Draft Final Report

Strengthening Green Fiscal Federalism in India

Prepared for
Fifteenth Finance Commission

The Energy and Resources Institute

...towards global sustainable development

Cover page Photograph credit : www.shutterstock.com

For more information

Project Monitoring Cell
T E R I
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003
India

Tel. 2468 2100 or 2468 2111
E-mail pmc@teri.res.in
Fax 2468 2144 or 2468 2145
Web www.teriin.org
India +91 • Delhi (0)11

Team members

Principal investigator
Divya Datt

Project team
Sumit Sharma
Isha Khanna
Nimish Singh
Anshu Yadav
Nidhi Srivastava
Shailly Kedia
Joyita Ghose
Swati Agarwal
Jonathan D Syiemlieh

Project advisors

Dr. Prodipto Ghosh, Mr. R R Rashmi, Mr. Ajay Shankar, Ms. Naini Jayaseelan

Secretarial assistance

Mr. John Andruse, Mr.M.K Binesan and Ms. Valsa Charles

Acknowledgement

We express our gratitude to the Fifteen Finance Commission for giving us the opportunity to undertake this important study and for their inputs at various stages of this assignment.

The study benefitted in large measure from our interactions with stakeholders in the Central and State Governments, Central and State Pollution Control Boards, national and international research organizations and policy think tanks, as well as independent experts, particularly those in the States of Punjab and Haryana.

We acknowledge with gratitude the valuable help and advice that we received from Ms.Naini Jayaseelan, without which this study would have been incomplete.

We are extremely grateful to our internal advisors- Dr Prodipto Ghosh and Mr R R Rashmi for guiding us throughout the study, bringing to bear years of invaluable experience and understanding of the issues at hand.

Last but not the least; we thank the secretarial team at TERI – Mr. John Andruse, Mr.M.K Binesan and Ms. Valsa Charles for providing secretarial support towards the publication of this report.

Table of contents

List of tables

List of figures

Acronyms

AOD	:	Aerosol Optical Depth
AQI	:	Air Quality Index
BS VI	:	Bharat Standard VI
CEPI	:	Comprehensive Environment Pollution Index
COP 21	:	Conference of Parties
CPCB	:	Central Pollution Control Board
DALYs	:	Disability Adjusted Life-Years
EPI	:	Environmental Performance Index
FC	:	Finance Commission
GBD	:	Global Burden of Disease
GCF	:	Green Climate Fund
GoI	:	Government of India
GRAP	:	Graded Response Action Plan
ICMR	:	Indian Council for Medical Research
IFPRI	:	International Food Policy Research Institute
IHME	:	Institute for Health Metrics and Evaluation
IITM	:	Indian Institute of Tropical Meteorology
INDC	:	Intended Nationally Determined Contribution
LIFE	:	EU's L' Instrument Financier pour l' Environment
LPG	:	Liquefied petroleum gas
MNRE	:	Ministry of New and Renewable Energy
MoA	:	Ministry of Agriculture and Farmers Welfare
MOEFCC	:	Ministry of Environment Forest and Climate Change
MoP	:	Ministry of Power
MoPNG	:	Ministry of Petroleum and Natural Gas
MoRTH	:	Ministry of Road Transport & Highways
MSME	:	Micro, Small and Medium Enterprises
NAAQS	:	National Ambient Air Quality Standards
NAMP	:	National Air Monitoring Programme
NCAP	:	National Clean Air Plan
NDC	:	Nationally Determined Contributions
NIPFP	:	National Institute of Public Finance and Policy
NITI Aayog	:	National Institution for Transforming India Aayog
NPRE	:	Non-Plan Revenue Expenditure
NTPC	:	National Thermal Power Corporation
ODF	:	open defecation free
PHFI	:	Public Health Foundation of India
PI	:	Pollution Index
PM	:	Particulate Matter
PMUY	:	Pradhan Mantri Ujjwala Yojana
RH	:	Relative Humidity
RSPM	:	Respirable Suspended Particulate Matter
SAC	:	Space Applications Centre

SDGs	:	Sustainable Development Goals
ToRs	:	Terms of Reference
ULBs	:	Urban Local Bodies
UN	:	United Nations
UNDP	:	United Nations Development Programme
UNEP	:	United Nations Environment Programme
UNFCCC	:	UN Framework Convention on Climate Change
USEPA	:	United States Environmental Protection Agency
VGF	:	Viability Gap Funding
WHO	:	Wold Health Organization
XV FC	:	15th Finance Commission

Executive Summary

Context of the study

Since the XII Finance Commission, successive Finance Commissions have aimed at promoting environmental stewardship in different ways. The XII FC recommended Rs.1000 crore spread over the award period 2005-2010 for maintenance and preservation of forests, which was to be over and above the budget of the State Forest Departments. For the first time, the ToR of XIII Finance Commission included "the need to manage ecology, environment and climate change consistent with sustainable development". Inter alia, it recommended a grant of Rs. 5000 crore for the generation of grid electricity from renewable sources. The role of intergovernmental fiscal transfers in promoting sustainable development has been recognised in the ToRs of Fifteenth Finance Commission too.

The Energy and Resources Institute (TERI) was awarded this study by the Fifteenth Finance Commission to analyse how inter-governmental transfers can be designed as an effective instrument of environmental sustainability. In particular, the study provides recommendations, for consideration of the Fifteenth Finance Commission, on how the fiscal federal architecture and transfers for the period 2020-2025, can be used to promote environmentally sustainable development and contribute to India's global sustainable development and climate change commitments. It makes specific recommendations for improving air quality in India.

This study contributes to several parts of the Terms of Reference (ToRs) of the Fifteenth Finance Commission. In particular, it responds to the following sections of the ToR:

- *The Commission may consider proposing measurable performance-based incentives for States, at the appropriate level of government*, in the area of *Sustainable Development Goals (SDGs)*, among others (Para 4, iii). While there is no specific SDG for tackling air pollution, it is covered in at least two SDGs - Goal 3 on health and wellbeing has a clear target to 'substantially reduce the number of deaths and illnesses from …air, water and soil pollution and contamination'. Goal 11 for sustainable cities and communities has a target 'to reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management'. Ensuring access to affordable, reliable, sustainable and modern energy is enshrined in SDG 7. Combustion of fossil fuels is a significant cause of degrading the quality of air. Lack of access to clean energy for household needs is one of the main causes of indoor air pollution, and associated negative health effects.
- To the extent that adopting or maintaining an environmentally sustainable growth trajectory will have a bearing on overall economic condition of a State, the study also has a bearing on ToR 3(iii) which deals with the *demand on the resources of the State Governments, particularly on account of financing socioeconomic development and critical infrastructure, assets maintenance expenditure, balanced regional development and impact of the debt and liabilities of their public utilities.*

Sustainable Development Goals and pollution abatement

The Sustainable Development Goals are a set of seventeen goals with 169 targets, represent a global consensus on the development agenda for 2030 and were agreed upon by member states at the United Nations Sustainable Development Summit in 2015 and adopted through a general assembly resolution (A/RES/70/1). (United Nations, 2015) India is committed to the SDGs, as is also evident from their incorporation in the ToRs of the XV Finance Commission. The inter linkages between pollution abatement and SDGs are explored in Figure I.

Figure I: Achieving SDGs in India through pollution abatement

Source: Prepared by authors using multiple sources

Various environmental issues need intervention and support, including fiscal support, to achieve the national and international policy goals for sustainable development. Improved management of air, water and waste are crucial for ensuring sustainable development. Although cognizant of the multidimensional nature of environmental issues, this study is

limited to the issue of improving ***air quality***, primarily due to paucity of consistent data for other issues (water and waste).

Air quality in India

Air pollution has emerged as one of the biggest environmental challenges in India as a result of rapid economic growth and urbanisation. The demand and consumption of all fossil fuels has increased tremendously. Ten cities in India are listed among the top 20 cities globally with highest concentration of ambient particulate matter (less than 2.5 microns in size) (WHO, 2016).[1] Even when measured against India's air pollution standards, which are less stringent than the WHO norms, more than 70% of Indian cities where air quality is being measured exceed the safe threshold level.

Some efforts have been made by both the central and state governments in India for control of air pollution, including measures like advancement of vehicle and fuel quality norms, enhanced LPG penetration, introduction of gaseous fuels and stringent environmental standards for industries. However, despite these measures, the current state of air pollution in Indian cities shows that growth in the sources of air pollution is negating the positive impact of control measures, which have proved to be insufficient to address the scale of the problem.

Air quality monitoring in India

Ambient air quality parameters include sulphur dioxide (SO_2), oxides of nitrogen (NO_x), carbon monoxide (CO), ozone (O_3) and particulate matter (PM- PM_{10}, $PM_{2.5}$). Under the country's National Air Monitoring Programme (NAMP), four air pollutants viz. SO_2, NO_2, Respirable Suspended Particulate Matter (RSPM / PM_{10}) are monitored regularly at all the locations.

The Central Pollution Control Board (CPCB) has notified National Ambient Air Quality Standards. In order to assess the air quality against these standards, ambient air pollutant concentrations are monitored in all the states by CPCB and SPCBs under NAMP through a network of 731 manual operating stations covering 312 cities/towns in the country.

In addition to manual stations, CPCB has installed 134 real-time Continuous Ambient Air Quality Monitoring stations (CAAQMS) in 71 cities across 17 states monitoring eight pollutants viz. PM10, PM2.5, SO2, NOx, ammonia (NH3), CO, ozone (O3), and benzene.

An Air Quality Index has been launched in 2014 for effective and simpler communication of air quality status. The index converts complex air quality data of eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb) into a single value and category (good to severe).

State of air quality in India

An attempt was made in this study to analyse the trends and gap between the NAAQS and actually observed pollutant concentrations on the basis of data from manual stations. The analysis reveals that in case of both PM10 and PM2.5, both average and maximum values

[1] Particulate Matter is generally categorized into two types based on the size: PM_{10} (10 micrometers or less in diameter) and $PM_{2.5}$ (2.5 micrometers or less in diameter). PM2.5 is considered to be more harmful to health due to its finer size which leads to higher permeability in the lungs and also due to carcinogenicity associated with its constituents.

are higher than the prescribed annual average standards for all years, while SO2 and NOx concentrations are within standards in most of the cities. It is evident that PM pollution levels are of immediate concern to India.

State-wise analysis of average ambient PM_{10} concentration shows that most states are above the National Ambient Air Quality Standard (NAAQS) of 60 µg/m^3. While the air quality has improved for some States, it is still higher than the NAAQS. It is evident that states falling in the Indo-Gangetic plains like Bihar, Uttar Pradesh and Jharkhand, also Punjab and West Bengal show higher PM10 levels. Surprisingly, Uttarakhand and Jammu and Kashmir also show high values, possibly attributable to solid fuel use (for cooking and heating), forest fires, and traffic congestion etc. Southern and NE states like Kerala, Goa, Mizoram and Meghalaya show the best air quality. Meteorological and geographical factors are also responsible for this improved air quality.

Both anthropogenic and natural factors lead to degradation of air quality. In terms of source of origin, pollutants can be categorized as primary and secondary in nature. The major anthropogenic sources of air pollution are biomass burning in cookstoves in rural households, industrial process, vehicular emissions, diesel generator sets, agricultural residue burning, municipal solid waste burning and construction activities.

In order to design cost effective programs and strategies for reduction of pollutant concentration in the ambient air, it is necessary to have information about the sources and their respective contributions. Most source apportionment studies in India have been conducted in and around Delhi, Mumbai, Chennai and Kolkata with some contributions from Hyderabad, Tirupati, Durg, Kanpur, Agra and Chandigarh. Majority of these studies have focussed on PM_{10} and SPM. These studies have identified vehicular emissions, industries, biomass burning, road dust, construction dust and secondary formations as the major sources of PM_{10} and PM2.5 concentrations, with their contributions varying from city to city. Seasonal variation of PM_{10} shows significantly higher contribution of dusty sources in summer as compared to winter. This can be attributed to dry conditions and higher wind velocities in summers resulting in natural contributions from western regions in India and also trans-boundary sources.

Governance of air quality in India

The MoEFCC, along with the CPCB (Central Pollution Control Board) and SPCBs (State Pollution Control Boards) forms the regulatory and administrative core for pollution management in the country, while other ministries and bodies, such as Ministry of Science and Technology, Ministry of Earth Sciences, Ministry of Road Transport and Highways, Ministry of Agriculture, are also involved through various functions, policies, and schemes. In addition, a network of government and non-governmental institutions and laboratories are involved in monitoring, reporting, and conduct of air quality management studies.

The primary legislation governing air quality in India is the Air (Prevention and Control of Pollution) Act, 1981which prescribes various functions for the Central Pollution Control Board (CPCB) and State Pollution Control Boards at the state level. CPCB notifies the National Ambient Air Quality Standards under the Act. Under this Act, power and functions are allocated to CPCB.

A number of Rules and Regulations have been notified under the Environment (Protection) Act, 1986, an umbrella legislation, including the ones relevant for improving air quality. These Central Rules lay down environment standards for several industrial units, including thermal power plants, cement plants, iron & steel plants, smelting units, brick kilns and diesel generator sets, on parameters such as particulate matter, SO2, NOX and mercury. Certain other Rules also have a direct implication for safeguarding and improving air quality, such as solid waste management, construction and demolition waste rules.

Emissions from vehicles are regulated as per standards notified under the Motor Vehicles Act of 1988 and Rules thereunder.

The Government of India has taken several initiatives for control of pollution in India. As the nodal agency, MoEFCC has notified ambient air quality standards and also source emission standards for certain industries and sectors.

A number of action plans have been formulated by the central and state governments for control of air pollution in Indian cities in the past decade. Air Quality Index (AQI) was launched in 2014 with the aim of providing data related ambient air quality in colour coded format. Various measures taken for curbing air pollution from different contributing sectors include implementation of advanced Bharat Standard VI (BS VI) for vehicles, introduction of electric vehicles, banning of pet coke and furnace oil in NCR, setting up of Continuous Emission Monitoring System for industries, replacing coal-based power plants with natural gas-based power plants, subsidies on machinery for tilling the agricultural residue back into soil instead of burning it, among others.

In 2018, MoEFCC formalized the National Clean Air Programme (NCAP) for addressing air pollution at the national scale, especially in the 102 non-attainment cities in India. It is a time-bound, national strategy to bring down levels of deadly particle air pollution ($PM_{2.5}$ and PM_{10}) by 20-30% by 2024 (compared to 2017 levels). The NCAP is expected to expand the national air quality monitoring network, build capacity for air pollution management, and strengthen public awareness about the dangers of air pollution.

Challenges in management of air quality in India

State Pollution Control Boards are severely constrained with respect to financial resources, staff, and laboratory facilities. Lack of human resources on account of vacant positions across States affects the day to day functioning and performance of the SPCBs such as regular monitoring of industrial stacks. Moreover, while the capacity of SPCBs has remained almost stagnant, their responsibilities have increased over time.

An SPCB receives money on account of consist of fees for issuing consent and authorisation, compensation received from the Government of India etc. One of the major sources of SPCB's income was the share of water cess collected from industries/municipal bodies under Water Cess Act, 1977. With water cess being subsumed under GST financial resources of the Boards will suffer.

Given the variation in local sources and meteorological conditions of each city, state-level (regional) and city-level scientific air quality management plans are needed to address air pollution. A major issue in effective development and implementation of air pollution

management plans has been the lack of technical capacity and manpower, infrastructure in the PCBs, and effective collaboration amongst stakeholders.

Another glaring issue in management of air quality in India is inadequacy of monitoring infrastructure and data. The air quality monitoring network currently only covers 14-92% of the urban population in the States, with an all India average of about 40% of the urban population covered. Clearly, there is a need to augment the network in urban areas and also in rural areas, which are still not covered in the program.

Parameters that are being monitored under the national air quality monitoring system also need to be revisited and rationalized. An optimal mix of measurement techniques that include manual, continuous, sensor & satellite-based measurements is required. Simultaneously, there is a need for quality assurance and quality control at the monitoring stations to ensure credibility.

Political economy considerations also pose challenges in both assessing the extent of air pollution and taking measures for abatement of pollution. The geopolitics of pollution exports between cities, states and countries are an important consideration in finding solutions to trans-boundary pollution issues. It is difficult to reach and agree upon cooperative solutions especially when costs and benefits are poorly understood and/or spatially mismatched. A case in point is the issue of crop residue burning in the Indo-Gangetic plains, where the political gains of allowing crop burning override health costs faced in and around regions where the burning takes place. Much of the political discourse in States where the practise is prevalent unfortunately ignores the immediately affected vulnerable population and remains focused on the high costs of alternatives to burning residue.

Interventions that have an adverse economic impact on poor and marginalised sections of the society can become politically sensitive. The MSME sector is an important aspect of India's industrial sector. Since many MSMEs are unregistered and operate out of non-conforming areas, their compliance with pollution regulations becomes difficult to monitor. There is also a lack of sectoral accountability due to limited source apportionment analyses.

Finally, air pollution is a cross-sectoral issues but the lack of horizontal and vertical coordination and collaboration within the government structure is a major inhibiting factor is designing and implanting effective solutions. There is an urgent need for centre-state and inter-state cooperation, and collaboration for regional scale air quality planning.

Recommendations for intergovernmental transfer

With its overall mandate of strengthening equity and efficiency of the fiscal system, Finance Commission is well placed to take up the issue of air pollution in its recommendations and to suggest recommendations on devolution grants. The specific TORs of the XV FC relating to the SDGs provide a strong entry point for the FC to take up this issue, as discussed in the previous chapter. The following arguments serve to further buttress the rationale for the FC to intervene in this area:

1) Air pollution is a widespread issue across the country and pollution levels are above the WHO guidelines in all cities where air quality is being monitored. Indian standards, which are more lax than who standards, are violated in 70% cities where air quality is being monitored.

