers; Continuous Analyzers and Remote Sensors. Many cities measure the quality of city air through monitoring stations that measure the concentration of pollutants in the air, usually including SO2, NOX, PM10 or SPM, VOCs, etc. Monitoring of PM2.5 has started since the year 2022. The measurements of these air pollutants can be done continuously or on a regular (e.g., weekly) basis. The different sampling stations can either work independently or can have direct connections to a central station. This information can be displayed in a time series, showing the change in concentration of the pollutant over time.

India's ambient air quality monitoring network presently consists of 1340 stations (Manual & CAAQMS Stations), covering 489 cities in 28 states and 7 Union Territories. The government has proposed to augment the manual monitoring stations from 818 to 1936 by FY 2025-26 to monitor ambient air quality under NAMP. The Department of Science and Technology supported a project entitled "Indigenous Photonic System for Real-Time Remote Monitoring of Air Quality" for a period of 30 months during the FY 2019-20 and the project was completed on 10th July 2022.

3.3.2. Calculating/Estimating Air Pollution

Measuring air pollution can be very expensive. Not all cities have Models and calculations that are increasingly being used in extensive monitoring networks. Mobile monitoring equipment is scarce and the capacity to appropriately analyze samples is weak as well. Computer models are a relatively fast and inexpensive way of providing air quality information and are also suitable for planning and strategy development.

3.3.3. Use of Mapping

Mapping is also a very useful tool to display information and clarify queries. Thematic maps are useful in analysing the extent of the pollution problem from each activity sector in a geospatial context. These maps use various colours, symbols, and patterns to display specific thematic information related to pollution, making it easier to understand and interpret the data and identify hotspots. Thematic maps can show the location and intensity of pollution from each activity sector by using different symbols or colours. With thematic maps, it's possible to create multiple maps over time to analyze changes in pollution patterns from each activity sector revealing trends, identifying emerging issues, and assessing the effectiveness of pollution control measures. Policymakers and environmental authorities can use these maps to make informed decisions, develop targeted strategies, and allocate resources effectively to tackle pollution problems. These maps can be used to raise public awareness about pollution issues, making complex pollution data more understandable to a broader audience. Thematic maps also enable the integration of pollution data with other relevant datasets, such as population density, land use, and natural resources allowing for a comprehensive analysis of how pollution from each activity sector may interact with other factors and impact the environment and human health.

3.3.4. Emissions Inventories

Preparing an Emission Inventory is a compilation of all air-polluting activities in an area. It has two main components: the pollutants (e.g., NOX, SO2) and the sources (e.g., industry, traffic, and domestic). It specifies the location of each source (point source or mobile source) and the time variations in the emissions. Emission inventories can be of great assistance in clarifying air quality issues because they, among other things, assist in the evaluation of emission trends, which in turn assist in formulating air quality management policies. Utilising air monitors with Internet of Things (IoT) technology, smart cities can efficiently gather and analyse localised air pollution data across their communities to make better decisions for citizens. For example, studies link traffic pollution to poor academic performance. Urban planners utilising a network of air quality monitors can obtain insights into the best placement for a new school to minimise student exposure to harmful air.

Emission Inventory Report for 34 out of 132 non-attainment cities have been prepared and concerned State Pollution Control Boards/ Pollution Control Committees (SPCBs/ PCCs) have been directed to carry out Emission Inventory Studies in all non-attainment cities. Updated conceptual guidelines and Common Methodology for these studies along with Source Apportionment Studies for Indian cities have been prepared and shared with SPCBs/ PCCs to carry out such studies.

Section 4: Regulations, Standards & Enforcements

Knowing about air pollution, what's causing it, sources and its effect on health and the ecosystem is not enough to achieve clean air. This section talks about different control strategies in India by the state when it comes to air pollution.

4.1. What are Air Quality and Emission Regulations and Standards for?

Air pollution initially was recognised more as a nuisance than as a threat to human health. The earliest sign of pollution may have taken place in Northern Europe when the Industrial Revolution introduced point sources of larger emissions and the smoke was produced by burning poor-quality coal for energy production. Some laws, as early as the 1300s, were enacted to prevent this air pollution. As the years passed, air pollution got worse, and yet it was still not widely recognised as a threat to human health. Coal burning continued in small and large sources without required abatement except making the stacks elevated. The London air pollution episode in 1952 was the worst episode which caused an estimated 4,000 deaths in five days. This incident prompted more stringent laws in England and other countries and marked the beginning of modern history of air quality management.

The delay in recognising air pollution as a health risk was partly a result of the nature of air pollution. Air pollution is usually not recognisable as is water pollution; therefore, it can be ignored as a health threat until the problem reaches crisis proportions.

4.1.1. Air Quality Regulations and Standards

Many countries have begun efforts to control air pollution with the passage of laws and regulations. The process by which air quality laws and regulations are created is subject to a country's constitutional framework. In general, a law is enforced through a set of institutions, where both the executive and legislative bodies have to approve it. Once approved, the new law is called an Act. In order to make the laws work on a day-to-day level, the legislative body authorises certain government agencies to create regulations that set specific rules about what is legal and what is not. For example, regulation might state what levels of a pollutant such as sulfur dioxide are safe. It would tell industries how much sulfur dioxide they can legally emit into the air, and what the penalty will be if they emit too much. In some cases, the penalty may be defined in the laws. Laws and/or regulations can also include provisions regarding programs to address air quality problems, enforcement authority, source operating permits, ambient air quality and emissions standards, enforcement mechanisms, and other provisions.

Air Quality Management (AQM) activities can include standard setting, ambient monitoring, developing permitting programs, enforcement activities, and establishment of economic incentives to reduce air pollution. AQM, through policy and legislation, prescribes a set of responsibilities and relationships among government agencies at the national and local levels. Without an appropriate policy and adequate legislation, it is difficult to maintain a successful AQM program.

Air quality standards are intended to provide the basis for protecting human health and the environment from the harmful effects of air pollutants. Although they are considered to be protective to human health, it does not mean that it is a green light for pollution to increase until it reaches the allowable limits. Attempts should be made to keep air pollution levels as low as practically achievable. The following are some factors to be considered while setting legally binding standards:

- Sensitive receptor – human population such as children, the elderly and disabled persons, and people with asthma, vulnerable to air pollution
- Pollutant behaviour – the reactions the pollutant undergoes, its residence time, and its ability to accumulate or decompose
- Natural levels – concentration levels and fluctuations of pollutants that occur naturally or enter the atmosphere from uncontrollable sources such as volcanoes
- Technical feasibility – the cost and availability of technology to control or avoid emissions

The setting and application of air quality standards is an example of the authorities' right and obligation to define the standards and implement them.

4.1.2. Source-Specific Emissions Standards

In order to achieve the ambient air quality standards, it is necessary to define source-specific emissions standards. These include industries, power plants, and motor vehicles. The major air-polluting industries such as smelters, cement plants, chemical manufacturing units, iron and steel, petroleum refineries, and pulp and paper mills are covered through such emissions standards.

Emissions from power plants and major industries can be measured during stack sampling or continuous emission monitoring. In stack sampling, samples are collected using probes inserted into the exhaust stack, and pollutants are collected in or on various media and sent to a laboratory for analysis or analysed on-site. Continuous emission monitoring provides a continuous record of emissions and flow rates over an extended and uninterrupted period of time. Various principles are employed to measure the concentration of pollutants in the gas stream; they are usually based on photometric measurements.

Mobile sources have been recognised as one of the most important sources in cities. Many Asian countries have adopted European emission standards for automobiles and introduced increasingly stricter standards with the lag time as European standards are being reduced.

In-use vehicle standards are used for existing vehicles in operation. Testing of compliance against these standards is performed as part of vehicle inspections and maintenance programs.