2) Impacts of air pollution on health (as well as on agriculture, buildings and climate) are well documented in research studies and impose a significant cost on the efficiency of the economic system by adversely impacting the health, wellbeing and productivity of people and ecological systems.
3) On-going efforts by governments both at the central and state levels have not yielded adequate results to control this multi sectoral problem of this magnitude.
4) Air pollution is a trans-boundary, thus creating negative externalities beyond the jurisdiction where it originates, which local governments may have little or no incentive to address in the absence of targeted central intervention.
5) Air pollution causes are multi-sectoral and hence its control calls for intensive coordination between sectoral departments and agencies.
6) State level pollution control boards have limited technical and financial capacity to enforce existing laws for control of air pollution.

The intervention of the Finance Commission will provide a strong signal on the importance of air quality in the development agenda of States, thereby elevating the stature of the issue to the level that is required to address it effectively. By creating performance-based incentives, FC grants have the potential to not only provide resources for specific interventions, but also motivate leadership at the highest level in the States to design and implement multi-sectoral interventions to achieve measurable improvements in air quality.

Recommended grant

The study recommends an intergovernmental transfer in the nature of a grant based on a city level approach. It would assess air quality in terms of PM 10, which is a pollutant of concern and is also being most widely monitored across States. The grant would be made on the basis of air quality and the measures taken to address the problem of air pollutions in cities.

The proposed city level approach is targeted at air quality in Indian cities where PM10 concentrations are measured regularly under the National Air quality Monitoring Programme. The study proposes a hybrid approach comprising a) need based, b) performance based to provide the FC grant to top 100 cities with maximum PM10 exposure levels. 59 out of these 100 cities are also in the list of 102 non-attainment cities identified by the NCAP.

Total exposure caused by PM10 concentrations is estimated based on the following equation:

Total exposure = Population of city x Annual average PM10 concentrations in city

Based on this formula, Delhi being seventh highest in pollution and second highest in population will receive the maximum 15.1% share in the grant. Based on the calculations, Delhi (15.0%) Mumbai (6.7%), Lucknow (3.7%), Ahmedabad (3.6%), Hyderabad (3.5%), Kanpur (3.3%), and Bangalore (3.2%) are the other cities having somewhat higher shares than the rest, which will receive <3% of the total grant.

The grant will be disbursed in the form of yearly grants. In the first two years, the grant is proposed to be distributed based on the PM10 exposure. For the next three years, the

performance of the cities in terms of reduction of air pollution levels needs to be evaluated. This can be calculated using the following formula:

$$S_i = \left(\frac{C - P}{P}\right)_i$$

Where C is the concentration in year t+2, and P is the PM10 concentration in base year t.

Amount of grant:

The total grant recommended is in the range of Rs.10,000 - 8,000 Crores over a 5 year period. The grant would be targeted and would have the potential to make a difference in the air quality in the 100 cities where the largest recipient would receive Rs.1500-1200 Crores and the smallest recipient would receive at least 18 Crores - 14 Crores.

Conditionality of use:

The grant should be earmarked for activities directly and indirectly related to improving air quality. The States should be requested to draw up specific action plans choosing all/any of the sectors mentioned in table 1in the first year of the FC award and for the year remaining four years the release of funds will be dictated by the progress in the execution of the action plans.

Table I : Sectoral strategies recommended for use of FC grants

Sector	Strategy
Vehicles	▪ Public transport procurement based on electric buses modes, Metro rail etc. ▪ Development of old vehicle scrappage program ▪ Regional mobility infrastructure ▪ Incentives for retrofitment of pre BS-IV vehicle with diesel particulate filters
Industries	▪ Development of automated industrial pollution vigilance and control centres
Agricultural residue burning	▪ Development of in-situ and ex-situ programs for control and management of agricultural residue burning
Municipal waste burning	▪ Development of in-situ and ex-situ programs for control and management of municipal residue burning o Methane recovery from STPs and landfills o Composting o Waste to energy
Construction dust	▪ Enforcement of C&D rules within the municipal limits through incentivised use of construction dust control equipments by both public and private agencies
Road dust	▪ Vacuum cleaning of major arterial roads
Others	▪ Augmenting the air quality monitoring network ▪ Conducting studies on state-wise or city scale source apportionment

Under the recently launched National Clean Air Program (NCAP), MoEFCC has set a target of 20-30% reduction in pollution levels by 2024. The Finance Commission grant can contribute to the funding of some of the measures envisaged in NCAP. It can provide an incentive to States to put in efforts for control of air quality and achieve the target set in NCAP. The FC grants should be dove-tailed with NCAP grants so as to ensure synergy between grants coming from both sources with the common objectives.

1 Objectives and scope

The study examines how inter-governmental transfers can be designed as an effective instrument of environmental sustainability in India. In particular, it aims at providing recommendations, for consideration of the Fifteenth Finance Commission, on how the fiscal federal architecture and transfers for the period 2020-2025, can be used to promote environmentally sustainable development and contribute to India's global sustainable development and climate change commitments. The study makes specific recommendations for improving air quality in India. The study draws on analysis of available data, programmes and policies and stakeholder consultations at the state, regional and national levels as well as lessons from international experience.

This study contributes to several parts of the Terms of Reference (ToRs) of the Fifteenth Finance Commission. In particular, it responds to the following sections of the ToR:

- *The Commission may consider proposing measurable performance-based incentives for States, at the appropriate level of government*, in the area of *Sustainable Development Goals (SDGs)*, among others (Para 4, iii). The SDGs are a comprehensive set of seventeen developmental goals, which were endorsed by several countries, including India, at the United Nations (UN) General Assembly in 2015. SDG 13 is geared towards taking 'urgent action to combat climate change and its impacts'. Ensuring access to affordable, reliable, sustainable and modern energy is enshrined in SDG 7. While there is no specific SDG for tackling air pollution, it is covered at least in two SDGs- Goal 3 on health and wellbeing has a clear target to 'substantially reduce the number of deaths and illnesses from …air, water and soil pollution and contamination'. Goal 11 for sustainable cities and communities has a target 'to reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management'. These and indirect linkages with other SDGs are discussed is more detail in the next chapter.
- To the extent that adopting or maintaining an environmentally sustainable growth trajectory will have a bearing on overall economic condition of a State, the study also has a bearing on ToR 3(iii) which deals with the *demand on the resources of the State Governments, particularly on account of financing socioeconomic development and critical infrastructure, assets maintenance expenditure, balanced regional development and impact of the debt and liabilities of their public utilities.*

Objective and approach

The proposed study analyses evidence, experience and stakeholder perspectives in India and internationally with the objective to recommend, for the consideration of the XV Finance Commission, how inter-governmental fiscal transfers can serve as an effective instrument of environmental sustainability in India.

The study is motivated by the following areas of inquiry:

1. What is the status of pollution (air) in India, and the underlying drivers of this state?
2. Is there a rationale for the FC to play a role in these areas?

3. What has been the experience of previous Finance Commission transfers (water and renewable energy), taking into account perspective of different stakeholders?
4. How can FC transfers promote abatement of air pollution in India in a way that is efficient (e.g. make optimal use of FC grants in terms of creating a credible incentive for change, addressing solutions that are impactful, and leveraging other sources of funding); equitable (e.g. taking into account needs and constraints of different States in terms of their location, resource endowments or the type and scale of economic activity), and objective (e.g. using credible and comparable information across States)?
5. What are the indicators that can be used for inter-se distribution of grants to States to achieve the above? What is the state of available data and information to support such indicators?
6. Are there experiences from other countries that can offer lessons?

The following approach was adopted in undertaking the study and in attempting to answer the above questions.

1. Analyze the experience with previous FC transfers (mainly XIII) by analysing data on recommended transfers and actual releases to States based on fulfilment of grant conditionality and/or other factors; as well through interactions with stakeholders at the national and state levels;
2. Review and analysis of relevant National Acts and laws, Constitutional provisions, Central and States programmes and policies, as well as memoranda submitted by States to past and current Finance Commissions;
3. Based on the above, recommend, for the consideration of the XV FC, how fiscal transfers to States can promote better air quality in India. These recommendations include principles that should underlie the design of transfers, the actual form of transfers and the parameters to determine the relative share of States, as well as the conditionality of use in the case of a grant.

The analysis in the study was based on data compiled from multiple sources. These include the Ministry of Finance, Ministry of Environment, Forests & Climate Change, Central and State Pollution Control Boards, websites and documents of relevant schemes and programmes etc.

Scope of the study

Various environmental issues need intervention and support, including fiscal support, to achieve the national and international policy goals for sustainable development. Improved management of air, water and waste are crucial for ensuring sustainable development. Moreover, these domains are crucial from a federal perspective, as effective management requires cooperation between Centre and States, and amongst States. Although cognizant of the multidimensional nature of environmental issues, this study is limited to the issue of improving ***air quality***, primarily due to paucity of consistent data for other issues (water and waste).

2 Context and introduction

This chapter sets out the context for this study by examining the interface between air pollution management on the one hand and the SDGs and India's NDCs on the other. Both the SDGs and the NDCs are included in the ToRs of the XV FC, and as such become important entry points for environmental and energy issues in the recommendations of the XV FC. The Chapter also presents how previous Commissions have dealt with the subject and discusses the limited international experience in this area.

Environment and clean air in Sustainable Development Goals

The Sustainable Development Goals (SDGs), a set of seventeen goals with 169 targets, represent a global consensus on the development agenda for 2030 and were agreed upon by member states at the United Nations Sustainable Development Summit in 2015 and adopted through a general assembly resolution (A/RES/70/1). (United Nations, 2015)

India is committed to the SDGs, as is also evident from their incorporation in the ToRs of the XV Finance Commission. In fact, many of the SDGs are already on the developmental agenda of the Government of India and State Governments. This includes the goals on clean and renewable energy (specifically, Goal 7 on clean and affordable energy and Goal 13 on climate action). Combustion of fossil fuels is a significant cause of degrading the quality of air. Lack of access to clean energy for household needs is one of the main causes of indoor air pollution, and associated negative health effects. Besides SDG 7, there are others, particularly those related to environmental sustainability, which will require greater attention at all tiers of the Government in a cooperative manner.

We analyze below the interface between SDGs and environmental sustainability from the lens of pollution. For the purpose of this exercise, aspects of 'pollution' will include air quality, water quality and waste. Several SDGs contain references to objectives of pollution control and waste management and there are other SDGs, which are indirectly linked with pollution and waste issues. These interactions can be seen in three categories: enabling, reinforcing and indivisible (Table 1). Figure 1 represents the inter-linkages between addressing pollution objectives and different SDGs. An attempt is made to amplify this interaction in the context of India in the discussion that follows.

Table 1 : SDGs and interactions with pollution objectives Categories for interaction between pollution objectives and SDGs

Interaction type	Description
+1 ('enabling')	The pursuit of one objective enables the achievement of another objective
+2 ('reinforcing')	One objective directly creates conditions that lead to the achievement of another objective
+3 ('indivisible')	The strongest form of positive interaction in which one objective in inextricably linked to the achievement of another.

Sustainable Development Goal	**Interaction type with pollution**
Goal 1. End poverty in all its forms everywhere	+1 ('enabling')
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	+3 ('indivisible')
Goal 3. Ensure healthy lives and promote well-being for all at all ages	+2 ('reinforcing')
Goal 6. Ensure availability and sustainable management of water and sanitation for all	+3 ('indivisible')
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all	+3 ('indivisible')
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	+2 ('reinforcing')
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	+3 ('indivisible')
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	+3 ('indivisible')
Goal 12. Ensure sustainable consumption and production patterns	+3 ('indivisible')
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	+3 ('indivisible')
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	+3 ('indivisible')

Figure 1 : Achieving SDGs in India through pollution abatement

Source: Prepared by authors using multiple sources

According to NITI Aayog's SDG index baseline report, 264 million people in India are still dependent on solid biomass for cooking and 200 million people still do not have access to electricity (NITI 2018: 89). The health burden imposed by indoor air pollution in rural India and the number of people affected is significant and impacts women disproportionately. A study commissioned by the Central Pollution Control Board of India found that cooking with biomass increases the risk of lung function impairment, more among women, by more than two fold and the prevalence of potentially life-threatening chronic obstructive pulmonary disease (COPD) by more than seven fold (CPCB 2012a: 227). In urban settings, residents of slum households experience higher outdoor exposure to pollution (CPCB 2012b: 5). The interaction between pollution abatement and social goals of poverty (Goal 1) is that of providing enabling conditions. Given that Goal 3 relates to health and well-being, the linkages of Goal 3 with pollution abatement is that of reinforcement. The interactions between addressing air pollution and that of Goal 7 (energy) is inextricably linked to the achievement of another.

According to MoEFCC, the impact of pollution is not limited to health but gets extended to agriculture and general well-being of human, floral and faunal population. (MOEFCC, undated) The agriculture sector can be said to be both cause and victim of pollution. Pollution from non-point sources such as agriculture run-off is difficult to control. On the other hand, discharge of wastes from industries and the polluted runoff from agricultural fields have resulted in considerable degradation in the quality of water sources. According to a report of Indian Institute of Tropical Meteorology (IITM), stubble burning contributes to the total PM2.5 for the *kharif* season.[2] This estimated percentage share of stubble burning in PM2.5 reached a high of 36% on 26th October, 2018 and 33% on 5th November, 2018. A new study by International Food Policy Research Institute (IFPRI) and partner institutes estimates the economic costs of crop residue burning in northern India at over USD 35 billion annually. (Chakrabarti et al, 2019) In the current state, institutional mechanisms to address pollution in the agriculture sector are missing as the agriculture sector is out of the ambit of the pollution control boards.

There is no systematic assessment of soil pollution available in the country. However, nearly 120.4 million ha area of the country is subjected to land degradation. In terms of soil pollution, about 71% of India's cultivated fields or nearly 100 million ha of croplands are subjected to various forms of land degradation affecting farming[3]. Estimates[4] by the Indian Council of Agricultural Research show that an area of about 2.96 million hectare is affected by soil salinity across the country. Inland salinity is a common issue in arid and semi-arid regions of Rajasthan, Haryana, Punjab, Gujarat, Uttar Pradesh, Delhi, Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu. Coastal salinity is also a major issue in coastal states of the country. Groundwater at various parts of country is affected by problems like high concentration of fluoride, iron, and arsenic. Fluoride beyond permissible limit of >1.5mg/l has been observed in 19 states affecting 224 districts. (MDWS, 2018) Arsenic is reported[5] to be in high concentration in ground water from various parts of country especially large parts of Ganga-Brahmaputra Plains. Moreover, high nitrate concentration in groundwater in India has been found in almost all hydrogeologicasl formations. The goals of sustainable agriculture and pollution abatement are thus interlinked.

According to NITI Aayog's SDG index baseline report (NITI, 2018), the sewage treatment capacity of urban India is only 37.58%. As per the 2011 Census data, 85.5 per cent population had access to safe drinking water whereas only 30.8 per cent of the households in rural areas had toilet facilities. As on March 2018, only 32% of the districts had been declared open defecation free (ODF). Given that sanitation, domestic waste management and pollution are inter-related, Goal 6 (water and sanitation) and pollution abatement goals are indivisible. Similarly, since Goal 8 aims at decoupling environment pollution and waste generation from economic growth, the linkage of pollution abatement and waste management with Goal 8 is that of reinforcement.

[2] MOEFCC (Ministry of Environment Forest and Climate Change) (2018), "Air Pollution due to Stubble Burning", http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=74024&lsno=16
[3] MOAFW (Ministry of Agriculture and Farmers Welfare) (2019), "Soil Pollution", http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=76981&lsno=16
[4] MOAFW (Ministry of Agriculture and Farmers Welfare) (2016), "Salinity in Soil", http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=41528&lsno=16
[5] MDWS (Ministry of Drinking Water and Sanitation) "Arsenic and Fluoride Contaminated Water", http://164.100.47.190/loksabhaquestions/annex/16/AU2671.pdf

The MoEFCC has developed criteria of categorization of industrial sectors based on the Pollution Index (PI), which is a function of emissions (air pollutants), effluents (water pollutants), hazardous wastes generated and consumption of resources.[6] The PI of any industrial sector is a number from 0 to 100 and the increasing value of PI denotes the increasing degree of pollution load from the industrial sector. Sixty industry sectors fall in the 'red category' with a PI of 60 or more. These include industries such as power generation plants, cement, sugar, automobile manufacturing, mining, beneficiation and refining, etc. Industries have also been classified into Orange, green and white categories, based on their pollution index score. The White category is the least polluting and do not require a consent to operate. According to an assessment undertaken by CPCB, in 2014, the most proportion of non-complying industries were in the power, sugar, iron and steel, copper and cement sectors. (MoEFCC, 2014) Similarly, source apportionment studies find that the industrial sector contributes significantly to air pollution, especially to higher NO_x and SO_2 levels. (TERI, 2018)

Municipal solid waste generation in 2016-2017 amounted to 1,19,141 tonnes per day according to the CPCB. (CPCB, 2018) According to MoEFCC, out of the 62 million tonnes of waste annually, about 5.6 million tonnes was plastic waste, 0.17 million tonnes was biomedical waste, 7.90 million tonnes was hazardous waste and 1.5 million tonnes was e-waste. (MOEFCC, 2016a) Only 21 per cent of this collected waste was estimated to be treated. The management of this waste is one of the major functions ULBs (Urban Local Bodies) and has been a challenge due to limited availability of funds and technical capacities. In India, recycling is done largely through informal waste pickers and the sector is characterized by inefficient, unscientific and unsafe waste management.

Given that a large amount of pollution and waste related externalities stem from industries and urbanization, Goal 9 (industry, innovation and infrastructure), Goal 11 (sustainable cities and communities) and Goal 12 (sustainable consumption and production) are indivisible.

According to the MoEFCC, marine life in ocean and rivers is affected due to pollution caused by chemicals, waste, and sewage discharged into coastal waters from various sources including industries. (MOEFCC, 2018) These contaminants have adverse impacts on mammals including turtles and other forms of marine life. There have been incidences of fish deaths due to depletion of oxygen and algal blooms have caused change in colour of sea surface. Localized marine pollution is due to nutrient flux like nitrate and microbial activity from discharge of untreated domestic sewage in coastal waters. (MOEFCC, 2016) According to a report by the World Economic Forum, the Indus and the Ganges, which flow through India, carry the second and sixth highest amounts of plastic debris to the ocean. (WEF, 2018)

India is home to eight per cent of the world's biodiversity, including numerous endemic species that are found on terrestrial ecosystems which are increasingly facing threat due to land degradation and desertification. According to the Desertification and Land Degradation Atlas of India, approximately 30 per cent of India's land area is degraded. (SAC, 2016) The Space Applications Centre (SAC) in 2016 estimated that India had 96.54 million hectares under desertification and land degradation in 2011/2013, an increase of 1.87

[6] MOEFCC (2016), 'Environment Ministry releases new categorisation of industries', http://pib.nic.in/newsite/PrintRelease.aspx?relid=137373

million hectares since 2003/05. (SAC, 2016) In eight states—Rajasthan, Delhi, Goa, Maharashtra, Jharkhand, Nagaland, Tripura and Himachal Pradesh—around 40 to 70 per cent of land has undergone desertification. In addition, 26 of 29 Indian states have reported an increase in the area undergoing desertification in the past 10 years. While wind erosion was the main process leading to desertification in the arid regions, vegetal degradation and water erosion dominated in the semi-arid and dry sub-humid regions. An MoEFCC commissioned study estimates that the economic losses from land degradation and land use change in 2014-15 stood at 2.54 per cent of India's GDP or INR 3,177.39 billion (Approximately USD 46.9 billion) for that year. (TERI, 2018b) Thus, pollution is indivisibly linked to Goal 14 (marine life) and Goal 15 (terrestrial ecosystems).

Environment and clean energy in India's Nationally Determined Contributions

India communicated its INDCs at the 21st meeting of the Conference of Parties (COP 21) of United Nations Framework Convention for Climate Change (UNFCCC), in 2015, *keeping in view its development agenda, particularly the eradication of poverty coupled with its commitment to following the low carbon path to progress and being sanguine about the unencumbered availability of clean technologies and financial resource from around the world*. The INDCs are summarised in Box 1.

Box 1 : India's INDCs

1. To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation.
2. To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
3. To reduce the emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level.
4. To achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF).
5. To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.
6. To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
7. To mobilize domestic and new & additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
8. To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

Source: UNFCCC- https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf

The NDCs communicated by India envisage a climate friendly and a cleaner path than the one followed hitherto by other nations at corresponding level of economic development.

Specifically, two of the NDC objectives are relevant for improving environmental sustainability and addressing climate change. These are,

- To reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level.
- To achieve about 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF).

Environment and intergovernmental fiscal transfers in India

Inter-Governmental transfers are an important source of finance for subnational expenditures in many countries, financing approximately 60% of sub-national expenditures in developing countries, and approximately 30% in OECD countries. (UNDP, 2016) Several countries have used intergovernmental grants to incentivize environmental protection at the sub- national level. In India, the issue of compensation to States for conserving natural resources for inter-jurisdictional ecological services is more recent but has rapidly gained voice, especially in the context of forests. The issue was also discussed at length by the second Commission on Centre-State Relations (largely in the context of ecological services provided by forests) and has been taken up by successive Finance Commissions, since the XII Finance Commission.

The role of the Finance Commission in environmental and natural resource management emerges on at least two counts. First, subjects such as forests, air, and water are public goods characterized by inter-jurisdictional spill overs and are likely to be under-provided (e.g. forest conservation or clean air) compared to what is socially optimal if left entirely to State governments. Second, since the 73rd and 74th amendments to the Constitution in 1993, recognizing local bodies as the third tier of government, successive Finance Commissions starting with the X FC, have made explicit fiscal provisions for supporting local bodies. As many environment-related subjects have been devolved to local bodies, the finances of these bodies will be a crucial determinant of the status of environment in the country.

Since the XII Finance Commission, successive Finance Commissions have aimed at promoting environmental stewardship in different ways. The XII FC recommended Rs.1000 crore spread over the award period 2005-2010 for maintenance and preservation of forests, which was to be over and above the budget of the State Forest Departments. It recommended that the grant be distributed among States based on their forest area, and be spent for preservation of forest wealth only. (Finance Commission, 2004) Forests are the subject of separate study and are included here only for completeness.

For the first time, the ToR of XIII Finance Commission included "the need to manage ecology, environment and climate change consistent with sustainable development". It recommended Rs.15000 crore to be distributed, inter-se, based on states' relative performance in managing forests and water resources and promoting renewable energy.

The forest grant (Rs.5000 crore) was to be distributed across states based on a formula reflecting the state's share in the country's total forest area; percentage of forested area in the state's total geographical area relative to the national average; and a weight reflecting the quality of forests (Finance Commission of India, 2009). Grants for the first two years were untied but priority was given to the preparation of working plans. Release of grants for the

last three years was linked to progress in the number of approved working plans. Further, of the total released grant, States could use 75% for development purposes and the remaining 25% was to be used for preservation of forest wealth as an additional amount in the State's forestry and wildlife budget.

A grant amount of Rs. 5000 crore was recommended for the generation of grid electricity from renewable sources (as defined by Ministry of New and Renewable Energy). The incentive was based on the State's achievement in renewable energy capacity addition in MW between 1st April, 2010 and 31st March, 2014. The grant allocated for the renewable energy was performance based; therefore, no state-wise allocation was done upfront by the XIII FC. There were two sub components to the incentive:

1. Achievement in installed capacity addition relative to unachieved potential, with a weightage of 25%
2. Achievement in installed capacity addition relative to aggregate installed capacity addition across all states, with a weightage of 75%

Further, the Commission also recommended a cap in the incentive as follows:

- A cap of Rs 1.25 crore/MW of installed capacity addition during 2010-14 for general States
- A cap of Rs 1.50 crore/MW of installed capacity addition for special States, to account for factors related to access and consequent cost disability

An analysis of actual disbursement of the XII FC renewable energy grant shows that Rs 4992 crore of the Rs 5000 crore was finally disbursed to the States. Tamil Nadu received 20% of this amount and 9 States accounted for 90% of the total grant (see Figure 2.).

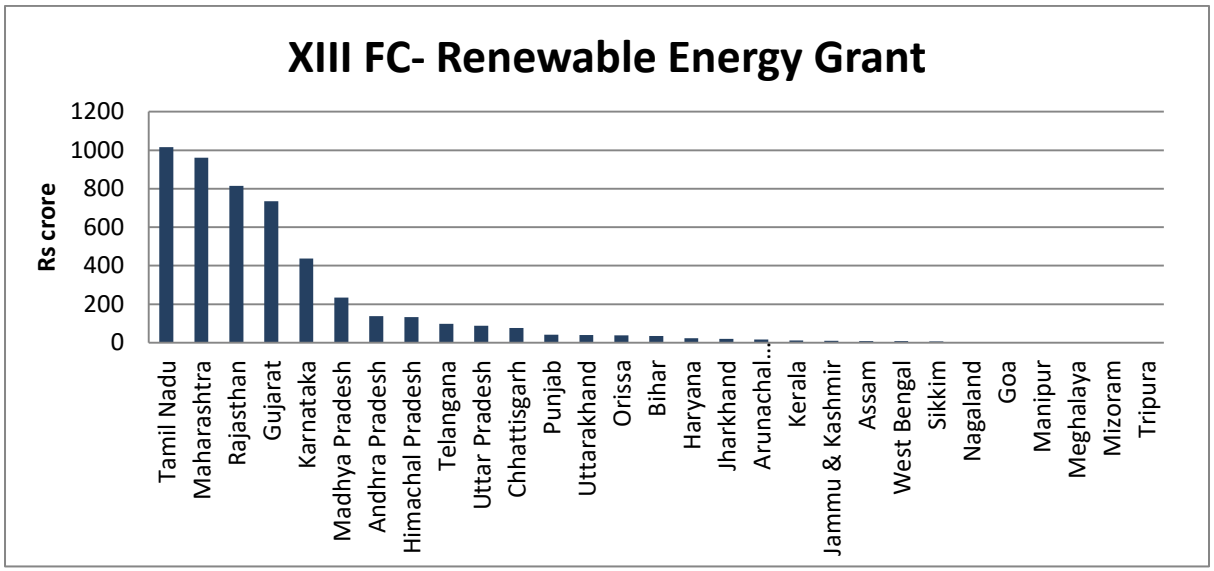


Figure 2 : XIII FC Grant for Renewable Energy: Actual Release (Rs Crore)
Source : Data from Ministry of Finance

The XIII Finance Commission also recommended an incentive grant of Rs 5000 crore for water sector management, including the setting up of a Water Regulatory Authority in each state and specification of a minimum level of recovery of water charges. The allocation of the grant to States was determined to be in proportion to their respective share in the total Non-Plan Revenue Expenditure (NPRE) across all states of expenditure on irrigation; and in

proportion to their respective share in all states Irrigation Potential Utilised (IPU) at the end of the 10th FYP. An analysis of actual release shows that only 28% (Rs 1415 crore) of the recommended Rs 5000 crore was ultimately released. Only Maharashtra received the full recommended amount, since it was the only State with a functional Water Regulatory Authority- see Figure 3. Most States did not receive the entire recommended amount, presumably because of non-fulfilment of grant conditionality. Some States received 25% of the recommended grant evidently because of notification of water charges- Table 2 shows the current status with respect of water charges in different States. In all, two States (UP and Maharashtra accounted for 50% of the grant amount released.

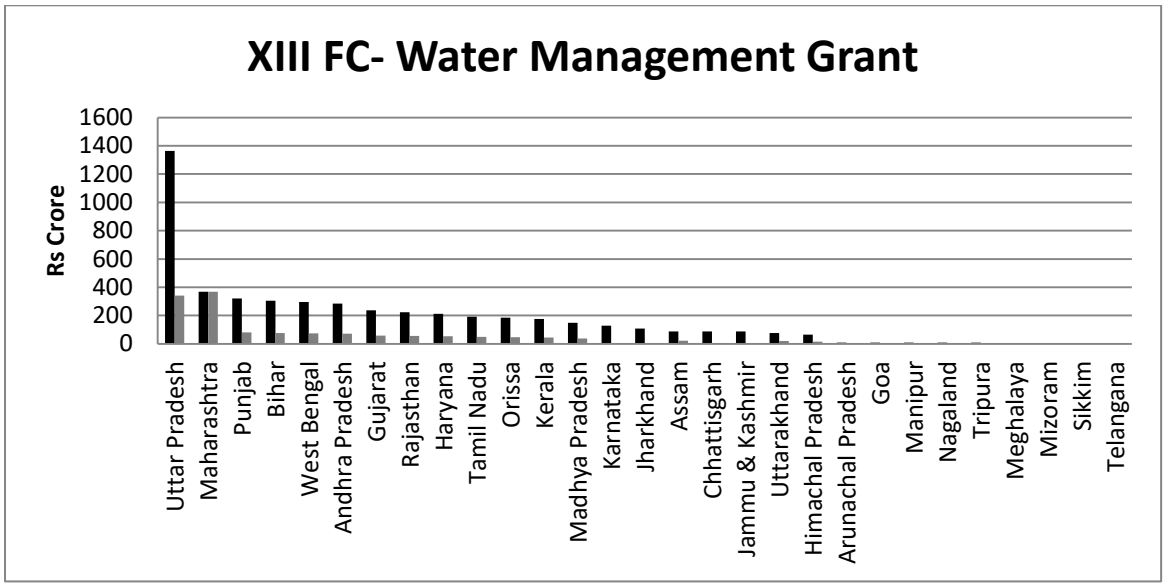


Figure 3 : XIII FC Grant for Water Management: Recommended vs Actual Release (Rs Crore)
Source : Data from Ministry of Finance

Table 2 : State/UT-wise Water Rates for Flow and Lift irrigation

(Unit in Rs/ ha)

S. No	State / UT	Flow Irrigation Range		Lift Irrigation Range		Date since applicable
		Maximum	Minimum	Maximum	Minimum	
1	Andhra Pradesh	864.50	148.20	NA	NA	01-07-1996
2	Arunachal Pradesh	No Water Rates				29-12-2008
3	Assam	751.00	150.00	751.00	150.00	30-03-2000
4	Bihar	370.50	74.10	NA	NA	Nov-2011
5	Chhattisgarh	741.00	123.50	741.00	123.50	15-06-1999
6	Delhi	148.20	34.03	148.20	33.35	2009
7	Goa	360.00	72.00	720.00	144.00	01-04-2013
8	Gujarat	300.00	160.00	100.00	53.33	01-01-2007
9	Haryana	197.60	24.70	98.80	12.35	27.07.2000
10	Himachal Pradesh	49.92	49.92	99.81	99.81	01-04-2015
11	Jammu & Kashmir	298.87	121.03	2998.58	298.87	01-04-2015
12	Jharkhand	370.50	74.10	370.50	74.10	26-11-2001
13	Karnataka	988.40	37.00	1976.80	74.00	13-07-2000
14	Kerala	99.00	37.00	148.00	93.00	18-09-1974

S. No	State / UT	Flow Irrigation Range		Lift Irrigation Range		Date since applicable
		Maximum	Minimum	Maximum	Minimum	
15	Madhya Pradesh	960.00	50.00	960.00	50.00	31-12-2005
16	Maharashtra	6297.00	119.00	5405.00	20.00	01-07-2003
17	Manipur	602.00	184.00	602.00	184.00	24-08-2013
18	Meghalaya	No Water Rates				
19	Mizoram	No Water Rates				
20	Nagaland	No Water Rates				
21	Orissa	930.00	60.00	NA	NA	05-04-2002
22	Punjab	123.50	123.50	123.50	123.50	12-11-2014
23	Rajasthan	286.52	29.64	573.04	14.82	24-05-1999
24	Sikkim	450.00	10.00	NA	NA	2002
25	Tamil Nadu	61.78	2.77	NA	NA	06-11-1987
26	Tripura	312.50	312.50	312.50	312.50	01-10-2003
27	Uttarakhand	474.00	30.00	237.00	15.00	18-09-1995
28	Uttar Pradesh	474.00	30.00	237.00	15.00	18-09-1995
29	West Bengal	123.50	37.06	2015.12	251.94	01-07-2003
30	A & N Islands	No Water Rates				
31	Chandigarh *	NA				
32	Dadra & Nagar Haveli	830	110	275	75	29-01-1996
33	Daman & Diu	286	286	286	286	2007
34	Lakshadweep	No Water Rates				
35	Puducherry	NA				

* In rural areas of Chandigarh, the water rates for irrigation purpose is Rs.23/- per hour w.e.f.01.01.2010

NA : Not Available

Source: Pricing of Water in Public System in India 2017, Information System Organisation Water Planning & Projects Wing, Central Water Commission, March 2017, page 11

The XIV FC was landmark in that it incorporated "Forest Cover" as a criterion in the horizontal tax devolution formula itself with a weightage of 7.5%. (Finance Commission of India, 2015) The Commission recognized that States had the responsibility of environment management and climate change while creating suitable conditions for sustainable economic growth and development; and went on to say that "Of these complex and multidimensional issues, we have addressed a key aspect, namely, forest cover, in the devolution formula". The rationale behind selecting forest cover was that a large forest cover provides huge ecological benefits, but also gives rise to an opportunity cost in terms of area not available for other economic activities and therefore, serves as an important indicator of fiscal disability (Finance Commission of India, 2015). The devolution formula, thus, was meant to capture both revenue and cost disability and also enable the States to consider forests as a national treasure that needed to be protected (XIV FC).

Table 3 : Criteria and Weights for Tax Devolution: XII, XIII and XIV Finance Commissions

XII FC		XIII FC		XIV FC	
Criteria	Weight (%)	Criteria	Weight (%)	Criteria	Weight (%)
Population (1971)	25.0	Population (1971)	25.0	Population (1971)	17.5
Income Distance[7]	50.0	Area	10.0	Demographic Change[8]	10.0
Area	10.0	Fiscal Capacity Distance[9]	47.5	Income Distance[10]	50.0
Tax Effort[11]	7.5	Fiscal Discipline	17.5	Area	15.0
Fiscal Discipline[12]	7.5			Forest Cover	7.5

Source: XII, XIII, XIV Finance Commission Reports

In 2012, the erstwhile Planning Commission of India had engaged with the inclusion of environmental performance as a criterion in the allocation of central assistance to State plans. The exercise aimed to recognise environmental management efforts (pollution abatement, natural resource conservation and reduction of GHG's) made by States and rank States based on their environmental performance. The Planning Commission had selected 5 criteria (air pollution, water quality, forests, waste and climate change) and 16 indicators to prepare a composite EPI ranking of the States (see Table 4). Eventually, the index was not used.

7 For determining the state-wise **Income Distance** index, the Commission considered average per capita comparable Gross State Domestic Product (GSDP) of each of the 28 states for the last three years (1999-2000, 2000-2001 and 2001-2002), Following 10th& 11th FC, average of the top three states with highest per capita income was taken to compute the income distance of each state.