In-use standards may also be tested during on-road testing, where vehicles are stopped through random testing. In-use standards generally specify the maximum allowable concentration during the idling of CO and HC for petrol vehicles and smoke for diesel vehicles.

4.2. Need for Mainstreaming Air Quality for Effective Enforcement of Standards and Regulations

Mainstreaming air quality involves the active promotion of better air as a component while identifying, planning, designing, and implementing development strategies and policies. Mainstreaming in this context refers to addressing air quality issues strategically as a cross-cutting aspect of development and goes beyond just air pollution mitigation to a more holistic and strategic approach to achieving sustainable development. It requires considering the impact of air quality in the early stages of the decision-making process when development challenges and proposed implementation plans are being designed. Taking into consideration air quality as an integral part of development planning- especially in the context of our cities can play a major part in achieving broader development objectives. It can also define how initiatives outside the conventional environment sector can be designed to support environmentally sustainable development.

Mainstreaming air quality identifies interventions that create long-term economic development benefits and take better air quality into account. While the benefits of mainstreaming air quality exist, some basic considerations need to be understood for its practical and effective application. Attention to a problem such as air pollution is typically understood in the development community as an exercise in recognising and mitigating adverse environmental impacts of projects. This traditional understanding is the result of the emphasis placed on the implementation of policies designed to reduce adverse environmental impacts by development agencies. The protectionist approach focuses on compliance with certain procedural standards. However, we must go beyond this traditional approach from a conservation perspective and think about benefits. Instead of emphasising cleaning up of air, we must therefore talk about clean approaches that take externalities into account and highlight economic benefits. Mainstreaming requires a focus on proactive investment in policies and projects promoting air integration into development strategies. To reduce air pollution in India, it requires the mainstreaming of air pollution into the national dialogue. Mainstreaming is best approached by asking the right questions, involving stakeholders, and creating consultative decision-making that promotes innovative strategies and is inclusive.

4.3. Local and National Regulations and Standards in Comparison With International Perspectives

Many Asian countries have set air quality regulations and standards to achieve cleaner air. Types of air quality regulations generally range from command- and-control to self-imposition of regulations.

There are five types of regulations, each having its advantages and disadvantages. These regulations include: Command and control, Economic instruments, Co-regulations and voluntary initiatives, Self-regulation, and Education and information.

Types of Environment Regulations	Description	Example
Command and Control	Issues of licenses, setting standards, checking for compliance with standards, sanctions for non-compliance	➢ Air pollution control regulations ➢ Government Monitoring ➢ Emission Standards ➢ Enforcement Policies
Economic Instruments	Use of pricing, subsidies, taxes and charges to alter production and consumption patterns	➢ Load- based emission charges ➢ Tradable emission permits ➢ Differential Taxes ➢ True Cost pricing of the resources
Co-regulations and Voluntary Regulations	Adoption of rules, regulations and guidelines, negotiated within prescribed boundaries. Voluntary adoption of rules and guidelines and environmental management measures between individual organisations and regulators	➢ National registers of pollution emission inventory ➢ Environmental Management systems
Self-regulation	Self imposition of rules, guidelines and environmental audits by industry groups	➢ Industry code of practice ➢ Self- Audit within industry groups ➢ Emission reduction Targets
Education and information	Education and Training; community's right to know; Corporate reporting programmes	➢ Education, training and information programmes ➢ Pollution Inventories Corporate Sustainability Reports

4.4. Government Efforts for Air Pollution Mitigation

After the 1972 Stockholm Conference on the Human Environment, it became clear that the nation needed a uniform environmental law. As a result, the Government of India enacted the Air (Prevention and Control of Pollution) Act 1981 to arrest the deterioration in air quality. The act prescribes various functions for the Central Pollution Control Board (CPCB) at the apex level and State Pollution Control Boards at the state level and Pollution Control Committees for the Union Territories.

Year	Government Efforts to Mitigate Air Pollution
1974	Establishment of the Central Pollution Control Board
1981	The Government of India enacted the Air (Prevention and Control of Pollution) Act to prevent and control air pollution in India.
1982	The Air (Prevention and Control of Pollution) Rules defined the procedures of the meetings of the Boards and the powers entrusted to them. The Atomic Energy Act deals with radioactive waste. NAAQS set by the CPCB are essential for the development of effective management of ambient air quality.
1984-1985	The CPCB initiated the National Ambient Air Quality Monitoring Network to assess the present and anticipated air pollution impacts through air quality survey/ monitoring programmes. Over the years, the number of stations have increased, and the programme was renamed NAMP.
1986	The Environment (Protection) Act, provisioned by the CPCB further emphasized the need to reduce air pollutant emissions.
1988	The Motor Vehicles Act was enacted with road safety standards and pollution control measures, among others.
1997	MoEFCC establishes action plan for Delhi’s pollution

1998	The Ministry of Environment and Forests established the Pollution (Prevention and Control) Authority (EPCA) for the NCR of Delhi to control and tackle environmental pollution in the NCR.
2000	The government introduced the Bharat Stage Emission Standards (BSES)- emission standards instituted to regulate the output of air pollutants from internal combustion engines and spark-ignition engines.
2009	Comprehensive Environmental Pollution index introduced for the assessment of industrial clusters. NAAQS standards revised and PM2.5 added
2010	Bharat stage III norms have been enforced across the country. In 13 major cities, Bharat Stage IV emissions have been in place and are enforced for the whole country since April 2017. In 2016, the Indian Government announced that the country would skip the BS-V norms and adopt BS-VI norms by April 2020.
2014	AQI methodology adopted
2016	The GoI published Construction and Demolition Waste Management Rules to tackle the issues of pollution and waste management. Graded Response Action Plan (GRAP) was established to address air pollution emergencies in Delhi-NCR. PM2.5 is included in all manual stations under the National Air Quality Monitoring Programme (NAMP).
2018	MoEFCC issued a Dust Mitigation notification making mandatory dust mitigation measures in infrastructure projects and demolition activities in the country.
2019	The National Green Tribunal directed SPCBs to install air quality monitoring stations and to report to the CPCB on the installation of the stations by 1st April 2020. National Clean Air Program (NCAP) final proposal released with an initial budget of Rs. 300 crores. 3 membered central committee examined and approved Clean Air Action Plan. 102 NAC were announced. 20 new NAC added
2020	The Commission for Air Quality Management was established as a statutory body by the government in August 2021 as an overarching body to carry out air quality management in Delhi NCR.

Table: Timeline of Government Efforts for Air Pollution Mitigation

4.4.1. National Air Quality Monitoring Programme (NAMP)

NAMP is a nationwide program to monitor ambient air quality through four air pollutants viz., Sulphur Dioxide, Oxides of Nitrogen, Respirable Suspended Particulate Matter (RSPM / PM10), and Fine Particulate Matter (PM2.5). The monitoring of meteorological parameters such as wind speed and wind direction, relative humidity, and temperature are also integrated with the monitoring of air quality. The network consists of 793 operating stations covering 344 cities/ towns in 29 states and 6 Union Territories of the country. The monitoring is being carried out with the help of CPCBs (coordinator & financial and technical facilitator), SPCBs, PCCs; National Environmental Engineering Research Institute (NEERI), Nagpur.

Objectives:

- Determine status and trends of ambient air quality;
- To ascertain whether the prescribed ambient air quality standards are violated;
- To Identify Non-attainment Cities;
- To obtain the knowledge and understanding necessary for developing preventive and corrective measures

Targets:

- To increase the number of Monitoring stations across India;
- The network already consists of 804 operating stations in 344 cities/towns in 28 states and 6 Union Territories of the control

4.4.2. National Action Plan on Climate Change (NAPCC)

Launched in 2008, NAPCC included eight core “national missions” which represent a multi-pronged, long-term, and integrated approach for achieving key goals in the context of climate change. These include the National Solar Mission; National Mission for Enhanced Energy Efficiency; National Mission on Sustainable Habitat; National Water Mission; National Mission for Sustaining the Himalayan Ecosystem; National Mission for a Green India; National Mission for Sustainable Agriculture and National Mission on Strategic Knowledge for Climate Change.