8 The ToR of the 14th FC recognized **Demographic Change** and provided space for these changes across States to be taken into consideration while deciding devolution shares. Migration was seen as an important factor affecting population of a State. It posed several challenges including resource utilization leading to additional administrative and other costs. The 14th Finance Commission concluded that a weight to the 2011 population would capture the demographic changes since 1971, both in terms of migration and age structure.

9 **Fiscal Capacity Distance** is the distance between states in tax capacity. The Commission estimated state-wise per capita tax revenue using the three year average per capita GSDP for 2004-05 to 2006-07 and obtained the average tax to comparable GSDP ratio as the weighted mean separately for general and special category states. These group specific averages were applied to the constituent states in each group to obtain per capita tax revenue. Finally, fiscal distance was obtained for each state as the distance between its estimated per capita revenue and the estimated per capita revenue of the second highest state in per capita income ranking.

10 The 14th FC reverted back to the method of representing fiscal capacity in terms of **income distance**. It adopted the 12th FC methodology for estimating income distance.

11 **Tax Effort** criterion was worked out by taking the three year average (1999/00- 2001/02) of the ratios of own tax revenue to comparable GSDP weighted by the square root of the inverse of the per capita GSDP.

12 **Fiscal Discipline** was proposed by 11th FC view to provide for an incentive for better fiscal management. It was computed as a ratio of the state's revenue receipts to revenue expenditure for base year and reference period. E.g. the 12th FC computed the index using the base period from 1993-94 to 1995-96 and the reference period from 2000-01 to 2002-03.

Table 4 : Criteria and indicators of EPI by Planning Commission

Criteria	Indicators	Number of variables
Air Pollution	NOx, SOx, RSPM	3
Water quality	% domestic waste water treated, Surface water quality, % Ground water extraction	3
Forest	Forest cover as % of state geographical area and contribution to national average, increase in forest cover, growing Stock and afforestation efforts	4
Waste	% MSW, % bio-medical waste, and % industrial waste disposed.	3
Climate change	Status of preparation of State Action Plan on Climate Change, renewable energy growth rate including mini hydro, electricity intensity of SGDP.	3
TOTAL		16

Source: Chandrasekharan etal 2013

An environmental index at the national or state level is a useful idea for understanding the impact of environmental problems that are cross-cutting in nature. However, its use as a basis for compensating states or incentivising their behaviour in favour of environmental actions may be fraught with difficulties in the present context. While, it is possible to evolve and provide separate parameters for air quality and water quality (apart from forests) for States, the performance of states will need to be judged on the basis of transparently available and measurable data. Adequate number of measurement stations and relevant time series data are not available uniformly in all states. Environmental index at the state level, both in case of air and water, at the state level may therefore suffer from data constraints, and questions may be raised about how representative these are at the state level. Determining weights for different parameters will necessarily be subjective resulting in debate over acceptability of such a comprehensive state level environmental index. The EPI exercise conducted by erstwhile Planning Commission could not be carried forward due to similar reasons.

While a state level index is fraught with challenges, a city-level approach for both determining environmental quality and proposing use of grants for specific environment-related interventions/purposes is possible in view of the fact that source apportionment studies are usually undertaken for cities or urban agglomerations and data at city level is more robust and comparable than at the State level. Moreover, the poorest urban households face a higher infant mortality rate than the average effect seen in rural areas.

International experience

Globally, while countries have begun to address the issue of environmental degradation through policy instruments, the use of inter-governmental fiscal transfers has been limited, and not documented well in the literature. In some countries, national governments award grants to local governments for activities and initiatives related to environmental conservation and climate change. For example, in the United States Environmental

Protection Agency (USEPA) awards grants to state governments for state-led climate interventions as well as the prevention and mitigation of pollution (USEPA, 2016).[13] 65% of the state's funding will be to support air related regulations including the implementation of National Ambient Air Quality Standards, state implementation plans, developing and implementing activities to reduce air toxins, and state level activities to address climate change, while 35% will be for high priority activities which are identified by states including air and water pollution control, hazardous waste management, among others (USEPA, 2016). There have also been other measures that allow central institutions to encourage action. For example, in 1990, the Federal Clean Air Act was amended to authorise EPA to impose sanctions in case of failure to submit an adequate plan or to demonstrate attainment.[14] One way of doing this was calculating payments made by stationary sources in relation to projected emissions. Another measure was withholding highway funds for non-attainment areas[15].

The European Union has also been providing assistance to Member States in the form of funding to address the challenge of air quality through direct and indirect interventions. As per 2018 EC Communication, one third of investments under the European Fund for Strategic Investments have gone into energy, transport and environment with an indirect positive effect on air quality. The LIFE programme (EU's funding instrument for environment and climate) has provided financial support for implementation of air quality plan and improvement of quality of life in in Poland, Slovakia and the Czech Republic. (European Commission, 2018) [16]

Taxation instruments have been developed to promote energy efficiency in several countries either through linking subsidies to energy usage, or tax exemptions, or through carbon taxes. For example, in Russia energy efficient equipment is exempt from property tax for a certain number of years; Japan has lower taxation rates for vehicles that emit lower levels of pollutions (such as those run on methanol, compressed natural gas, or electricity, or hybrid cars) and higher taxation rates for older vehicles; in the United States, energy efficient tax deductions are provided to commercial buildings; and the Netherlands was one of the first countries to introduce a tax on natural gas and electricity in 1996 (NIPFP, 2012). Congestion charges, to charge road users in order to reduce congestion, have been imposed in several cities including in Singapore, Stockholm, London, Milan and Hong Kong (Pike, 2010; Amelsfort, 2015).

Ecological fiscal transfers have been introduced in some countries, largely on the basis of protected areas (PAs) (Brazil, France, and Portugal). They have been suggested for other countries such as Germany, Indonesia, Poland and Switzerland, also using protected area coverage as a criterion. Criteria other than PAs, including waste management and watershed management have been included at the subnational level in some states of Brazil (Droste 2015, Ring 2008).

---

[13] USEPA (2016) *Grant Guidance for Multipurpose Grants to States and Tribes*. Available online at: https://www.epa.gov/sites/production/files/2016-04/documents/final_multipurpose_grant_guidance_0.pdf

[14] Danish National Environmental Research Institute and the Center for Clean Air Policy (2004) Assessment of the effectiveness of European Air Quality Policies and Measures, http://ec.europa.eu/environment/archives/cafe/activities/pdf/database_report.pdf

[15] non-attainment area is an area with air quality below the National Ambient Air Quality Standards under the Clean Air Act

[16] European Commission, (2018) Communication "A Europe that protects: Clean air for all" Dated 17 May 2018

Against this overall backdrop of experience with environment-related inter-governmental transfers in India and globally, the following chapters take up the issue of air pollution in greater detail. The objective is to understand the role of the Finance Commission in general and discuss the alternative approaches that the XV FC can adopt in this regard.

3 Air quality: status and governance framework

Introduction

Air pollution is a complex and dynamic phenomenon, often confused with haze, dust or even smog (smoke + fog). However, its sources are actually far more intertwined and multi-sectoral as are its impacts on human health.

An air pollutant is a substance, which mixes with the air and causes various types of health impacts. Air pollutants can be grouped in two broad categories:

(a) particulates (including carbon, ions, heavy metals), and

(b) gases (oxides of sulphur (SO2), oxides of nitrogen (NOx), carbon monoxide (CO), ozone, volatile organic compounds (VOCs, dioxins etc.).

The different composition of air pollutants, as well as the time and amounts of exposure from one pollutant and/or a mixture of pollutants can lead to diverse impacts on human health. Vulnerability factors such as age, nutritional status and pre-disposed earlier conditions exacerbate the effects of air pollution on human health.

Air pollution has emerged as one of the biggest environmental challenges in India as a result of rapid economic growth and urbanisation. The demand and consumption of all fossil fuels has increased tremendously.

Ten cities in India are listed among the top 20 cities globally with highest concentration of ambient particulate matter (less than 2.5 microns in size) (WHO, 2016).[17] Even when measured against India's air pollution standards, which are less stringent than the WHO norms, more than 70% of Indian cities where air quality is being measured exceed the safe threshold level.

Table 5 shows the differences in Indian national ambient air quality standards and WHO guidelines. Also, Indian cities which are not meeting even the national ambient air quality standards, are way above the prescribed WHO air quality guidelines.

Table 5 : Comparison of Indian NAAQS, and WHO guidelines (µg/m3)

Parameter	Averaged over	Indian NAAQS (Industrial, residential, rura)	Indian NAAQS (sensitive)	WHO guideline
PM10	24-hour	100	100	50
	Annual	60	60	20
PM2.5	24-hour	60	60	25
	Annual	40	40	10
SO2	24-hour	80	80	20
	Annual	50	20	500 (10 min)-
NO2	24-hour	80	80	200 (1-hour)

[17] Particulate Matter is generally categorized into two types based on the size: PM_{10} (10 micrometers or less in diameter) and $PM_{2.5}$ (2.5 micrometers or less in diameter). PM2.5 is considered to be more harmful to health due to its finer size which leads to higher permeability in the lungs and also due to carcinogenicity associated with its constituents.

Parameter	Averaged over	Indian NAAQS (Industrial, residential, rura)	Indian NAAQS (sensitive)	WHO guideline
	Annual	40	30	40
O3	8-hour	100	100	100
	1-hour	180	180	-
CO	8-hour	2000	2000	-
	1-hour	4000	4000	-
NH3	24-hour	400	400	-
	Annual	100	100	-
Lead	24-hour	1	1	-
	Annual	0.5	0.5	-
Benzene	Annual	5	5	-
BaP	Annual	1	1	-
As	Annual	6	6	-
Ni	Annual	20	20	-

Source: CPCB (2009)[18] WHO (2005)[19]-

WHO estimates that ambient and household air pollution contributes to approximately 1.8 million premature deaths and 49 million disability adjusted life-years (DALYs) lost in India - ranking it among the top risk factors of human health in the country (Global Burden of Disease, 2015).[20] A World Bank study reported that diseases associated with air pollution have cost India as much as 8.5 per cent of its GDP in 2013. The total welfare loss of the country due to air pollution during 2013 had increased nearly 4-folds compared to that in 1990 (World Bank, 2016). A recent study by ICMR, PHFI and IHME found that 6.7 lakh deaths in India were caused due to outdoor particulate matter in 2017 (ICMR, 2018). In addition to human health impacts, air pollution is also associated with severe impacts on agricultural productivity and climate.

Some efforts made by both the central and state governments in India for control of air pollution, include measures like advancement of vehicle and fuel quality norms, enhanced LPG penetration, introduction of gaseous fuels and stringent environmental standards for industries. Despite these measures, the current state of air pollution in Indian cities shows that growth in the sources of air pollution is negating the positive impact of control measures, which have proved to be insufficient to address the scale of the problem.

Moreover, other than big cities like Delhi, Mumbai, and Bangalore, the issue has not received adequate attention in several parts of the country where pollution levels are significant. This is due to variety of reasons which include competing priorities, weak

[18] https://www.cpcb.nic.in/air-quality-standard/?&page_id=air-quality-standard

[19] https://www.who.int/phe/health_topics/outdoorair/outdoorair_aqg/en/

[20] Disability-Adjusted Life Year (DALY) is a measure for quantifying the burden of disease from mortality and morbidity. One DALY can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.

understanding of the underlying causes and solutions as well as capacity and regulatory constraints.

Since air pollution is a trans-boundary issue, it requires a cooperative approach at a wider regional level.

In this chapter, we analyse the status of air quality in India, its underlying determinants; as well as the policy and regulatory framework that governs air quality management in India. This analysis is used as the basis for defining the potential role and recommendations for the 15th Finance Commission.

Air Quality in India

Air quality monitoring in India

Ambient air quality parameters include sulphur dioxide (SO_2), oxides of nitrogen (NO_x), carbon monoxide (CO), ozone (O_3) and particulate matter (PM- PM_{10}, $PM_{2.5}$). The Central Pollution Control Board (CPCB) had notified standards for ambient air quality in India. Since 2009, revised National Ambient Air Quality Standards (NAAQS) have been adopted. The revised standards merged industrial, residential and rural areas with a uniform air quality standard as opposed to lower permissible limit for industrial locations in the previous version. This change was accompanied by addition of a second category of locations, which was designated as ecologically sensitive areas. Additionally, several other pollution parameters were introduced to the list considering the toxicity associated with these pollutants. These included $PM_{2.5}$, Ozone, Ammonia (NH_3), Benzene, Benzo-α-pyrene (BaP) , Arsenic (As) and Nickel (Ni).

In order to assess the air quality against these standards, ambient air pollutant concentrations are monitored in all the states by CPCB and SPCBs under the National Air Monitoring Programme (NAMP). The network consists of 731 operating stations covering 312 cities/towns in the country. Under NAMP, four air pollutants viz. SO_2, NO_2, Respirable Suspended Particulate Matter (RSPM / PM_{10}) are monitored regularly at all the locations. The monitoring of meteorological parameters such as wind speed and wind direction, relative humidity (RH) and temperature have also been integrated with the monitoring of air quality.

Continuous monitoring of air quality

In addition to manual stations, CPCB has installed 134 real-time Continuous Ambient Air Quality Monitoring stations (CAAQMS) in 71 cities across 17 states monitoring eight pollutants viz. PM10, PM2.5, SO2, NOx, ammonia (NH3), CO, ozone (O3), and benzene. The National Clean Air Plan (NCAP), discussed in more detail later, has proposed to augment the continuous ambient air quality monitoring by setting up approximately 150 additional stations in various cities, focussing on cities in the Indo-Gangetic Plains.

In addition to continuous monitoring by CPCB (MoEFCC), Ministry of Earth Sciences (MoES), started an initiative, System of Air Quality and Weather Forecasting and Research (SAFAR) for some cities like Delhi, Pune, Ahmedabad etc. to provide real time air quality and its forecast for next 1-3 days in advance.

Air quality index

An Air Quality Index has been launched in 2014 for effective and simpler communication of air quality status. The index converts complex air quality data of eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb) into a single value and category (good to severe). The categories are based on ambient concentration values of air pollutants and their possible health impacts thresholds. Based on the measured ambient concentrations of a pollutant, a sub-index is calculated for each pollutant and the worst sub-index is chosen as the overall AQI. The AQI categories and pollutant-wise thresholds are shown in Table 6.

Table 6 : AQI categories and thresholds

AQI Category	AQI	Concentration range*							
		PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	NH_3	Pb
Good	0 - 50	0 - 50	0 - 30	0 - 40	0 - 50	0 - 1.0	0 - 40	0 - 200	0 - 0.5
Satisfactory	51 - 100	51 - 100	31 - 60	41 - 80	51 - 100	1.1 - 2.0	41 - 80	201 - 400	0.5 - 1.0
Moderately polluted	101 - 200	101 - 250	61 - 90	81 - 180	101 - 168	2.1 - 10	81 - 380	401 - 800	1.1 - 2.0
Poor	201 - 300	251 - 350	91 - 120	181 - 280	169 - 208	10 - 17	381 - 800	801 - 1200	2.1 - 3.0
Very poor	301 – 400	351 - 430	121 - 250	281 - 400	209 - 748*	17 - 34	801 - 1600	1200 -1800	3.1 - 3.5
Severe	401 - 500	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

* CO in mg/m^3 and other pollutants in $\mu g/m^3$; 2h-hourly average values for PM_{10}, $PM_{2.5}$, NO_2, SO_2, NH_3, and Pb, and 8-hourly values for CO and O_3.

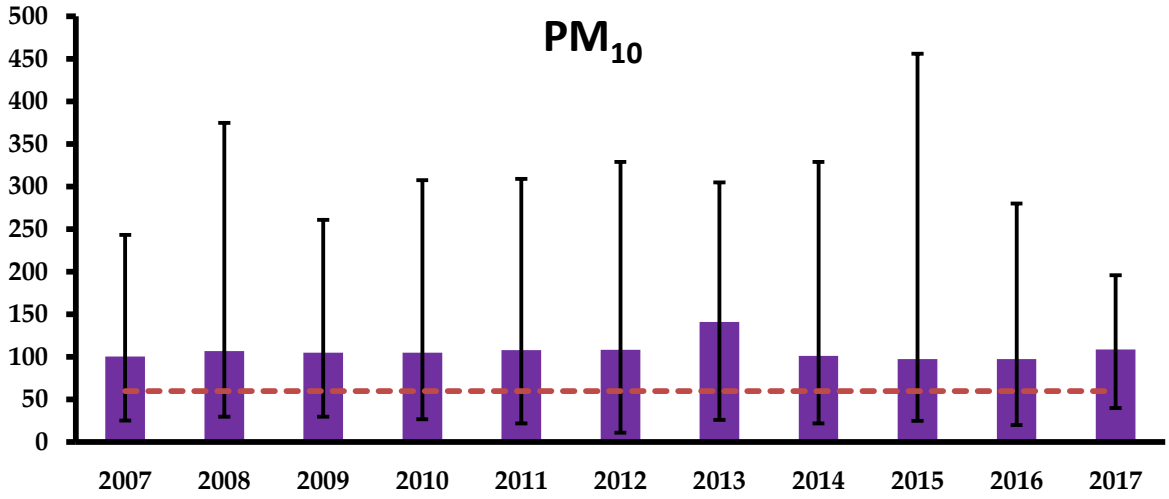
State of air quality in India

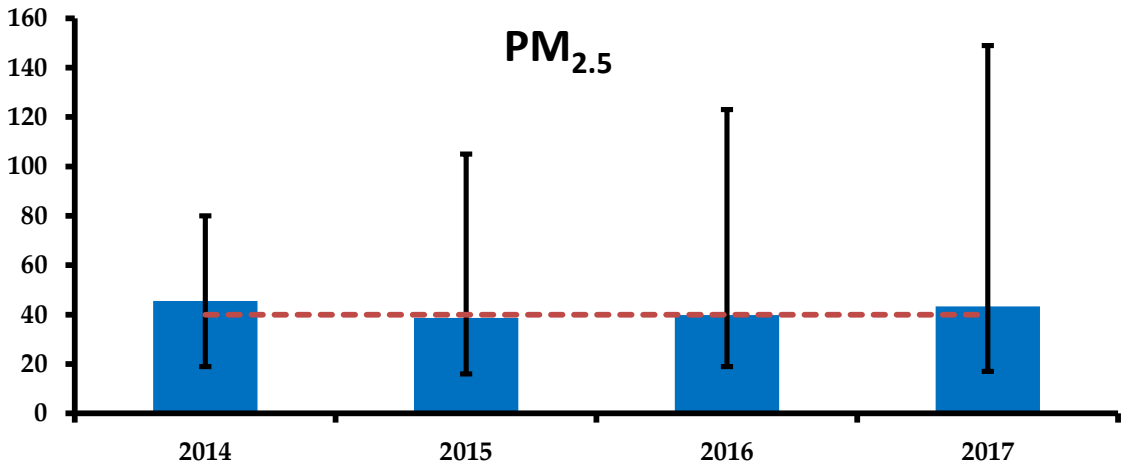
In order to present an overall picture of air quality in India, annual averaged data for cities (where air quality monitoring is carried out) have been collected from CPCB NAMP stations. While continuous monitoring is also available for some cities now, data of manual stations across 300 cities chosen by TERI for the present study for the 15th Finance Commission for carrying out the analysis because of its widespread spatial and temporal coverage. The data trends for different pollutants –PM10, PM2.5 , SO2 and NOX is presented in Figure 4 . While PM10 , SO2, and NOx data are available since 1999, PM2.5 monitoring is more recent. It is evident from the figures that PM levels exceed NAAQS for both sizes, whereas SO_2 and NO_x are within the NAAQS at most places in the country.

Why particulate matter is of maximum concern

Based on the data of manual stations in India, an attempt has been made in this study to analyse the trends and gap between the NAAQS and actually observed pollutant concentrations. Figure shows the average pollutant levels in India and a range of concentrations shown by various cities in the country. It can be observed that PM10 showed

fluctuating trends between 2007 and 2017. This could be attributable to variations in meteorological conditions, and increasing monitoring stations over the years. In case of PM2.5, an increasing trend can be observed for maximum values during 2014-2017. In case of both PM10 and PM2.5, both average and maximum values are higher than the prescribed annual average standards for all years. In case of SO2 and NOx, the average values are well below the prescribed standard but there are cities which violate the standards and hence, the chart shows violation of maximum values of these two gases. It is evident that PM pollution levels are of immediate concern to India, while SO2 and NOx concentrations are within standards in most of the cities where air quality monitoring is done. Conclusively, PM can be considered as the pollutant of main concern for India.





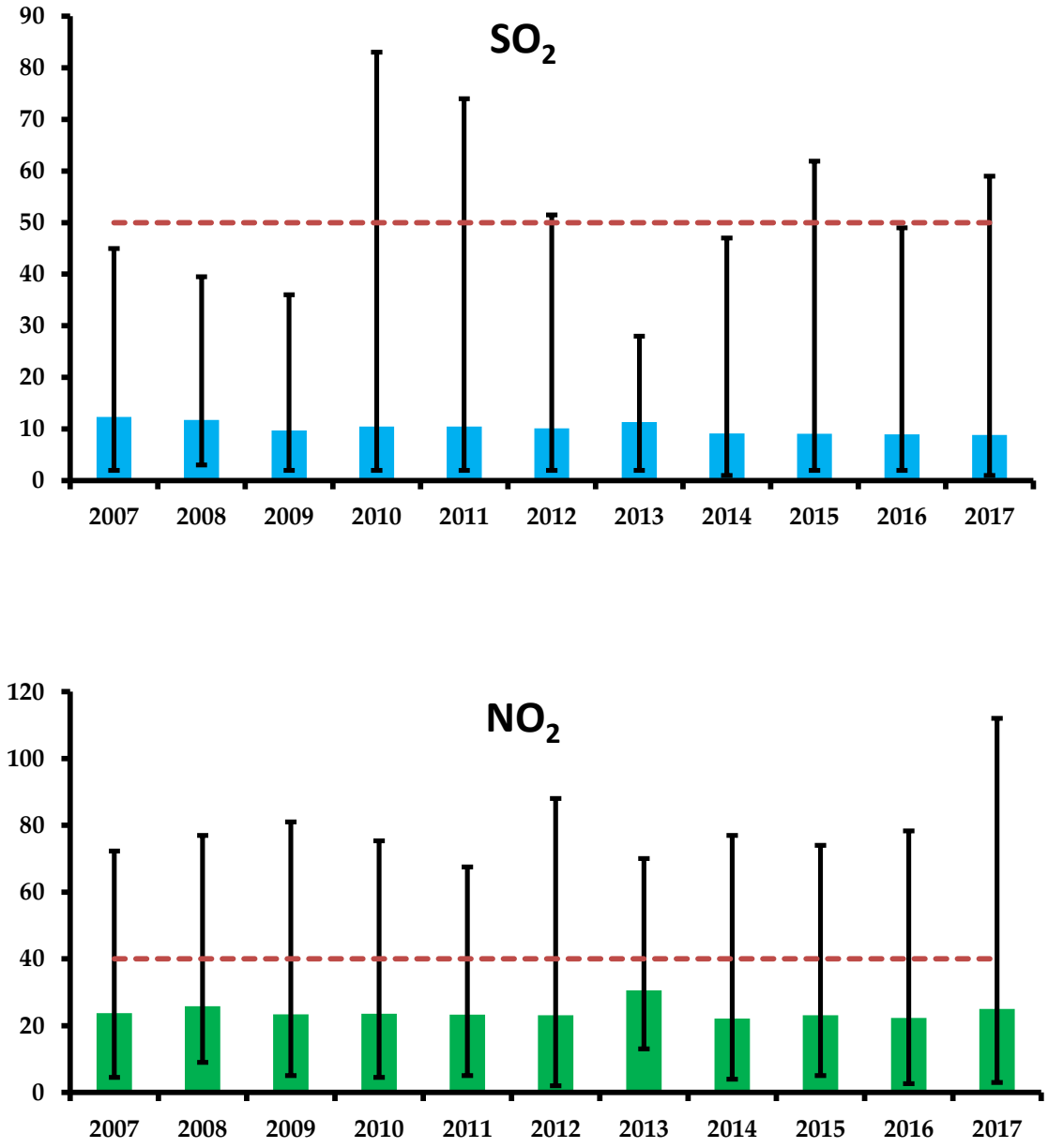


Figure 4 : Trends of annual average pollutant concentrations (averaged for several cities with range) in India
Data Source: NAMP data for various years from CPCB

Statewise analysis of air quality

For the purpose of this study, state-wise averages of concentrations of different pollutants have been calculated by averaging existing city level data. Figure 5 shows the State-wise average ambient air quality status for SO2 and NOx for the period 2007-16. As can be seen all States are well within the SO2 standard. Most also are within the NOx standard, with the noticeable exception of Delhi. West Bengal, Jharkhand and Bihar are close to the standard. The possible reasons for higher NOx in cities of these states is increased vehicular population and coal based power plants in the vicinity; which are the two primary causes of NOx emissions in India. While cities like Delhi have tremendous load of vehicles, States like Bihar, Jharkhand, West Bengal also deal with emissions from coal based power generation.

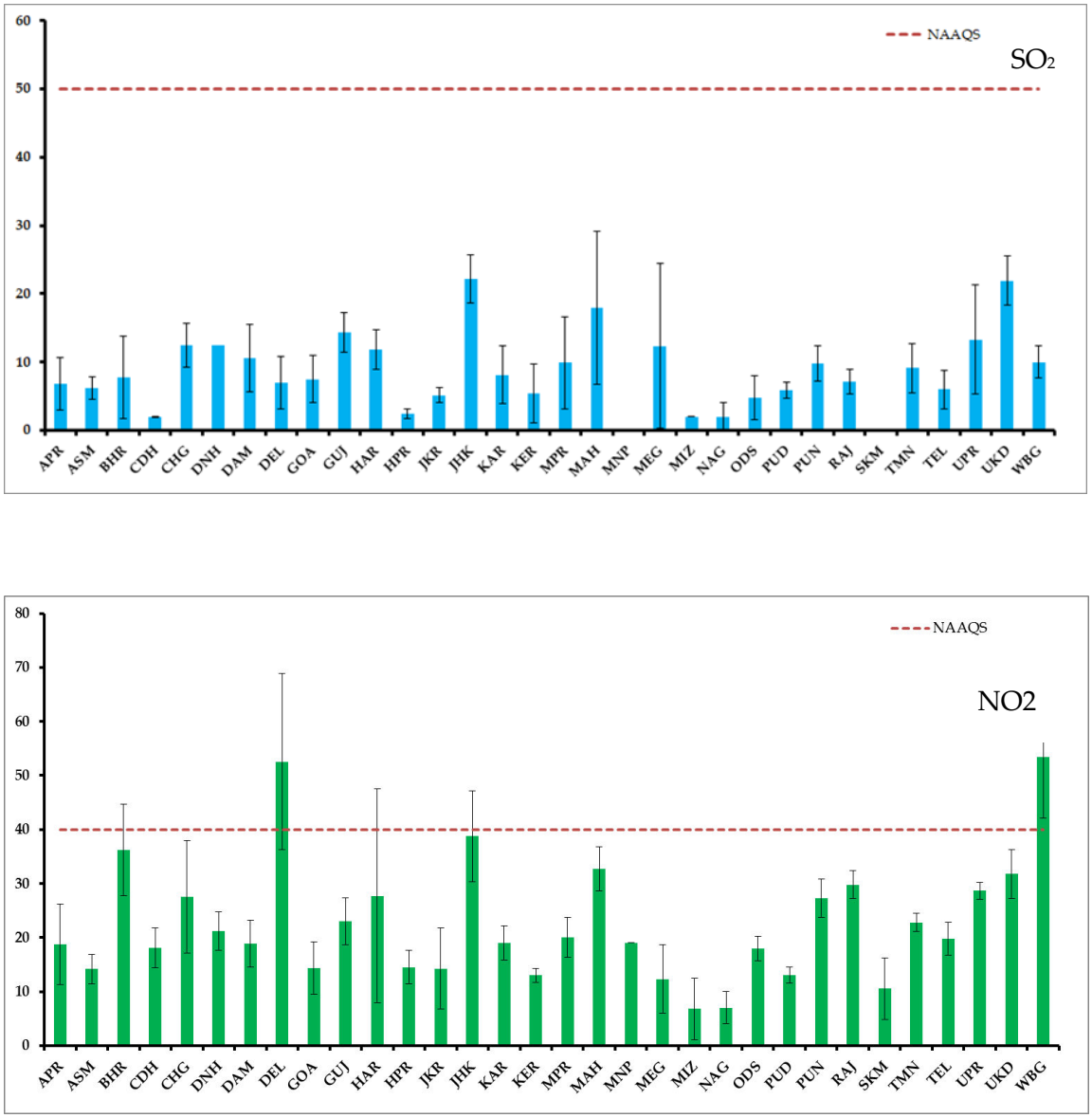


Figure 5 : State-wise average ambient air quality status of different pollutant parameters (SO2 and NOx) for the period 2007-16

Here again, it is PM that is the pollutant of concern in most States. For the purpose of this study, state-wise averages of PM10 concentrations were calculated by averaging city level data. Data for various monitoring stations was collected for 2010, 2011, 2015, and 2016. The data was available for most places, except a few States (Arunachal Pradesh, Manipur, and Tripura) that did not have any monitoring stations till 2016.

Figure 6 shows the averaged PM10 concentrations for different states in India. The average ambient PM_{10} concentration shows that most states are above the National Ambient Air Quality Standard (NAAQS) of 60 µg/m^3. The Figure shows the temporal variation in concentrations for each of the states over the last five years.

The air quality has improved for some states; however, it is still higher than the NAAQS. It is evident that states falling in the Indo-Gangetic plains like Bihar, Uttar Pradesh and Jharkhand also Punjab and West Bengal show higher PM10 levels. Surprisingly, Uttarakhand and Jammu and Kashmir also show high values (in Dehradun and Srinagar),

which could be attributed to solid fuel use (for cooking and heating), forest fires, and traffic congestion etc. Limited number of air quality monitoring stations in the state can also be a factor, highlighting the need to expand the monitoring network for better a more accurate data on air quality. Due to additional contributions from natural factors, States like Rajasthan show very high PM concentrations. Southern and NE states like Kerala, Goa, Mizoram and Meghalaya show the best air quality. Meteorological and geographical factors are also responsible for this improved air quality.

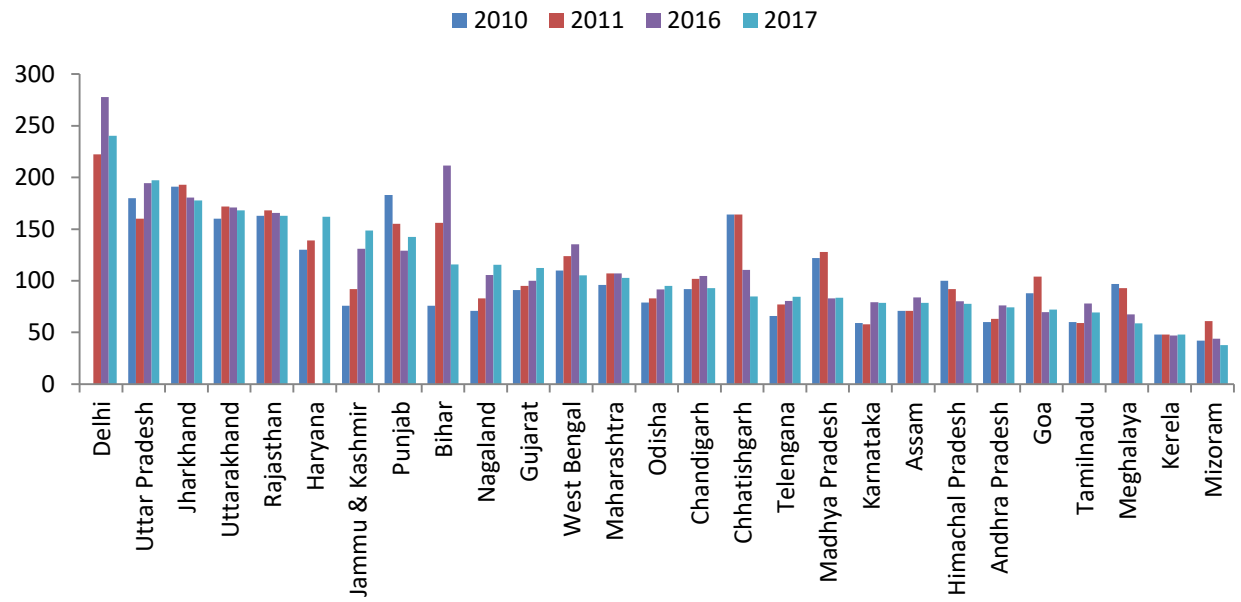


Figure 6 : Annual average PM_{10} concentrations of the Indian states
Source: NAMP

Modelling and satellite based assessments also establish the widespread nature of the problem across the country. Figure 7 shows annual averaged modelled PM2.5 concentrations in India (HEI& IITM, 2018). The Indo-Gangetic plains show the highest levels of PM2.5 (more than 80 µg/m3), however the levels are above the prescribed annual average standard of 40 µg/m3 at most places in India. It can be concluded that Indo-Gangetic plains is the most polluted region in India. However, since the rest of the country at several places does not meet the standards there is a need for nation-wide intervention.

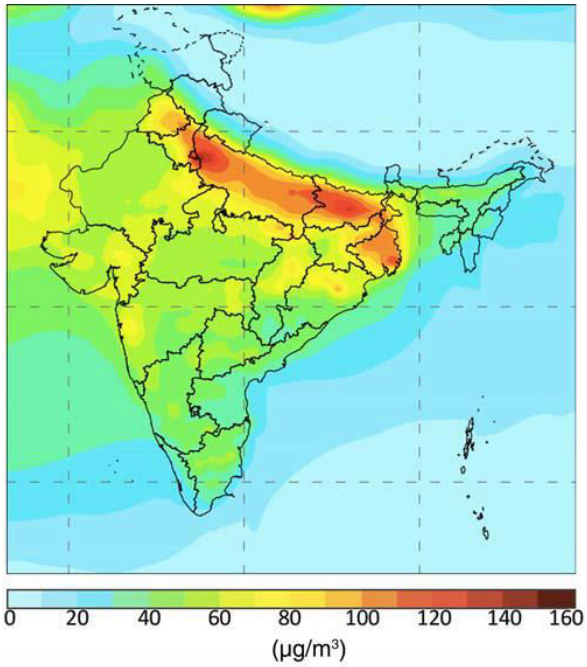


Figure 7 : Annual averaged modelled PM2.5 concentrations (2015) for India
Source : HEI & IITM (2018)

AQI analysis

AQI values are reported on a daily basis for various cities. However, limited data is available on monthly and yearly averages for some cities across India. Figure 8 shows the monthly averaged values for cities in NCR. It is evident that air pollution levels reach 'severe ' category in winters and are lowest during the monsoon months. Even in summers, the air quality remains 'poor' in the NCR cities.