Objectives:

- Protecting the poor through an inclusive and sustainable development strategy, sensitive to climate change
- Achieving national growth and poverty alleviation objectives while ensuring ecological sustainability
- Efficient and cost-effective strategies for end-use demand-side management
- Extensive and accelerated deployment of appropriate technologies for adaptation and mitigation
- New and innovative market, regulatory, and voluntary mechanisms for sustainable development
- Effective implementation through unique linkages – with civil society, LGUs, and public-private partnerships

4.4.3. National Ambient Air Quality Standard (NAAQS)

NAAQS are set taking into consideration geographical conditions, pollutant background concentrations, available air pollution control technologies and the cost of treatment, international standards (WHO, USEPA, EU, and Chinese), and the sensitivity/tolerance of the receptor. The SPCBs/PCCs can set more stringent standards than the existing national standards in their respective states but do not have the power to relax these standards. According to the rules of the CPCB, NAAQS should be met for at least 98% of the days in a year. They may exceed the limit only for 2% of the time, but not on two consecutive days of monitoring.

Objectives:

- Determine if air quality is meeting national standards
- Determine the highest pollutant concentrations
- Understand how pollutants behave and their relationship with the weather.
- Validate pollution modeling, used to test 'what if' scenarios. Forecast air quality
- Evaluate the effectiveness of air pollution control programs
- Evaluate the effects of air pollution on public health
- Track the progress of plans for meeting air quality standards
- Determine air quality trends
- Develop responsible and cost-effective pollution control strategies and policy decisions

4.4.4. National Clean Air Programme (NCAP)

On 10th of January 2019, the Ministry of Environment, Forest and Climate Change launched a five-year national clean air programme. 132 urban local bodies have been identified as non-attainment cities as they were not meeting the annual average ambient air quality standards for PM10. NCAP has set a tentative national level target of 20-30% reduction of PM concentrations by 2024 later changed to 30%-40% reduction by 2026. NCAP's approach includes collaborative, multi-scale, and cross-sectoral coordination between the relevant central ministries, state governments, and local bodies. This includes coordination with existing policies and programmes. Development of Source Apportionment Studies, city-specific plans, and Emission Inventories are part and parcel of the program.

Objectives:

- To ensure stringent implementation of mitigation measures for prevention, control, and abatement of air pollution.
- To augment and evolve an effective and proficient ambient air quality monitoring network across the country to ensure a comprehensive and reliable database.
- To augment public awareness and capacity-building measures encompassing data dissemination and public outreach programmes for inclusive public participation and for ensuring trained manpower and infrastructure on air pollution.

Target:

Reductions up to 40% or achievement of National Ambient Air Quality Standards for Particulate Matter 10 (PM 10) concentrations by 2025-26

4.4.5. Commission for Air Quality Management (CAQM)

The Commission for Air Quality Management was promulgated on April 13, 2021 for air quality management in Delhi and adjoining areas (Haryana, Punjab, Rajasthan, and Uttar Pradesh) and is responsible for training and creating a special workforce to deal with issues related to air pollution along with preparing various action plans. The Commission holds powers to issue directions and entertain complaints as it deems necessary for protecting and improving the quality of air in the region. It can lay down parameters for control of air pollution and is in charge of identifying violators and monitoring industries and other polluting units in the region. It can also overrule directives issued by the state governments in the region.

Objective: To better facilitate coordination, research, identification, and resolution of problems surrounding the air quality in the National Capital Region and Adjoining Areas

Target: To improve the overall air quality of the National Capital Region and Adjoining Areas

4.4.6. Sustainable Alternative Towards Affordable Transportation (SATAT)

The SATAT scheme on Compressed BioGas (CBG) was launched on October 1, 2018. The scheme envisages to target production of 15 million tons of CBG by 2023, from 5000 Plants. The initiative aims to produce CBG from Waste and Bio-mass sources like agricultural residue, cattle dung, sugarcane press mud, Municipal Solid Waste and sewage treatment plant waste.

Objective: To produce compressed biogas (CBG) from Waste and Biomass sources like agricultural residue, cattle dung, sugarcane press mud, Municipal Solid Waste (MSW) and sewage treatment plant waste.

Targets:

- 5000 Compressed Biogas (CBG) plants,
- Production of 15 Million Metric Ton (MMT) per annum of CBG
- Production of 50 MMT of bio manure by 2023-24

4.4.7. Bharat Stage Emission Standards

BS Emission Standards are government-instituted emission standards that all motor vehicles have to comply with if they are to be sold and driven in India. It is regulated by the Government of India to control the output of pollutants expelled by Internal Combustion Engine vehicles into the air. These emission norms are based on the Euro standard emission norms and are updated regularly to make vehicles more environmentally friendly and greener. The current emission norm in India is BS-VI which came into play across the country on April 1 2020, based on the Euro 6 vehicle emission standards. The standards dictate the amount of gases a vehicle is allowed to emit.

Objective: To regulate tailpipe emissions of air pollutants including particulate matter, SOx and NOx as well as carbon monoxide, hydrocarbons and methane. They have been developed for all vehicle categories and apply to vehicles manufactured since April 2020.

4.4.8. Continuous Emission Monitoring System (CEMS)

It is a real-time air and water pollution monitoring system, consisting of sampling, conditioning, and analytical components and software that is designed to provide direct, real-time, continuous measurements of pollution by analysing representative samples of air and water. The system ensures data accuracy, higher monitoring frequency, minimal manual intervention, firm regulatory monitoring and better transparency to strengthen the pollution control regime.

Objective: To regulate tailpipe emissions of air pollutants including particulate matter, SOx and NOx as well as carbon monoxide, hydrocarbons and methane. They have been developed for all vehicle categories and apply to vehicles manufactured since April 2020.

Section 5: Departmental Roles & Responsibilities

A: Pollution Control Board

I: Collection and Monitoring of Air Quality Data

1. Find a suitable location and install functional and manual CAAQMS in accordance to the CPCB Guidelines
2. Monitor installation and functioning of PCTs in industries at regular intervals
3. Monitor installation and functioning of PCTs at construction and demolition sites

II: Sensitisation of the Masses

1. Regular data collection on air quality and display of particulate matter levels at major locations for public display of AQI information in accordance to the institutional, infrastructural and other requirements
2. Inform the health adversities and precautionary measures to be taken during different AQI
3. Organise campaigns for industries to sensitise them on the benefits of clean technologies
4. Run campaigns, both online and offline, for local issues concerning Air pollution in the industrial sector, C&D activities, waste management mechanism, automobile industry, households, etc.
5. Promote a Healthy Air Zone
6. Encourage citizens' participation to hold the government accountable for the expected actions and bring a behavioral change among locals to curb air pollution
7. Increased use of multimedia and social media in order to educate the maximum number of people about the daily AQI, air quality legislations and regulations, air pollutant-specific health adversities, possible measures at all levels, etc.

III: Grievance Redressal

1. Regular and full response to the grievances received against polluting sources
2. Keep records of the complaints received and actions taken

IV: Record Keeping

1. Prepare a directory of producers of PCTs for polluting industries
2. Prepare Annual Report on activities undertaken to curb dust and air pollution
3. Inventories occupiers and data on all kinds of waste generation, treatment, and disposal

V: Audits & Inquiries

1. Environmental Audit of Common/ Captive Treatment, Storage, and Disposal Facilities and examine the closure audit report
2. Inquire the status and progress of the Source Apportionment Study
3. Conduct Feasibility study and Environmental Assessment of proposed sites for developmental projects

VI: Institutional Support, Restrictions & Fines

1. Institutional Support to Source Apportionment Study
2. Initiate and complete activities designed under the City Clean Air Action Plan according to the timelines set
3. Provide technical, knowledge, and financial assistance for clean air projects
4. Restrict sensitive projects/activities and residences in buffer zones/ environmentally sensitive zones
5. Ensure that TSDF uses tracking applications to report the quantity of waste and excess waste disposed
6. Impose a strict ban on garbage burning and promote alternatives to burning
7. Ensure that adequate types of machinery are available at SPCBs/ PCCs to ensure compliance with guidelines issued by CPCB
8. To advise the State Government on any matter concerning the prevention, control, or abatement of air pollution
9. To lay down, in consultation with the Central Board and having regard to the standards for the quality of air laid down by the Central Board, standards for the emission of air pollutants into the atmosphere from industrial plants and automobiles or for the discharge of any air pollutant into the atmosphere from any other source.
10. Improve inter-agency coordination mechanisms to support mainstreaming air quality management and integrate air quality with relevant sectors such as transportation, energy, industries, coal, agriculture, and others
11. Impose liability for harmful emissions in the environment including financial penalty for violation of guidelines

VII: Early Warning System

1. Develop an Emergency Warning & Response Mechanism with locals and knowledge and technical experts at the ward/block level
    - Alert schools of the pollution risk, alert vulnerable groups via social media during Poor or worse AQ
    - Activate the Health Alert and Response System of all relevant departments during Very Poor or worse AQ
    - Alert newspapers/TV/radio/FM Stations to advise people with respiratory and cardiac illnesses to avoid polluted areas and restrict outdoor movement during Very Poor or worse AQ

B: Municipal Board

I: Administrative Support and Actions to be Taken

1. Issue site-specific guidelines for local construction sites concerning pollution
2. Ensure adherence to CPCB Guidelines at construction sites
3. Take actions for non-adherence to CPCB Guidelines at C&D and industrial sites
   - Support the design and construction of green infrastructure and energy-efficient buildings
4. Cater to decentralized clean air projects under central and state schemes and missions

II: Dust and Waste Management

1. Allocate a specific route for adequately- covered transportation of construction material and C&D waste
2. Allow C&D activities after builders adopt dust mitigation plans (E.g., solid barriers and nets around the site boundary)
3. Designate a safe sight away from residential areas and water bodies for disposal of C&D Waste
4. Set up incinerators for solid waste treatment
5. Identify pollution hotspots
6. Plant pollution absorbents and sprinkle water regularly at the pollution hotspots
7. Strict ban on garbage burning
8. Install Bulk Waste Generators
9. Avail composting pits in residential as well as public places
10. Facilitate timely and environment-friendly storage, transportation, and disposal of animal carcasses, bio-medical waste, electronic waste, and municipal waste (E.g., covered vehicles, compulsory segregation of wastes)
11. Identify potential sites for landfills according to the guidelines issued by CPCB and ensure that the owner/ operator prepares a contingency plan for emergencies (E.g., scientific landfill closure)
12. Store flammable, ignitable, reactive, and non-compatible wastes in containers made of suitable material separately with flameproof electrical fittings and a minimum of 15 m distance between the storage sheds
13. Ensure a Buffer zone around the TSDFs
14. Facilitate 100 percent door-to-door collection of segregated waste
15. Facilitate segregated disposal of wastes in landfills
16. Facilitate regular road sweeping at least twice a day

17. Facilitate regular water sprinkling on roads and C&D sites at least twice a day
18. Provide safety kits for waste operators
19. Ensure that hazardous wastes, sand, gravel, ash, cement, radioactive wastes, smelly products and other hazardous materials are packed properly while transportation
20. Implement buy back/take back/DRS/e-waste exchange
21. Research on economically viable options for waste recycling
22. Ensure that adequate infrastructure is available for waste management

III: Monitoring

1. Monitor construction sites at a regular interval
2. Frequent monitoring of TSDFs and illegal dump sites

IV: Clean Energy and Green Infrastructure

1. Promote e-vehicles and set up charging stations
2. Create a Greening Plan
3. Plant pollution absorbing trees
4. Provide infrastructure for active transportation (cycling and walking tracks; public cycles)
5. Promote a Healthy Air Zone(s)
6. Integrate air quality targets in the overall development goals, performance indicators, and plans

V: Capacity Building

1. Conduct training sessions and capacity-building programs on air pollution in urban as well as rural areas
2. Conduct training and capacity-building programs for waste operators

C: Department of Transport

1. Set up 'Auto Emission Testing Stations' in the ULBs
2. Collect tax differentials favoring abatement technology and vehicle taxes for emission levels
3. Differentiated fuel pricing favoring cleaner fuels
4. Issue necessary 'Pollution Under Control' certificate according to guidelines issued
5. Strengthen inspection of phase-out vehicles
6. Prepare an action plan to check fuel adulteration and random checks at petrol stations
7. Provide fiscal incentives for scrapping old vehicles, carpool programs
8. Support fleet modernization and retrofit to reduce tailpipe emissions
9. Conduct programs to promote EVs and public transportation
10. Ensure maintenance of the public transport system
11. Ensure recycling of EVs and waste oils at registered recycling or refining unit
12. Advocate for renewable energy-induced charging infrastructure for EVs
13. Ensure that high-traffic zones and timings are well broadcasted among the public with proper traffic signs displayed at traffic zones
14. Promote active transportation (i.e., cycling, walking)
15. Strict vigilance and no tolerance for visible emissions and stop plying of visibly polluting vehicles by impounding or heavy fines during Very Poor or worse AQ
16. Increase parking fee by 3-4 times and ensure higher frequency of public buses during Severe AQ

D: Department of Power & New and Renewable Energy

1. 24*7 electricity supply to 100 percent households
2. Electricity supply to all public institutions during the time of functioning
3. Cater to clean energy projects (Eg. PM KUSUM; PMUY; Solar Parks Scheme; Green Energy Corridor; Floating Solar Power Plant; Rooftop Solar Project; Off-grid Solar Photo-Voltaic System; Unnat Chulha Abhiyan; Wind Monitoring Stations; etc.)

E: Department of Health

1. Capacity Building for physicians and ASHA workers for proper information dissemination among the public
2. Conduct training programs for staff at hospitals and laboratories on bio-medical waste management
3. Introduce a platform to inform the public about deal health precautions during different levels of air pollution
4. Instruct hospitals to collect patient information taking air pollution as a socio-economic risk factor
5. Ensure record keeping of patients admitted for respiratory and cardiopulmonary diseases
6. Conduct air-pollution-related IEC activities at regular intervals
7. Ensure segregated collection, disposal, and treatment of bio-medical waste
8. Provide safety kits for waste operators
9. Inform hospitals to prepare for higher cases of respiratory illness when the AQI is poor or worse

F: Department of Agriculture

1. Issue a complete ban on burning agricultural residues
2. Promote 'slash and char' and other alternatives to burning
3. Sensitize and avail clean energy technology to farmers

G: Department of Public Works

1. Ensure 100 percent paved roads
2. Ensure regular repair and maintenance of potholes
3. Support the design and construction of energy-efficient buildings

H: Department of Environment & Forest

1. Support government, NGOs, CSOs, and educational institutions in undertaking eco-friendly activities
2. Provide pollution absorbents for plantation drives
3. Conduct plantation activities in the pollution hotspots and in public spaces
4. Ensure that accidental forest fires do not take place
5. Ensure quick response in case of accidental forest fires