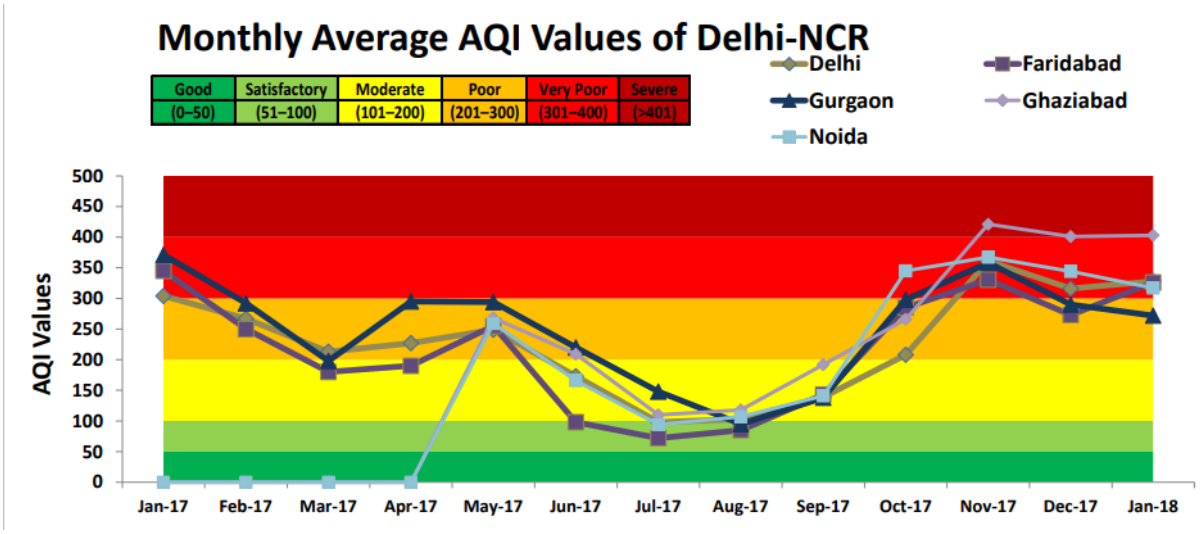


Figure 8 : Monthly average AQI values for Delhi-NCR for the year 2017

Impacts of air pollution

Scientific research has established an association between air pollutants like particulate matter (PM10 and PM2.5), VOCs, oxides of sulphur (SOx), oxides of nitrogen (NOx), ozone, and carbon monoxide (CO) and their adverse health effects, especially on respiratory and cardiovascular diseases. Immediate aggravated cardiovascular and respiratory illness due to high air pollution in particular high levels of particular matter damage cells of the respiratory system. Chronic exposure of polluted air leads to permanent adverse health effects such as accelerated aging of the lungs, loss of lung capacity and decreased lung function and asthma, bronchitis, emphysema, and possibly cancer. Most vulnerable are persons with heart disease, coronary artery disease or congestive heart failure, lung diseases such as asthma, emphysema or chronic obstructive pulmonary disease (COPD), pregnant women, outdoor workers, older adults and the elderly, children under age 14, and athletes who exercise vigorously outdoors. The annual population-weighted mean exposure to ambient particulate matter $PM_{2.5}$ in India was 89.9 $\mu g/m^3$ (67–112 $\mu g/m^3$) in 2017 (Balakrishnan et al., 2018). This is much higher when compared to WHO guidelines and India's national ambient air quality standards. Such a high national average of PM2.5 concentrations in India also indicates the wide spread nature of air pollution across the country. A recent study by ICMR, PHFI and IHME found that 6.7 lakh deaths in India were caused due to outdoor particulate matter air pollution in 2017 (ICMR, 2018). The highest $PM_{2.5}$ exposure level was in Delhi, followed by the other north Indian States of Uttar Pradesh, Bihar and Haryana.

Within the mortalities due to air pollution, half of the deaths were attributed to population less than 70 years of age. The report also found that India holds 18% of the global population, while suffers 26% of premature mortality and health loss due to air pollution. As per their estimates, 77% population of India in 2017 was exposed to PM2.5 levels of more than 40 μg/m3, which is the prescribed annual average standard in India. The report found average PM2.5 annual exposure in India to be one of the highest in the world. The study concluded that average life expectancy in India would have been 1.7 years higher if the air pollution level were within the levels above which it causes health impacts.

Also, there is a two-way relationship between agricultural production and air pollution: agricultural production contributes significantly to air pollution; in turn, air pollution impacts agricultural productivity. Agriculture is the single largest contributor of ammonia emissions in India. In turn, ground-level ozone, which is formed by the reaction of nitrogen oxides and volatile organic compounds (VOCs), impacts agricultural productivity as well. As per a recent study, yields in 2010 in India were up to 36% lower for wheat than they otherwise would have been in absence of climate and pollutant emissions trends, with some densely populated states experiencing a 50% relative yield losses (Burney and Ramanathan, 2014).

Other than health and agricultural impacts, a range of other indirect impacts of air pollution like poor visibility and decreased tourist footfalls For example, Delhi, which is known for being among the most polluted cities in the world, has experienced days of very poor visibility causing disruptions in air, rail and road traffic; often leading to cancellation of international sporting events. Reports of a fall in international tourists visiting Delhi in the

winter months and anecdotal evidence of people moving out of Delhi have reinforced public perception of this problem.

Factors responsible for air pollution

Both anthropogenic and natural factors lead to degradation of air quality. In terms of source of origin, pollutants can be categorized as primary and secondary in nature. Primary pollutants are directly emitted into the atmosphere by natural and anthropogenic sources. These can further be classified as stationary and mobile sources. Stationary sources comprise mainly emissions from industries, e.g. power plants (point sources) and industrial processing sites, diffuse burning in open fields (area sources). Mobile sources (also known as line sources) are spread in a line, for instance, railroad locomotives and vehicles. Secondary pollutants are formed in the atmosphere from a series of chemical reactions like condensation, nucleation, coagulation and evaporation.

The major anthropogenic sources of air pollution are:

a. Biomass burning in cookstoves in rural households
b. Industrial process
c. Vehicular emissions
d. Diesel generator (DG) sets
e. Agricultural residue burning
f. Municipal solid waste burning
g. Construction activities

The contribution of different sectors in India for average PM2.5 concentrations has been estimated in modelling based research studies. Table 7 shows the contribution of different sectors to annual average PM2.5 concentrations in India estimated by HEI & IITM (2018) at the national scale. Residential biomass burning is evidently the major contributor, followed by contribution from industry. Transport sector has a smaller role to play, however, at the city level the role of the transport sector is much larger. Other than anthropogenic sources within India, natural dust from within and outside India plays an important role in PM2.5 concentrations. The western part of Northern India is especially influenced by dust from outside the country.

Table 7 : Contribution of different sectors to annual average PM2.5 concentrations in India

Source Sector	All India (%)	Rural India (%)	Urban India (%)
Residential biomass	23.90	24.20	22.10
Total coal	15.70	15.50	17.10
Industrial coal	7.70	7.60	8.50
Power plant coal	7.60	7.50	8.00
Open burning	5.50	5.50	5.60
Transportation	2.10	2.10	2.10
Brick production	2.20	2.10	2.20
Distributed diesel	1.80	1.80	1.40

Source Sector	All India (%)	Rural India (%)	Urban India (%)
Anthropogenic dust[b]	8.90	8.80	9.60
Total dust[c]	38.80	38.70	39.50

Source: HEI & IITM (2018)

City level source apportionments studies for India

In order to design cost effective programs and strategies for reduction of pollutant concentration in the ambient air, it is necessary to have information about the sources and their respective contributions. The term source apportionment describes techniques used to quantify the contribution of different sources to atmospheric pollutant concentrations.

Most source apportionment studies in India have been conducted in and around Delhi, Mumbai, Chennai and Kolkata with some contributions from Hyderabad, Tirupati, Durg, Kanpur, Agra and Chandigarh. Majority of these studies have focussed on PM_{10} and SPM and only in few instances, $PM_{2.5}$ has been considered. Studies on PM2.5 are increasing as it is the pollutant of most concern from the health perspective.

These studies have identified vehicular emissions, industries, biomass burning, road dust, construction dust and secondary formations as the major sources of PM_{10} and PM2.5 concentrations, with their contributions varying from city to city. Seasonal variation of PM_{10} shows significantly higher contribution of dusty sources in summer as compared to winter. This can be attributed to dry conditions and higher wind velocities in summers resulting in natural contributions from western regions in India and also trans-boundary sources.

Dust from road dust re-suspension, construction activities, and soil has the major contribution (6–58 per cent) to PM10 concentrations in the cities (Figure 8). The share of transport sector increases significantly, when focus is shifted from PM10 to PM2.5 (finer fractions) concentrations. The average share of transport sector increases from 19 per cent in PM10 to 31 per cent in PM2.5 concentrations. In Bangalore, it emerged as the single largest source (49 per cent) of PM2.5. Biomass burning contribution was significantly higher in winter than in summer, which is due to the use of biomass for heating and also because of agricultural residue burning. Variation in the contribution of sources may be attributed to the variation in activities at the local level and meteorology. Contribution from sources such as agricultural waste burning, industries (tall stacks) and natural dust particles (which are not so prominent within the city regions) are also observed to be high, mainly due to atmospheric transport of these emissions to cities from sources that may be remote. Share of combustion based sources increases dramatically, as we shift focus from PM10 to PM2.5 concentrations (Figure 9).

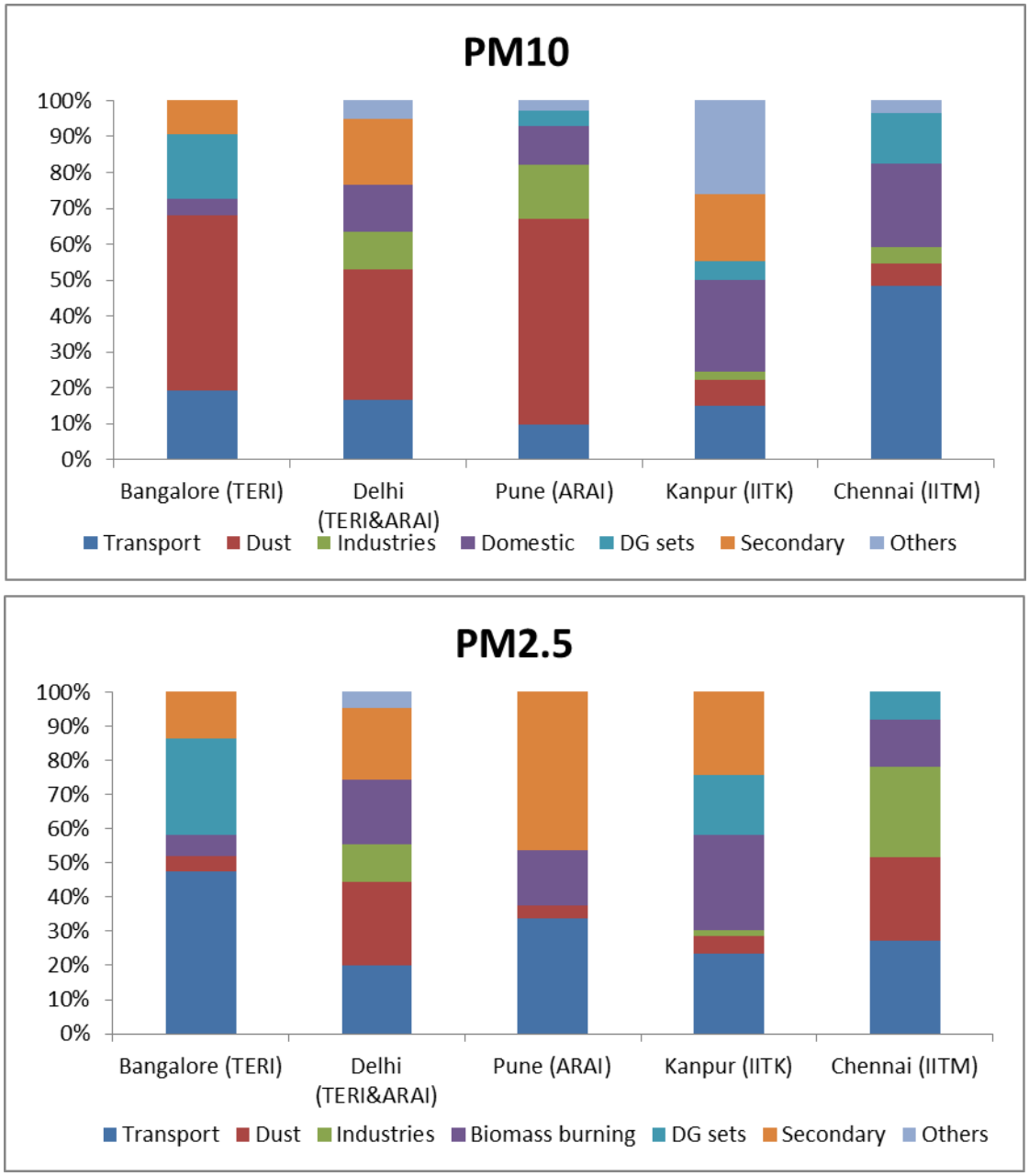


Figure 9 : Source contributions from different studies conducted in India for PM10 and PM2.5
Source : CPCB (2011), TERI & ARAI (2018)

Meteorology and Long Range Transport

Meteorology has an important application in the area of control and management of air quality. High air pollution concentrations can be transported over long distances by large-scale meteorological patterns. Pollutant concentrations in a city are dependent on local/urban sources (isolated factories, power plants, waste disposals, etc.) and also on regional basis formed by sources outside of the city limits. Pollutants emitted from major industrial areas or agricultural /forest fires retain high concentrations for greater distances and are dispersed on small and meso-scales.

Trans-boundary air pollution is a particular problem for pollutants that are not easily destroyed or react in the atmosphere to form secondary pollutants. It has been seen that

trans-boundary transport occurs either because the pollutants settle down at a very low rate (finer particulates) or stay suspended in the atmosphere for long durations. Several gaseous pollutants remain in the atmosphere and form new pollutants (e.g. secondary particulates, ozone) to add to the pool of pollutant emissions.

There are various challenges with trans-boundary pollutants, for instance, inter-state/international co-operation and collective action is required to deal with the issue and appropriate data collection is also necessary to apportion sources. In 1998, the United Nations Environment Programme (UNEP), together with the Stockholm Environment Institute (SEI) drew attention to the possibility of the impacts of trans-boundary air pollution in South Asia. This initiative led to the adoption of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Trans-boundary Effects for South Asia. Unfortunately, the available literature on trans-boundary dispersion of air pollutants is still very limited.

Trans-boundary impacts of air pollution are very relevant for Indian cities, which are influenced by contributions from outside of their limits. However, at a wider scale, or at the state level, the impact of trans-boundary pollution is somewhat lower.

Agricultural residue burning

The issue of crop residue burning is being discussed separately as it is a significant source of episodic atmospheric pollution in the Indo-Gangetic plains particularly during wheat, rice, sugarcane and cotton harvesting periods. Despite the focus on the issue, no clear solutions have emerged yet. Each year, residue burning leads to intensification of pollutant concentrations in the air and significant episodic pollution levels in the region. The problem is made more severe due to change in weather patterns in the winter months, which reduces the dispersion of pollution. This pollution not only contributes to local pollutant concentrations but also is a major regional source of pollution, contributing significantly to PM concentrations in the entire northern Indo-Gangetic Plains. It also results in emission of other harmful gases like methane, nitrogen oxide and ammonia. Residue burning is also associated with loss of vital nutrients such as nitrogen, phosphorus, sulphur and potassium from the topsoil.

Figure 10 shows the increasing trend of PM10 concentrations in 2017 and 2018, associated with the rise in the number of fire events detected around Delhi (300 km radius around Delhi) from satellite.

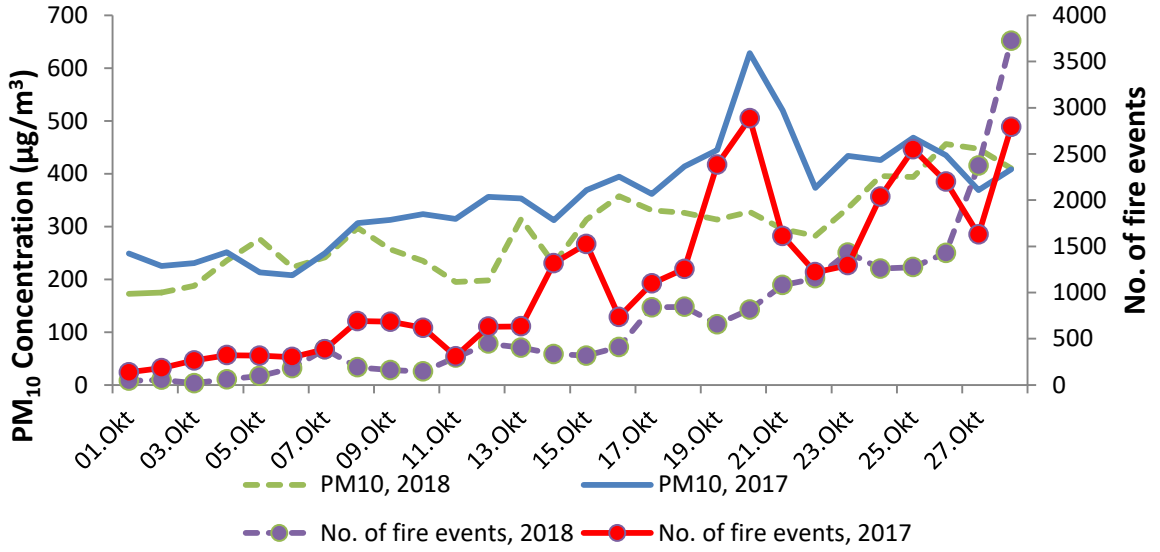


Figure 10 : PM_{10} concentrations and number of fire events around Delhi in 2017 and 2018

Uttar Pradesh, Punjab, Haryana, Bihar, Madhya Pradesh, and Himachal Pradesh have the largest areas under rice-wheat cropping system system among Indian states. Punjab produces approximately 19-20 million tonnes of paddy straw and about 20 million tonnes of wheat straw. Haryana produces an estimated 2 million tonnes of paddy straw. About 85-90 per cent of paddy straw is burnt in Punjab and Haryana (and increasingly, wheat straw is also being burnt during the Rabi harvesting season) while the share is much lower (0.1 per cent) in states like Odisha, Andhra Pradesh, and West Bengal. The differential may be attributable to the increased use of mechanical harvesters in Punjab and Haryana. Farmers use combine harvester machines for reaping, threshing and winnowing, which are convenient and economical for large areas. However, these machines only reap the grains, leaving stalks or stubble of around 40 cm. The stubble then needs to be removed manually, by specialized machines. However, the stubble is often burned to save labour and time to be prepare for the next crop.