I: Department of Industries & Commerce/ Industries Associations

1. Conduct sensitisation program for industry-owners on the accessibility and advantages of PCTs
2. Prepare an Action Plan to implement best available clean technology
3. Provide licenses for specified polluting processes
4. Ensure strict compliance of industries to the guidelines issued by CPCB on the installation and maintenance of PCTs, DG sets etc.
5. Conduct regulation and monitoring exercises of industrial emissions at regular intervals
6. Assist industry-owners in investment opportunities for decarbonisation efforts
7. Ensure local recycling mechanism in all industries
8. Ensure AQ monitors in industrial areas
9. Ensure CEMS devices with >85% data availability in major industries
10. Instruct industries to identify materials generated from industrial processes as wastes or by-products
11. Facilitate programs to identify and support entrepreneurships for abatement of air pollution
12. Promote land use planning and zoning to establish industrial clusters and restrict the location of new industries
13. Compulsory environmental impact assessment for specified new major industries to assess their potential for Air pollution and to recommend improvement in location, processes, fuels, industry technology and emission limits
14. Relocation of existing industries emitting harmful pollutants away from residential and other sensitive land uses

J: Department of Science & Technology

1. Cater to clean air projects (Eg. Floating Solar Power Plants; Unnat Chulha Abhiyan; Wind Resource Assessment; Suryamitra Skill Development Program; Rooftop Solar Project; Off-grid Solar Photo-Voltaic System; Research and Development Program; etc.)
2. Design innovative technology for abatement of air pollution

K: Panchayati Raj Institutions

1. Conduct sensitization programs on air pollution and benefitting schemes in rural areas
2. Conduct training sessions and capacity-building programs for rural youth on green jobs
3. Assist the rural population in availing of renewable energy projects

L: Office of the District Commissioner

1. Support Clean Air Action Plan, Action Plan for the Abatement of Air Pollution in Non-Attainment Cities
2. Avail policies and programs designed to mitigate air pollution of all kinds at all levels to all beneficiaries
3. Conduct audits for actions according to the plans and policies launched to curb air pollution
4. Integrate air quality goals and considerations in the overall development goals, performance indicators, and plans

Section 6: Air Quality Management

Better air quality can only be achieved if all stakeholders are committed to reducing polluting air emissions. Raising awareness is, therefore, a key factor in air quality management as different stakeholder groups (e.g. citizens, medical professionals, industries and policymakers, etc.) can be both victims of air pollution and contributors to the problem. Local government's management of the main sources of polluting emissions (e.g. industry, business, and domestic, transport sectors), together with its role in urban planning, contribute to the state of regional and local air quality. The adoption of air pollution prevention and control measures will only be effective if the relevance and impact can be conveyed to those empowered to take action, and to those interested parties likely to be affected by the intervention.

6.1. Air Quality Management Framework

Air quality management (AQM) is the strategic framework within which air pollution can be addressed and air quality can be improved. It aims to maintain the quality of the air that protects human health and welfare but also provides protection to animals, plants (crops, forests, and natural vegetation), ecosystems, materials, and aesthetics, such as natural levels of visibility. Governmental authorities in collaboration with other stakeholders can determine the individual steps of the implementation of this process according to (a) Local circumstances with respect to background concentrations of air pollutants and technological feasibility (b) Cultural and social conditions; and (c) Financial and human resources available

AQM enables government authorities, in collaboration with other stakeholders, to:

- Identify all major sources of air pollution caused due to human activities
- Facilitate the monitoring of air quality and its effects on human health and the environment
- Set appropriate objectives and targets for human and environmental health
- Set priorities for achieving objectives and target
- Identify and establish appropriate policies, laws, and regulations on air quality with climate co-benefits
- Establish an institutional structure and programme to implement policies and achieve objectives and targets
- Ensure compliance with emission and air quality standards
- Generate content for AQ communication

6.2. Air Pollution Control Measures for Better Air Quality

A city-specific Clean Air Action Plan (CAAP) enables the government as well as the wider stakeholder groups to recognise the vision and goals for air quality improvement, set objectives, mobilise resources and collaborate effectively and efficiently to achieve improved air quality. Under India's NCAP, 122 non-attainment cities are required to prepare city air action plans along with Graded Rapid Action Plans. The key features of a city CAAP plan may include:

- Measures to set-up or strengthen the air quality monitoring and analysis system
- Measures to communicate air quality status to the public, vulnerable groups, and relevant stakeholders for reducing exposure
- Adoption and implementation of control measures
- Instruments and strategies to comply with air quality and emission standards and fixing the time-bound accountability of all responsible agencies/ stakeholders.
- Regular review of the progress of the action plan at the level of the Chief Secretary of the state.
- Continuous improvement after compliance, including through public reporting
- A city CAAP is also a collection of regulations, policies and programmes for cleaner air

Pollutant	Prevention and Control
Ozone (O3)	Reduce motor vehicle Reactive Organic Gas (ROG) and Nitrogen Oxides (NOX) emissions through emission standards, reformulated fuels, inspection program, and reduce vehicle use. Limit ROG emissions from commercial operations and consumer products. Limit ROG and NOX emissions from industrial sources such as power plants and refineries. Conserve energy.
Respirable Particulate Matter(PM10)	Control dust sources, industrial particulate emissions, wood-burning stoves, and fireplaces. Reduce secondary pollutants which react to form PM10, conserve energy.
Fine Particulate Matter (PM2.5) & Visibility Reducing Particle	Reduce combustion emissions from motor vehicles, equipment, industries and agricultural and residential burning. Precursor control, like those from O3, reduce fine particle formation in the atmosphere
Carbon Monoxide(CO)	Control motor vehicle and industrial emissions. Use oxygenated gasoline during winter months. Conserve energy.
Nitrogen Dioxide(NO2)	Control motor vehicle and industrial combustion emission. Conserve energy
Lead	Control metal smelters. No lead in gasoline, replace lead paint with non lead substitutes
Hydrocarbons (HC)	Inspection and maintenance of motor vehicles, emission control, and conserving energy sources.
Sulphur Dioxide(SO2) & Sulphate	Reduction of high sulphur fuels (e.g., use low sulphur reformulated diesel or natural gas). Conserve energy
Hydrogen Sulphide	Control emission from geothermal power plants, petroleum production and refining, sewage treatment plants.

Table: Major Air Pollutants Management

Several types of measures for improving air quality can be broadly identified and categorised. These include:

- Conservation: reducing the use of resources through energy conservation
- Efficiency: carrying out activities in a more efficient manner, thus reducing resource use and emissions of air pollutants
- Abatement: the application of a technological approach to reducing emissions
- Fuel Switching: substituting a lower emission fuel in place of a higher emission fuel
- Demand Management: implementation of policies or measures that serve to control or influence the demand for a product or service
- Behavioural Change: changing the habits of individuals or organisations in such a way as to reduce emissions e.g. traveling by public transportation instead of privately owned vehicles.

These measures can be brought about in many different ways including through legislation, economic instruments, voluntary agreements, and ongoing technological change. In specific terms, measures to reduce air pollution from mobile and stationary sources i.e. transport sector, industries, construction and demolition, etc. can be summarised as follows.

6.2.1. Construction and Demolition

Road dust and dust arising from construction and demolition are the major contributors to air pollution in Indian cities. Dust is all airborne PM that is suspended in the air or has settled out onto a surface after having been suspended in the air. Three types of construction and demolition dust exist. They are silica dust (created when working on silica-containing materials such as concrete, mortar, and sandstone), wood dust (created when working on softwood, hardwood, and wood-based products such as MDF and plywood), and general dust (created when working on other materials containing very little or no silica such as gypsum (e.g. in plasterboard), limestone, marble, and dolomite). Construction works such as drilling and grinding undertaken in excavation, installation, and demolition also emit an enormous quantity of particles into the air.

Measures to control dust pollution from construction sites include:

- Locating machinery and dust-causing activities should be located away from sensitive receptors
- Covering lorries that leave the site carrying waste
- Not burning waste material
- Using dust bags, spraying water, or, when using disk cutters, making the working area wet before using the machinery
- Revegetation programs
- Using water sprays or sprinklers to keep reduced dust during activities such as filling skips, breaking concrete, and managing stockpiles
- Cleaning and repairing the road and footpath near the site entrance when needed
- Erecting solid barriers around the site boundary
- Washing the wheels of vehicles leaving the site, if they are carrying mud or waste

6.2.2. Transport

Transport accounts for approximately 4% of PM emissions with emissions concentrated in urban centers that have important health and environmental effects, especially road transport. India is one of the largest markets in the world for vehicle sales by volume. Therefore, reducing emissions from road transport is a key part of local AQM. Several measures can be adopted that address not only vehicle pollution control but demand management. Emissions from motor vehicles are determined by vehicle technology, fuel type and quality, land use, and use of vehicles. Hence, controlling emissions involves addressing each one of the following measures:

- Improved emissions standards for conventional emissions (CO, HC, NO2, PM) and for toxic air pollutants
- Improved and clean technologies
- Improved transport planning, parking control measures, and traffic demand management to increase the share of optimal anti-congestion measures, combine with measures controlling kilometers traveled by vehicles
- Shift to electric vehicles, public transport, promotion of non-motorised/ active transport (i.e., cycling, walking)
- Fuel quality standards for gasoline (lead, volatility, benzene, aromatics)
- Differentiated fuel pricing favoring cleaner fuels
- Fiscal incentives for scrapping old vehicles
- Maximum power/ weight ratios
- Car use restrictions

- Privileges (e.g. restricted highway lanes) for high occupancy vehicles
- Limitations and restrictions on freight transport
- Parking charges
- Insurance adjustment for distance
- Strengthen inspection of phase-out old vehicles, vehicle maintenance and certification
- Support fleet modernisation and retrofit to reduce tailpipe emissions
- Set up mass rapid transit systems, improve infrastructure for walking and cycling, and establish measures for restricting or reducing the growth of motorised trips by congestion charging and parking restraints
- Improved inspection and maintenance, anti-tampering, and enforcement programs
- Certification and assembly line testing
- R&D incentives (direct funding, tax credits, emissions test exemptions); Individual ownership limitations; Pedestrian-only zones in cities
- Fuel quality standards for diesel fuel (volatility, sulphur, aromatics, cetane number, PAH)
- Tax differentials favoring abatement technology (Eg., Vehicle and Fuel taxes for emissions levels)
- Limitations on fuel additives
- Fuel efficiency for vehicle fleets
- Diesel smoke control programs
- ”Park and ride” programs
- Land-use and physical planning instruments to reduce commute travel and redistribute urban activities
- Road pricing or distance charges
- Fiscal incentives for carpool programs
- Redistribute mechanisms for financing more efficient transport modes
- Prepare an action plan to check fuel adulteration and random checks at petrol stations
- Reduce emissions by congestion management
- Develop e-mobility action plans at the city level, including charging infrastructure and conversion of public buses, two wheelers to electric mode and/or CNG plan and conversion to CNG

6.2.3. Open Waste Burner

The CPCB defines open burning as the burning of any matter in such a manner that products of combustion resulting from burning are emitted directly into the ambient air without passing through an adequate stack, duct, or chimney. Open burning of municipal solid waste (MSW) on streets and landfills is a major concern in India. The materials openly burned include wood, biomass, forest waste, agricultural waste, and MSW. It serves as a non-point source of various pollutants such as PM, CO, NO2, SO2, dioxin/furans, HC, benzene, ethyl benzene, toluene, and 1-hexene. These emissions are associated with short-term (aggravation of asthma, shortness of breath, chest pains) and long-term (circulatory, respiratory, and pulmonary diseases) health risks. Controlling emissions from openly burning municipal, C&D, household, agriculture, and biomedical waste involves addressing the following measures:

- Strict enforcement of bans on burning of materials or waste by imposing fines
- Proper segregation of waste at source and maintain segregated disposal at the dumping ground or landfill
- Avail composting pits in residential as well as public places
- Identify potential sites for landfills according to the guidelines issued by CPCB and ensure that the owner/ operator prepares a contingency plan for emergencies- Scientific landfill closure)
- Implement buy-back/take-back/DRS/e-waste exchange
- Promotion of alternatives to burning- Incinerator, Recycling, Bulk Waste Generator
- Facilitate timely and environment-friendly transportation of waste in covered vehicles;
- Ensure a buffer zone around the disposal and treatment facilities
- Frequent monitoring of TSDFs and illegal dump sites
- Store flammable, ignitable, reactive, and non-compatible wastes in containers made of suitable material separately with flameproof electrical fittings and a minimum of 15m distance between the storage sheds.

6.2.4. Industry

Industries are growing at common centres/estates/parks to form industrial clusters such as medium- and small-scale industries. These industrial clusters are a major hub of pollution in India, indicating the lack of awareness and enforcement issues. The Indian government has developed a total of 63 industry-specific emission standards. Ten emission standards (diesel and LPG/CNG gensets; petrol and LPG/CNG gensets; dedicated LPG/CNG gensets; industrial boiler; SO2 and NOX standards for glass, lime kiln, reheating furnaces, foundry, ceramic industry, and airport noise) have been developed and six emission standards (thermal power plant, sugar, man-made fibers, fertiliSer, cement, and brick kiln) have been revised. The main strategies for addressing industrial pollution are the promotion of cleaner production and emissions reduction by industry, and land use planning and zoning:

1. Land Use Planning and Zoning

- Use of planning regulations to restrict the location of new industries and to establish suitable industrial areas/zones
- Compulsory environmental impact assessment for specified new major industries to assess their potential for air pollution and to recommend improvement in location, processes, fuels, industry technology, and emission limits
- Relocation of existing industries away from residential and other sensitive land uses

2. Promotion of Cleaner Production

- Increase the efficiency of industrial processes
- Use of improved quality fuels or switch to cleaner fuels
- Energy and materials saving
- Adoption of new technologies

3. Reduction of Emissions in Industry

- Setting priorities by focusing on emissions from the major emission sources
- Requirements for the use of cleaner fuels
- The industry must provide an action plan to implement the best available technology
- Licensing of specified polluting processes
- Requiring the use of the best available technology for specific industrial processes
- Compulsory notification of accidents
- Compulsory emission standards for different types of industries. An enforcement strategy should be addressed
- Setting strict fines for exceeding emission standards

6.2.5. Household

Exposure to household air pollution from the combustion of solid fuels for daily cooking and heating is a risk to human health. A large proportion of the world's low-income households still cook with solid fuels that are a low-cost and easily available alternative cooking fuel for many and the adoption and use of clean cooking technologies, particularly clean fuels, remains low. Clean cooking fuels such as gas and electricity can reduce household air pollution exposure in households that depend on solid fuel combustion to meet daily energy needs. India has made an ambitious effort for a large-scale transition from solid fuel combustion to clean cooking fuels. The widespread adoption of clean cooking fuels is a necessary step towards reducing household air pollution and improving population health. Several measures can be taken to reduce household air pollution. These include:

- Public awareness
- Modification of the design of the cooking stove
- Change in pattern of fuel use

6.3. Co-benefits of Air pollution Control and Climate Change Mitigation

Measures to control air pollution tend to be immediate, more certain, and occur at the place where the control measure is taken (at a local or regional scale). In contrast, the impact of control measures on climate change is long-term and global. Looking at air quality and climate change from an integrated perspective and addressing these issues simultaneously offers the potential for large cost reductions in health and risks to ecosystems.

Controlling air pollution and greenhouse gasses in an integrated way will be more effective than targeting each one individually, particularly for developing countries where economic and social development is a higher priority rather than climate change mitigation. Co-benefits also mean joint strategies that maximize synergies.

The following table presents measures that are likely to lead to reductions in emissions of both air pollutants and GHGs.