The Cabinet Committee on Economic Affairs has approved a special fund of Rs.1151 crore for Punjab, Haryana, Uttar Pradesh and Delhi to deal with the post-harvest in-situ crop residue burning in the next two years period (by 2020). The sanctioned amount is to be spent on improving farmers' access to a range of farm machineries for in-situ management of crop residue as well as for information, education and communication. In addition, farmers get 40% subsidy under the sub-mission on agriculture mechanization on tractors combine harvesters, lesser leveller etc.

TERI interacted with several government and non-government entities in Haryana and Punjab to understand the views of stakeholders on residue management. The State Agricultural Department of Haryana emphasized the need for higher budget allocation and enforcement for effective control of agricultural burning. They also emphasized the need for ex-situ management such as conversion of residue to ethanol or gas. The State has signed a MOU with IOCL on ex-situ management of residue. The Punjab Agricultural Department highlighted the issues (such as difficulties in the production process, only marginal increase in yields, high costs, and unavailability of machine parts) being faced in the use of Happy Seeders, which were being initially promoted by the State Agricultural Universities as the

main solution. The present central allocation was also felt to be insufficient to cover the entire farmer community. It was pointed out that in the present scenario of limited equipment supply, restricted budget and almost insignificant ex-situ management, only 6 MT out of 15 MT of residue could be tackled. According to the Punjab State Pollution Control Board (PSPCB), in-situ management cannot be a full scale solution as strict enforcement year after year is a challenge. The PSPCB is working with entrepreneurs for the conversion of residue to fuels which can be supplied to power plants. The PSPCB was of the view that residue management should be linked to income generating opportunities of farmers through ex-situ management options, instead of pushing for a single in-situ technological solution.

Legal, institutional and policy framework for air quality management in India

The Constitution of India assigns functions, legislative competence, and fiscal powers for different subject to both the Centre and the States. Schedule VII, read with Article 246, assigns powers through three Lists: List I, the Union List, covers subjects that serve at a national level; List II, the State List, sets out those areas which are a State's exclusive jurisdiction, subject to other clauses; List III, the Concurrent List, identifies areas where both the Parliament and a State legislature can make laws, subject to central laws prevailing in case of a conflict where there is no scope for a harmonious reading of the provisions. Only Parliament has the residuary power to make laws on matters not included in the three lists. The relevant entries, which are relevant for air quality, and environment in general, and how they are distributed amongst Centre and States are listed in Table 8.

With the 73rd and 74th amendment decentralized governance was extended to local and rural level. (Table 9) Consequently, States *may* devolve the 'necessary' powers to municipalities and 'panchayats at appropriate level'. (Art 243 G) While envisaged as institutions of self-government, local and rural units are subject to State's control as they derive their powers and functions from respective State governments and not directly from the Constitution.

Table 8 : List of subjects distributed across different levels of governance under the Constitution of India

Jurisdiction	Items
Union	International Conferences and decisions
	Residuary powers
State	Public health and sanitation
	Land
	Agriculture
	Works, lands and buildings vested in or in the possession of the State
	Industries
	Taxes on the consumption or sale of electricity
Concurrent	Electricity
	Mechanically propelled vehicles

Jurisdiction	Items
	Factories
	Economic and social planning
	Forests

Source: Schedule VII of the Constitution of India, read with Article 246

Table 9 : List of subjects that can be delegated to Municipalities and Panchayats

Jurisdiction	Items
Municipal	Regulation of land-use and construction of buildings
	Urban forestry, protection of the environment and promotion of ecological aspects
	Economic and social development planning
	Public health, sanitation conservancy and solid waste management
Panchayat	Fuel and fodder
	Non-conventional energy sources
	Rural electrification, including distribution of electricity
	Health and sanitation

Source: Schedule XI and XII of the Constitution of India, read with Art 243G and Art 243W

In addition to the competence mentioned above, Parliament has the power to legislate upon a subject to give effect to decisions and commitments under an international agreement or convention (Art 253). The two most important laws regulating air quality in India, Air (Prevention and Control of Pollution) Act and Environment (Protection) Act, were legislated by the Centre under Art. 253 of the Constitution to implement the decisions taken at the United Nations Conference on Human Environment held at Stockholm in June 1972, where India was a participant. Water (Prevention and Control of Pollution) Act, under which CPCB and SPCBs were created, was enacted in response to a resolution passed by 12 States asking for a Central Regulation.

Legal framework for air quality in India

The following legislations have a bearing on air pollution in India.

Air (Prevention and Control of Pollution) Act, 1981: The Act was formulated for the prevention, control, and abatement of air pollution in India. It prescribes various functions for the Central Pollution Control Board (CPCB) and State Pollution Control Boards at the state level. CPCB notifies the National Ambient Air Quality Standards under the Act. Under this Act, power and functions are allocated to CPCB and SPCBs. The CPCB and SPCBs are empowered to (a) declare a specific area as a special air pollution control area, (b) allow or disallow any industrial activity based on environmental impacts/performance, (c) disallow someone from emitting pollutants in the environment, (d) enter, examine, and test any

relevant industry, control equipment, and related documents and material in the case of an offence under this Act.

Environment (Protection) Act, 1986: The Act was formulated as an umbrella legislation for the protection and improvement of environment. It provides the framework for coordination of the activities of various Central and State authorities. Under the Act, the Central Government has the power to set standards to protect and improve environmental quality, including air quality, control and reduce pollution from all sources, and prohibit or restrict the setting and/or operation of any industrial facility on environmental grounds. It also confers the enforcement agency with the necessary retributive powers to control any activity damaging the environment.

A number of Rules and Regulations have been notified under this Act, including the ones relevant for improving air quality. These Central Rules lay down environment standards for several industrial units, including thermal power plants, cement plants, iron & steel plants, smelting units, brick kilns and diesel generator sets, on parameters such as particulate matter, SO2, NOX and mercury. In addition to these industry specific emission standards, there are regulations for management and utilisation of waste by-products like flyash from power plants.

Certain other Rules also have a direct implication for safeguarding and improving air quality. For example, Municipal Solid Waste Management Rules, 2016 expressly prohibit burning of solid waste in open public spaces. Construction and Demolition Waste Management Rules, 2016 provide for segregation, storage, collection, reuse, recycling, transportation and disposal of any waste (such as building materials, debris, rubble) resulting from construction, re-modelling, repair and demolition of any civil structure.

Motor Vehicles Act, 1988: Vehicular pollution is an important source for degradation air quality in Indian cities. Emissions from vehicles are regulated as per standards notified under the Motor Vehicles Act of 1988. Central Motor Vehicle Rules, 1989 have been amended time to time to recommend vehicle emissions norms. Bharat Stage (BS) Emission Standards are adopted for vehicles across the country. Currently, BS IV standards are enforced and BS VI standards will be in force from 2020 onwards.

Institutional framework for air quality management

Under the federal governmental structure of India both the central and state governments have an important role in managing the ambient air quality. There are strong linkages between the Central and State Governments in the governance and implementation of various Laws and Acts.

The Ministry of Environment, Forest and Climate Change (MoEFCC) is the nodal agency in the administrative structure of the Central Government for planning, promotion, co-ordination and oversight of the implementation of India's environmental and forestry policies and programmes. The primary functions of the Ministry are implementation of policies and programmes relating to conservation of the country's natural resources including its lakes and rivers, its biodiversity, forests and wildlife, ensuring the welfare of animals, and the prevention and abatement of pollution. The Ministry formulates policies and enacts legislation at the national level.

The MoEFCC, along with the CPCB (Central Pollution Control Board) and SPCBs (State Pollution Control Boards) forms the regulatory and administrative core for pollution management in the country, while other ministries and bodies are also involved through various functions, policies, and schemes. In addition, a network of government and non-governmental institutions and laboratories involved in monitoring, reporting, and conduct of air quality management studies. The institutional framework to control air pollution in India is given in Figure 11:

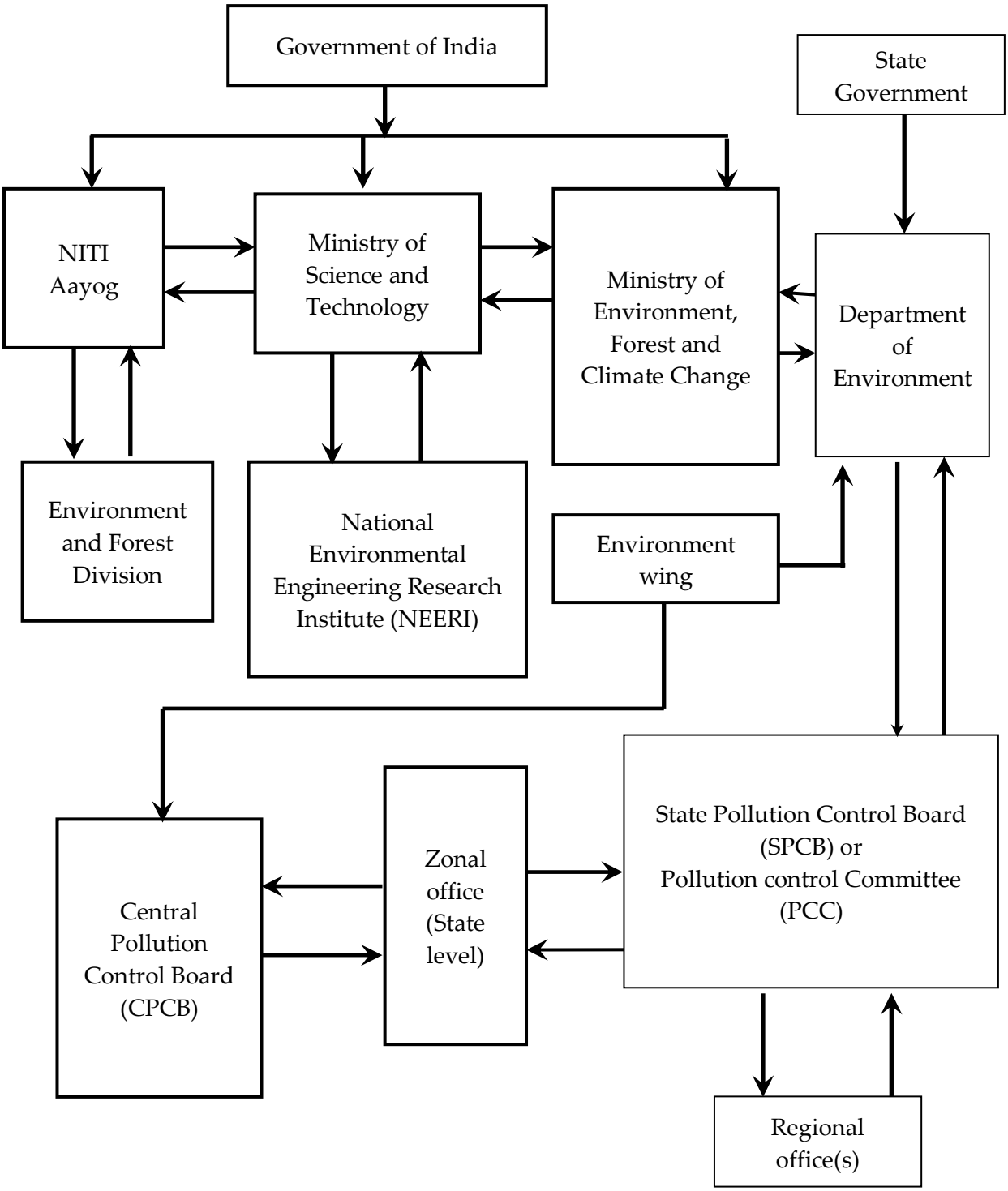


Figure 11 : Primary institutional framework for air quality management agencies

In addition to the Ministries and agencies mentioned in Figure 11, several other ministries and agencies are involved as far as interventions for addressing air pollution are concerned. These include the following.

Ministry of Road Transport & Highways (MoRTH) and state transport departments are responsible for registration of vehicles and ensuring compliance of vehicles with prescribed standards, including emission standards and choice of fuels for the fleet of vehicles. MoRTH notifies the Bharat Emission Standards for vehicles. The transport departments are also responsible for monitoring and issuance of pollution under control certificates. MoRTH plays an important role in improving air quality through other programmes such as Green Highways (Plantation, Transplantation, Beautification and Maintenance) Policy – 2015. The latter aims at developing eco-friendly highways with participation of the community, farmers, NGOs and private sector. Under the Green Highways Project, the government has made it mandatory to set aside 1 per cent of the total project cost of any NH contract to a Green Fund corpus that will be used for plantation purposes.

Ministry of Petroleum and Natural Gas (MoPNG) is another important agency for addressing air quality, both indoor and outdoor. Provision of clean cooking fuel is an important measure to check the indoor health pollution. The Central Government launched "**Pradhan Mantri Ujjwala Yojana**" (PMUY) in May, 2016 to provide deposit-free LPG connections to 5 crore families below poverty line (BPL) families over a period of 3 years from 2016-17. The scheme has been upgraded to provide 8 crore LPG connections by 2020 to BPL households according to the Union Budget 2017-18. High refill cost and long waiting period for refill have been highlighted as major hindrance by several reviews and reports on the Ujjwala Scheme. (Pandey et al, 2016) MoPNG is also instrumental in ensuring clean fuel options through the Auto Fuel Vision and Policy.

The **Ministry of Power and Ministry of New and Renewable Energy** play an important role in the supply of clean electricity.

Burning of crop residue during harvest season is a major source of pollution in the Indo-Gangetic plains, making **Ministry of Agriculture and Farmers Welfare (MoA)** a key stakeholder in prevention of air pollution. Initiatives like 'Agricultural Mechanization for in-situ Management of Crop Residue' in Punjab, Haryana and Uttar Pradesh and NCT of Delhi are integral to address the problem of air pollution during the harvest season in Northern India.

Some of the major initiatives that have been undertaken to address air pollution are discussed in the following section.

Policies and programmes

The Government of India has taken several initiatives for control of pollution in India. As the nodal agency, MoEFCC has notified ambient air quality standards and also source emission standards for certain industries and sectors.

A number of action plans have been formulated by the central and state governments for control of air pollution in Indian cities in the past decade. In the late nineties the initial action started in Delhi. Subsequently air quality management plans for seventeen highly polluted cities (which were then not complying with the national ambient air quality standards) were formulated in 2006-07. Thereafter a Comprehensive Environment Pollution

Index (CEPI) was formulated to characterize the environmental quality of an industrial area or cluster. Based on CEPI, 43 critically polluted industrial clusters were identified and action plans were formulated for the identified industrial clusters.

Air quality management plans were also proposed for six cities (i.e. Delhi, Bangalore, Pune, Kanpur, Chennai and Mumbai) on the basis of source apportionment studies conducted in 2011. Recently, in Delhi-NCR, an emergency action plan known as Graded Response Action Plan (GRAP) was notified for control of pollution based on different severities of air pollution. The Air Quality Index (AQI) was launched in 2014 with the aim of providing data related ambient air quality in colour coded format.

Various measures taken for curbing air pollution from different contributing sectors are listed below. These include implementation of advanced Bharat Standard VI (BS VI) for vehicles, introduction of electric vehicles, banning of pet coke and furnace oil in NCR, setting up of Continuous Emission Monitoring System for industries, replacing coal-based power plants with natural gas-based power plants, subsidies on machinery for tilling the agricultural residue back into soil instead of burning it, among others.

A list of key initiatives taken in India for air pollution control is presented in Table 10.

Table 10 : Key initiatives taken in India for air quality management

S.No	Initiatives	
	Transport sector	**Dates**
1	Notifying advanced vehicle emission and fuel quality standards– BS-IV from 2017 and BS-VI from 2020	2016
2	Introducing gas as an automotive fuel in many cities	Ongoing- 2003 onwards
3	Introduction of fuel efficiency standards for cars and in process to decide the norms for HDVs.	2015
4	Plan to introduce a voluntary fleet modernization and old vehicle scarappage program in India	2016 (currently being discussed)
5	Introducing National electric mobility mission plan 2020	2012
6	Introduction and enhancement of metro-rail and bus based public transport systems in select cities	Ongoing -2002 onwards
	Residential sector	
1	Push to accelerate the LPG penetration program for cooking in households	Ongoing – special emphasis 2015 onwards
2	Completing electrification to reduce kerosene consumption for lighting	Completed 2018
3.	Introducing energy efficiency labeling program for energy intensive home appliances like air conditioners	2006
	Power sector	
1	Ambitious targets for power generation through renewables (100 GW solar by 2022)	2015
2	Shift towards high efficiency super critical technology for power generation	Ongoing
3	Converting coal based power stations to gas based in select	-

	cities	
4	Notifying new stringent standards for PM and new standards for gaseous pollutants for coal based plants	2015
5	Notifying new stringent standards for diesel generator sets for stand by power generation	2016
	Industrial sector	
1	Notifying and revising standards for highly polluting industries	2018
2	Pilot testing of emission trading scheme (ETS) in select industrial zones	Announced in 2010
3	Continuous monitoring of select large industries	Ongoing under the ETS
4	Zig-zag technology for brick kilns	2018
5	Banning pet-coke and FO use in industries	2017
	Others	
1	Imposition of ban on open agricultural residue burning	2015, NGT
2	Imposition of ban on refuse burning in some cities	2015 (NGT)
3	Launch of an official air quality index for Indian cities	2015
4	Setting up the Steering Committee on Air Pollution and Health Related Issues	2014
5	Developing Graded Response Action Plan (GRAP) for NCR for emergency planning	2016
6	Construction & Demolition Waste Rules	2017
7	Formulation of National Clean Air Programme (NCAP)	2018

Source: Compiled by authors

In 2018, MoEFCC formalized the National Clean Air Programme (NCAP) for addressing air pollution at the national scale, especially in the 102 non-attainment cities in India. The programme aims at developing an effective ambient air quality monitoring network, and feasible management plans for prevention, control and abatement of air pollution.