Measure	Effect
Switching from coal to natural gas for power generation	Reduces CO2 emissions for each kilowatt generated and emissions of SO2 and NOX.
Efficiency improvements in domestic appliances and industrial processes	Reduces emissions of both types of pollutants, but efficiency measures sometimes result in increased demand, which must be avoided.
Energy conservation (use less energy)	Reduce emissions of both types of pollutants.
Use of new technologies in road transport. Eg. Hybrid vehicles; Hydrogen from natural gas or from renewable energy sources; Lean burn petrol vehicles fitted with nitrogen oxide traps	Reduces CO2 emissions for each kilometer traveled and also emissions of NOX and particulate matter. It is essential that the whole fuel/ vehicle cycle is analysed (e.g. the emissions associated with hydrogen generation)
Demand management/ behavioural change: improved public transport coupled with disincentives for private car usage	Reduces emissions of both types of pollutant.

Table: Examples of Measures to Reduce Emissions of Air Pollutants and GHGs

Section 7: Case Studies

Case 1: Schools for Clean Air and Youth for Clean Air Network (YCAN)

In 2019, Clean Air Asia in collaboration with the technology company, Phoenix Robotix, monitored air quality data in schools in Delhi, Nagpur, and Bhubaneswar. The main focus of the project was to improve awareness about the 'health impacts of air pollution on school-going children'. Deployed sensors to measure ambient air concentrations of particulate matter and generated an 'Air Quality Index'. The study provided real-time data from monitoring stations and an air quality index that flashes every few seconds. It provided advisories for children based on the category of AQI.

Clean Air Asia also initiated YCAN which is a group of young enthusiastic individuals, working to achieve solutions for better air quality in Indian cities. Members come from different academic backgrounds but they are all passionate about air quality issues and believe in finding a solution through different and unique perspectives. YCAN projects focus on diverse ways of bringing air quality to the mainstream. The YCAN is currently active in Delhi/NCR, Gandhinagar and Bhubaneswar, and is expected to expand to 10 more cities.

Case 2: Non-motorised Transport (NMT) in Chennai

In 2014, the municipal government of Chennai, now known as the Greater Chennai Corporation, adopted an NMT policy to prioritise walking and cycling and discourage the use of personal motor vehicles, and create a safe and pleasant network of footpaths, cycle tracks, greenways, and other NMT facilities. The Chennai NMT policy requires that at least 60% of the city's transport budget be allocated to constructing and maintaining infrastructure for NMT. This includes wider footpaths, safe bicycle infrastructure, better-designed intersections, and street furniture.

Since 2014, the city in collaboration with the Institute for Transport and Development Policy (ITDP) has inaugurated the Pondy Bazaar Pedestrian Plaza as a model 'people-friendly' public space; built the capacity of municipal engineers through study tours, workshops, and formal training programmes; launched a city-wide Public Bicycle Sharing system and a progressive on-street parking management system; adopted the Complete Street Guidelines to inform all future street design projects; launched a Car-free Sunday programme to promote the idea of celebrating streets as public spaces; and engaged the public for a participatory planning process through several tactical urbanism initiatives and stakeholder consultations.

Case 3: Electric Tuk Tuks in Jabalpur

Jabalpur is committed to encouraging the country's economic development and providing affordable access to the citizens reducing carbon emissions. Jabalpur started the adoption of zero-emission E tuk-tuks and a network of solar-powered charging stations has been established. As a pilot project in Jabalpur, local authorities plan to set up nine solar-powered charging stations to be used by 400 E tuk-tuks owners in the city. The charging stations can generate 50 kilowatts of electricity and can serve four E-tuk-tuks simultaneously, enabling the E-tuk-tuks to travel 100 to 150 kilometers. The solar panels in the station are also connected to the state grid to feed in additional power generated through net metering.

Case 4: Ahmedabad Heat Action Plan

Ahmedabad's Heat Action Plan is a comprehensive early warning system and preparedness plan to spread awareness amongst the public about how they can take immediate and long-term actions as precautionary measures against the extreme heat of Ahmedabad. The objectives include increased preparedness, information-sharing, and response coordination. The communication is done by making use of numerous media channels, for example, the distribution of informational materials such as pamphlets, print advertisements as well as television commercials addressing heat stress prevention, and the use of social media. Online platforms like Facebook, Instagram, and Twitter were used, in addition to traditional media such as television and radio to reach people with information about risk prevention from extreme heat. Special efforts are made to reach vulnerable people through interpersonal communication as well as other outreach methods. The Ahmedabad Municipal Corporation has created formal communication channels to relay news about the forecasted extreme temperatures and alert governmental agencies, the Met Centre, health officials and hospitals, emergency responders, local community groups, and media outlets.

In 2016, the Ahmedabad Heat and Climate Study Group commenced discussions to establish a parallel monitoring and risk communication network for Air pollution in the city. The Ahmedabad's Air Information and Response (AIR) Plan developed by the group describes a health-based governance framework designed to increase awareness, reduce exposure risk, and motivate longer-term policy action to reduce air pollution.

Case 5: Surat Emissions Trading Scheme

In 2019, the Gujarat Pollution Control Board launched the emission trading system (ETS) claimed to be the first scheme to address particulate pollution in the world. 158 plants in the industrial hub have signed up for this “cap and trade” scheme. Industrial clusters can set a limit on how much particulate pollution they can collectively emit. They can install equipment to cut their emissions, or purchase credits from those that do, to keep their collective emissions down. In this way, the system uses the power and flexibility of markets to deliver a win-win situation of simultaneously (i) reducing the total cost of regulation, (ii) increasing firm profits, and (iii) protecting citizens from air pollution.

Case 6: Use of AERMOD and ADMS-Urban for PM Monitoring in New Delhi

In New Delhi, the AERMOD (07026) and ADMS-Urban (2.2) were applied to undertake performance evaluation of these models with respect to estimate ambient PM concentrations for 2000 and 2004 over seven sites in the city. In addition, model evaluation and inter-comparison were performed that included emissions from all urban sources. The performance of the models was examined based on their boundary layer parameterisations. Concentrations were estimated for the winter seasons in both years.

Case 7: Andhra Pradesh SPCB Steps in to Curb Air Pollution in Cities

The Forest department has planned to upscale tree plantations, primarily focusing on the industries listed under the ‘Red’ and ‘Orange’ categories with periodic pollution checks by the SPCB. Efforts are on to shift Tadi village from its present location and rehabilitate people, as the pollution levels have gone up due to the presence of a large number of industries under the ‘Red’ and ‘Orange’ categories. Smart meters to be provided to about 2.63 lakh farmers, starting with meters supplied to about 25,000 farmers in Srikakulam district, as a pilot project. The new meters will save power by about 33%.

Case 8: BrihanMumbai Municipal Corporation (BMC) Gets on Action Mode with Pollution Mitigation Plan

In cognisance of the climate crisis faced in Maharashtra, the state government has ordered the BMC to implement a pollution mitigation plan in Mumbai. The civic body is not initiating a multi-level monitoring strategy for the city. The four major causes of air pollution in Mumbai and surrounding areas are road and construction dust, traffic congestion, industries and the power sector, and waste burning.

A total of 14 monitoring stations have been set up across Mumbai to check the air quality and provide collated information of the citizens through a website. The civic body has committed to plant 1 lakh trees through ecologically sustainable planting practices and is likely to set up Continuous Air Quality Monitoring Stations to monitor the ambient air quality across the city. The BMC plans to carry out a ward-level assessment of emissions with the help of IIT Bombay. It also highlighted commencing hotspot monitoring- “hyper-local monitoring” and has appointed consultants to coordinate with pollution-emitting companies. The civic body is also committed to conducting communication and awareness campaigns, along with the formation of eco clubs. Collaborations with NGOs is also a part of the above plan. The focus of the body is to implement clean construction and demolition practices. Construction guidelines have been issued to builders to reduce dust. Other measures like e-power sweepers, sprinklers, vehicle-mounted misting equipment, air pollution units, and ionisation-based air purification systems are being deployed. The civic body also claimed to set up two 600 metric tons per day capacity processing centers. Consultants are being appointed to direct vehicular traffic on the road using 395 automated signal systems, out of which they have been installed at 258 junctions. Automated ambient air quality monitoring stations are being installed in five places. Electrification of BMC vehicles, charging infrastructure, procurement of 3000 electric BEST buses, conversion of old BMC diesel/ petrol vehicles into CNG vehicles is on. It has also been proposed to install outdoor dust reduction systems in five locations.

Case 9: Revised Action Plan for Critically Polluted Area-Ranipet, Tamil Nadu

Critical locations for air quality monitoring are Malladi drudge Unit-I, Thirumalai Chemicals Ltd., Malladi drudge Unit-III, Ultramarine & Pigments Ltd, and SVISS Labs Ltd. The predominant sources contributing to various pollutants by these units as a part of the SIPCOT Industrial area are from one Petrochemical, three Bulk Drugs & Pharmaceuticals, and one Chemical Unit.

High-volume samplers are installed by major units to monitor ambient air quality. VOC monitors are provided at the units dealing in chemicals and drugs. The SPCB Laboratory at Vellore started regular monitoring of AAQ/ Stack emission surveys in all the major units. Wet scrubbers are provided to scrub the gas emission from the processes, dust collection systems such as bag filters, cyclone separators were provided to control the fugitive emissions from plant operations. High-volume samplers are installed by major units to monitor ambient air quality. The SPCB formed a CARE Air Centre at the Corporate Office for the continuous monitoring of the ambient air quality and stack emissions of the 17 category industries in the state.

Case 10: Uttar Pradesh's 12 Steps for Clean Air

Uttar Pradesh, which until a while ago, was considered a region of concern in terms of air pollution, is now driving solutions in the form of Swachh Vayu Sarvekshan. Micro Action Plans identifying air pollution sources with timelines and cost estimates of their mitigation projects were prepared and implemented. The Action Plans were designed for (i) Cost-Effective Science-Driven Actions (ii) Dynamic Emission Inventory (iii) Pioneering Airshed Approach (iv) Expansion of Air Quality Monitoring Network (v) Delineation of Micro-Airsheds (vi) Addressing Financial Gaps (vii) Dedicated Financing (viii) Effective Governance (ix) Robust Monitoring (x) Maximizing Capacity Utilization and (xi) Regional Cooperation.

Case 11: Bihar's Cleaner Brick Kiln Directive

On 18 February 2016, Bihar SPCB published a directive in leading newspapers of Bihar asking all brick kilns located in the five administrative blocks of Patna district to adopt cleaner brick production technologies before 31 August 2016. The directive also stated that existing kilns that failed to do so by the specified date would not be provided Consent to Operate. It was also informed that the directive was being piloted in brick kilns located near to the city of Patna first, and later extended to other parts of the state in the following year. Though the directive was issued in February 2016, efforts towards sensitising and building awareness amongst brick kiln owners had already begun by 2012. During the implementation phase (post-February 2016), BSPCB and DoEF maintained continuous communication with brickmakers through workshops, seminars, newspapers, and other channels. Brick kiln owners were educated about the environmental and economic benefits of technology upgrade. A technical support programme was devised that focused on awareness generation on cleaner kiln technologies, providing assistance to brick makers in technology selection, and imparting technical knowledge to brick enterprises in best practices.

Case 12: The Odisha Star Rating Program

The SPCB, Odisha, and EPIC India designed and launched the Odisha Star Rating Program in September 2018. It is a public disclosure program that categorises and broadcasts the environmental performance of major industrial plants in Odisha, utilising continuously monitored emissions data. As of July 2020, the Star Rating Program had successfully enrolled 124 industries. The Program rates industries on a 1 to 5-star scale based on their particulate matter emissions and relevant emissions standards and provides a monthly report card.

The Program has two main objectives: (i) to inform industries about their environmental performance relative to the prescribed standards, as well as the performance of their competitors to encourage better compliance (ii) to create an accessible platform for the public to learn about the environmental performance of local industries, which would empower them to engage with regulators, policymakers, and the media. Broadly, the Program also aims to strengthen the SPCB, Odisha’s regulatory efforts and capacity to manage industrial pollution in the state.

For successful Program implementation, the SPCB adopted a three-pronged approach. First, capacity-building efforts to support and further strengthen the technical capacity of the regulator. Second, sensitisation workshops and one-on-one interactions with industry owners to encourage adoption of new and complex technologies like CEMS and real-time data transmission. Third, a systematic outreach and awareness campaign to generate public awareness and galvanize support for the Program.

Case 13: Phytoremediation for Urban Landscaping and Air Pollution Control in Trivandrum

Air pollutant concentration of Trivandrum exceeded the limits of National Ambient Air Quality standards, according to a study conducted in 2015. These polluted corridors harbour vegetation on roadsides and traffic islands, planted solely for aesthetic appeal. Sixty-seven species, including flowering, fruit-bearing, ornamental, shade-providing, and timber-yielding species, were screened for their relative resistance to air pollution. Based on leaf pH, relative water content, chlorophyll, and ascorbic acid levels, the Air Pollution Tolerance Indices of each species were formulated and they were grouped into the following: tolerant, moderately tolerant, intermediate, and sensitive groups, and were planted accordingly at suitable locations.

Case 14: Sikkim is Working to End Plastic Pollution

Sikkim has been leading a green revolution of its own kind. In 1998, it became the first Indian state to ban disposable plastic bags, and is also among the first to target single-use plastic bottles. In 2016, Sikkim banned the use of packaged drinking water in government offices and government events. It also banned the use of Styrofoam and thermocol disposable plates and cutlery in the entire state in a move to cut down toxic plastic pollution and tackle its ever-increasing garbage problem. With massive awareness drives and penalties, this ban has been impactful. Sikkim's residents are now opting for plates made of paper, leaf, bagasse, and even areca nut. Government offices have switched to alternatives like filtered water, large reusable dispensers, and reusable water bottles for functions and meetings. However, with the large number of tourists visiting Sikkim, it is challenging to control the use of plastic water bottles. The government is considering banning plastic bottles in the entire state.

Gangtok-based ECOSS is working with other organisations like WWF, Swachh Bharat Campaign on the Zero Waste Himalaya project, which aims to tackle garbage in the Himalayan regions of Bhutan, India, and Nepal. The project has been actively campaigning and lobbying with the state government for the effective implementation of the ban in Sikkim. Through penalties, state-level policies, and a mass awareness programme, this tiny state is well on its way to becoming free of the scourge of plastic pollution.

Case 15: Road dust Mitigation in Rajasthan

In 2016, the Rajasthan SPCB started a detailed study in Non-Attainment cities in collaboration with IIT, Kanpur. The aim of the study was to prepare an emission inventory, which would highlight the sources and magnitude of Air Pollution. One of the major observations was that the road dust significantly contributed to Air Pollution in the state. Dust contribution on Jaipur Road makes up to 46% of total PM2.5 emissions; and in Bhiwadi, it accounts for 48%. Moreover, municipal waste treatment has also been given focus, as evidence suggests that the large-scale burning of municipal waste and horticulture waste contributes significantly to emissions of PM2.5 and PM10. More than 65 municipalities have already installed facilities to recycle municipal waste.

Case 16: Monitoring Network Enhancement Using Low-Cost Sensors in West Bengal

Sensor-based monitoring stations across the State have been set up by the West Bengal SPCB. The sensors were placed at strategic locations (from Darjeeling to the Sundarbans). The project targets the setting up of 150 sensor-based stations for boosting infrastructure in Air Quality monitoring. These sensors were installed on the campus of schools, colleges, and universities. The WB SPCB has started sprinkling water with the aim to stop dust resuspension to keep AQI in check.