The NCAP was formally launched by MoEFCC in January 2019, as a mid-term, five-year action plan to cover 102 cities across 23 States. It envisages an institutional framework comprising an Apex Committee, Steering Committee, and Monitoring Committee, National level PMU, National Level Project Implementation Unit and State level PMUs. The institutional framework is centralised with a PMU of 3-4 scientific staff at the State level. The Programme has been launched with a budget of Rupees 300 crores for the first two years. The estimated cost of the Programme was Rs.637 crores, which did not include the cost of city-specific action plan implementation. The cost of city specific plans was envisaged to be borne by the States.

The NCAP will expand the national air quality monitoring network, build capacity for air pollution management, and strengthen public awareness about the dangers of air pollution. It is a time-bound, national strategy to bring down levels of deadly particle air pollution ($PM_{2.5}$ and PM_{10}) by 20-30% by 2024 (compared to 2017 levels).

The NCAP's rationale for putting cities at the heart of air pollution action is precedence; it explains that global experience shows that city-specific (rather than country oriented) action had led to 25 per cent to 40 per cent reduction in fine particulate matter (PM2.5) in cities like Beijing and Seoul over a period of five years. Santiago and Mexico City, it says, have shown dramatic reduction in 22 to 25 years in PM2.5 and PM10 levels.

In this scenario, it becomes very important to understand the factors impeding the attainment of air quality standards in the cities and to identify measures for effective and optimal control of pollution using innovative technologies at the level of Centre and States.

Challenges in air quality management in India

There are several challenges in addressing the high levels of air pollution in Indian cities. These include overall low priority to environmental subjects, poor institutional coordination across relevant sectors and ministries, limited resources and powers of pollution control boards, lack of adequate understanding of underlying causes of pollution and effective remedial measures. Some of the important constraints are discussed below.

Constraints faced by Pollution Control Boards

There are several issues faced by State PCBs, including lack of financial resources, staff, and laboratory facilities. For instance, data shows that a large number of vacant positions in the SPCBs. For example - Rajasthan SPCB had 134 vacant posts out of 394 sanctioned posts in 2016-17; UP: 172 vacant out of 819 posts in 2015-16; Maharashtra: 196 vacant out of 838 posts in 2014-15; Andhra Pradesh: 159 vacant out of 292 vacant in 2014-15. Even smaller SPCBs like Meghalaya (57 vacant out of 123 posts in 2014-15) and Haryana (72 vacant out of 248 posts in 2014-15) had several vacant posts. This shortage of staff affects the day to day functioning and performance of the SPCBs such as regular monitoring of industrial stacks.

The receipts of SPCB consist of fees for issuing consent and authorisation, compensation received from the Government of India for the Water Cess (till it was abolished under the GST regime) and other miscellaneous receipts including interest on investments. The SPCBs spend the budget for a range of activities including pollution control measures, laboratory expenses, and awareness programmes etc.

One of the major sources of SPCB's income was the share of water cess collected from industries/municipal bodies under Water Cess Act, 1977. As per section 8 of the Water Cess Act, water cess was collected by the PCB and deposited with the Government of India (GoI). Eighty per cent of the amount realised and deposited by SPCB was required to be reimbursed back to it by the GoI. However, this amount was not always fully reimbursed to States as informed by the Pollution Boards during discussions with them. The water cess has now been abolished with the adoption of the GST. This has adversely affected the financial resources of the Boards.

Table 11 shows the income and expenditures for various SPCBs as compiled from their annual reports. Figure 12, separates out States where the water cess was included in the revenue from those where it was not. As can be seen, in the absence of the water cess, States face a significant shortfall in revenue as compared to expenditure.

Table 11 : Income and Expenditure of state PCBs (Rs crore)

State	Financial Year	Income	Expenditure
Andhra Pradesh	2014-15	38.24	34.63
Gujarat	2016-17	0.6	
Himachal Pradesh	2015-16	29.41	18.4
Goa	2014-15	15.9	10.46
Karnataka	2015-16	120.64	73.75
Kerala	2013-14	--	--
Maharashtra	2014-15	307.21	77.46
Meghalaya	2013-14	5.8	3.67
Odisha	2015-16	104.67	23.41
Rajasthan	2015-16	120.33	31.24
Tamil Nadu	2015-16	219.53	148.57
Uttar Pradesh	2015-16	52.94	57.33
West Bengal	2016-17	89.93	55.86
Haryana	2013-14	60.82	24.45

Source: Compiled from Annual Reports of State Pollution Control Boards.

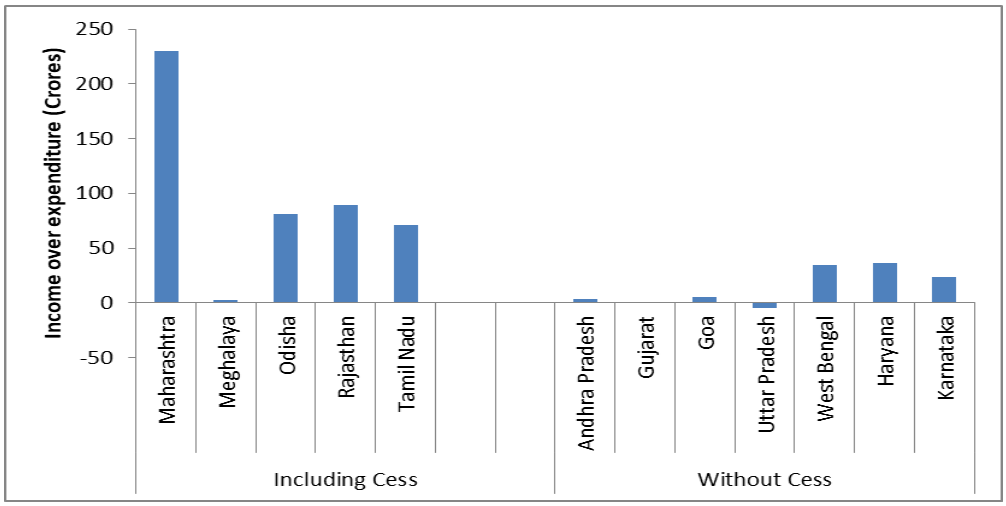


Figure 12 : Income over expenditure of State Pollution Control Boards: with and without water cess

Source : Compiled from Annual Reports of State Pollution Control Boards. Data is for different years between 2013/14 and 2016/17.

During the study team's interactions with the PCBs, many of them raised the issue of inadequate finances. Haryana PCB pointed out the need for greater resources for control of agricultural residue burning and other air pollution sources in the State. The need to

augment staff was also pointed out as being necessary for ensuring compliance with standards. It was reported that there were only seven regional officers for the 17 districts in Haryana. Similarly, Punjab PCB pointed out that while their capacity had remained almost stagnant, their responsibilities had increased over time due to more environmental laws and need for greater awareness etc. As per their assessment, their staff strength needs to be enhanced about 2.5 times to effectively carry out necessary activities.

Scientific air quality management plans

There is a need for state-level (regional) and city-level scientific air quality management plans for addressing air pollution since local sources and meteorological conditions vary for each city. Most states have been asked to prepare air quality management plans for the non-attainment cities. However, most action plans developed by the states are qualitative and not backed up by scientific studies. A major issue in effective development and implementation of air pollution management plans has been the lack of technical capacity and manpower, and infrastructure in the PCBs. Effective collaboration between government, universities and other research institutions which could address this constraint is also limited.

Monitoring infrastructure and data issues

The national air quality monitoring network is in urgent need of rationalization in terms of coverage of locations and pollutants as well as monitoring protocols and technologies.

The air quality monitoring network currently only covers 14-92% of the urban population in the States, with an all India average of about 40% of the urban population covered. Clearly, there is a need to augment the network in urban areas and also in rural areas, which are still not covered in the program.

Parameters that are being monitored under the national air quality monitoring system also need to be revisited and rationalized. An optimal mix of measurement techniques that include manual, continuous, sensor & satellite-based measurements is required. Simultaneously, there is a need for quality assurance and quality control practices to be followed at the monitoring stations to ensure that the data generate are credible.

Guidelines for Ambient Air Quality Monitoring were last issued by CPCB in 2003. These guidelines need an urgent revision with respect to selection of pollutants and locations, frequency and duration of sampling, sampling techniques, infrastructural facilities, quality control, and man power and operation and maintenance costs.

Limitations in the number and coverage of monitoring stations, differences in types of monitors (manual/ continuous) and weaknesses/differences in air quality parameters monitored across sites impair a robust understanding of the state of air quality. There is also limited knowledge of sectorial and geographical (including trans-boundary contribution) to ambient air quality and limited (uncertain) understanding of the impacts of air pollution. Capacity constraints of the Boards adversely affect vigilance and enforcement of standards.

Political economy considerations

The geopolitics of pollution exports between cities, states and countries are an important consideration in finding solutions to trans-boundary pollution issues. It is difficult to reach and agree upon cooperative solutions especially when costs and benefits are poorly understood and/or spatially mismatched. A case in point is the issue of crop residue burning in the Indo-Gangetic plains, where the political gains of allowing crop burning override health costs faced in and around regions where the burning takes place. A new study by International Food Policy Research Institute (IFPRI) and partner institutes estimates the economic costs of crop residue burning in northern India at over USD 35 billion annually. (Chakrabarti et al, 2019) Among other factors, smoke from the burning of agricultural crop residue by farmers in Haryana and Punjab, especially contributes to Delhi's poor air, but also increases the risk of ARI three-fold for those living in districts with intense crop burning. The study clearly shows that it is not only the residents of Delhi, but also the residents of rural Haryana who are the first victims of crop residue burning. Much of the political discourse in States where the practise is prevalent unfortunately ignores the immediately affected vulnerable population and remains focused on the high costs of alternatives to burning residue. It is essential to look beyond short-terms political gains and provide for long-term solutions based on appropriate technologies or business models which might be win –win for farmers, politicians and entrepreneurs.

Similarly, any increase in energy prices to address environmental externalities can have a disproportionate impact on economically weaker sections whose share of energy expenditure to total expenditure is high. Such interventions can become politically sensitive unless accompanied by compensatory support to identified households; the latter being a complicated exercise in itself.

The MSME sector is an important aspect of India's industrial sector. Pollution from MSMEs often goes unaddressed since many of these units operate out of non-conforming areas and are unregistered, making it difficult to ensure their compliance with pollution regulations. Petty corruption is also a factor that allows the situation to continue.

Another issue is that of sectoral accountability due to limited source apportionment analyses which can establish the contribution of an individual source to ambient pollution levels. This can lead to ineffectual solutions or limited participation of stakeholders.

Economic and budgetary considerations are a deciding factor, whether it is provision of adequate infrastructure for public transport by the government, management of crop residue by farmers or switching to less polluting fuels by the industry. Unless adequate resources and /or incentives are provided, these transitions are not likely to happen as soon as we would like them to.

Finally, air pollution is a cross-sectoral issues but the lack of horizontal and vertical coordination and collaboration within the government structure is a major inhibiting factor is designing and implanting effective solutions. There is an urgent need for centre-state and inter-state cooperation, and collaboration for regional scale air quality planning.

4. Recommendations for managing air pollution through FC grants

This chapter discusses the role of the Finance Commission in terms of how fiscal transfers from the Centre to the States can be leveraged to address the critical issue of air pollution in Indian cities. Based on analysis of data and issues discussed in the previous chapter as well as the perspectives that have emerged during consultations with stakeholders, including State Pollution Control Boards and experts, we present the options that the XV FC may consider in designing its devolutions/grants.

This chapter is structured as follows. The next section discusses the rationale for the role of the Finance Commission in the management of air quality. The following section details the different options that the Finance Commission might adopt along with their indicative implications for inter-se share of States in the transfers. The final section concludes with a summary of the recommendations.

Role of the Finance Commission in addressing air quality concerns

With its overall mandate of strengthening equity and efficiency of the fiscal system, it is strongly felt that the Finance Commission is well placed to take up the issue of air pollution in its recommendations and to suggest recommendations on devolution grants. The specific TORs of the XV FC relating to the SDGs provide a strong entry point for the FC to take up this issue, as discussed in the previous chapter. The following arguments serve to further buttress the rationale for the FC to intervene in this area:

7) Air pollution is a widespread issue across the country and pollution levels are above the WHO guidelines in all cities where air quality is being monitored. Indian standards, which are more lax than WHO standards, are violated in 70% cities where air quality is being monitored.

8) Impacts of air pollution on health (as well as on agriculture, buildings and climate) are well documented in research studies and impose a significant cost on the efficiency of the economic system by adversely impacting the health, wellbeing and productivity of people and ecological systems.

9) On-going efforts by governments both at the central and state levels have not yielded results to control this multi sectoral problem of this magnitude. Also, despite its economic burden and a fair account of sensitization, air pollution has not become an issue of immediate concern. Although the National Clean Air Program launched in January, 2019 by MoEFCC for control of air pollution has budgeted an amount of Rs.300 crores, a large part of the cost will also have to be borne by the States, which going by past experience, is going to be a challenge.

10) Air pollution is a trans-boundary, thus creating negative externalities beyond the jurisdiction where it originates, which local governments may have little or no incentive to address in the absence of targeted central intervention.

11) Air pollution causes are multi-sectoral and hence its control calls for intensive coordination between sectoral departments and agencies. This requires the active involvement of leadership at the highest level in each State and central level.

12) State level pollution control boards have limited technical and financial capacity to enforce existing laws for control of air pollution. Limitations of staff, lab facilities, monitoring infrastructure, technical knowhow, and technologies are well known.

The intervention of the Finance Commission will provide a strong signal on the importance of air quality in the development agenda of States, thereby elevating the stature of the issue to the level that is required to address it effectively. By creating performance-based incentives, FC grants have the potential to not only provide resources for specific interventions, but also motivate leadership at the highest level in the States to design and implement multi-sectoral interventions to achieve measurable improvements in air quality. In USA, the central allocations for certain infrastructural projects to the States are based on their air quality performance in past years[21]. The 1990 CAA Amendments has authorized USEPA to impose sanctions when an area falls in the nonattainment category and also fails to provide an adequate air quality management plan. There sanctions could be in the form of emission offsets and or withholding of federal highway funds. Emission offset sanction forces newly constructed or expanded industrial units to reduce emissions from other facilities, to the extent of twice the amount projected to be emitted from them. Alternatively, funds for transportation projects in areas where air quality standards are not met can be withheld (with some exceptions for projects designed to improve safety, transit, etc.).

We discuss below some options for the XV FC to address this important issue in its recommendations.

Alternative approaches for designing FC grants

There are two broad alternative approaches to designing FC grants in order to address air pollution. The first is a state level approach, which is based on air pollution indices at the level of the State; the second is a city-level approach, based on air quality in specific cities with the grant being linked to specific interventions in the cities e.g. public transport. It is important to identify the common parameter that can constitute the basis of evaluating air quality and accordingly determining the share of states/cities in the grant.

Choice of parameter for determining air quality in grant formula

As discussed in the previous Chapter, Particulate Matter (PM) is the prime pollutant of concern across the country. Within PM, monitoring of ambient PM2.5 has only started since 2014 and is being carried out in limited number of cities. Hence, for a comprehensive and comparable analysis at the State level, PM10 becomes the choice indicator of air quality. PM10 is being monitored in all states. PM10 levels include PM2.5 fractions which are known for the severe impacts on human health. PM10 levels also indirectly capture other gaseous pollutants, which form secondary particulates. Reactions of gaseous pollutants like NOx,

[21] Danish National Environment Research Institute and Centre for Clean air policy, 2004, Comparison of the EU and US air quality standards and planning requirement, URL : http://ec.europa.eu/environment/archives/cafe/activities/pdf/case_study2.pdf

SO_2 and ammonia, form secondary particulates in the atmosphere and add to the already existing mass of PM10 and PM2.5.

The Air Quality Index, developed by CPCB, could also have been used for the analysis. However, in the present scenario, where PM10 violations are far greater than any other pollutants, AQI values which are based on the worst pollutant, will primarily also reflect PM10 values.

Using PM10 has a limitation that it is also contributed by natural sources, which are beyond human control. With enhanced network of PM2.5 monitoring in India in future, there is no doubt that PM2.5 is a better indicator of anthropogenic contributions to air pollution.

There are few methods which can be employed to compare the states in India on air quality grounds. A method is to go by the ground measurements of PM10 which are being conducted regularly across the year by the CPCB and SPCBs. However, one of the limitations of choosing ground level measurements of PM10 is that it is being monitored only in urban areas of the country. Presently, TERI estimates that about 43% of urban population is covered by some form of air quality monitoring under the NAMP program of CPCB. However, rural air quality is also important due to presence of sources like biomass burning in rural kitchens and agricultural fields, and industries beyond city boundaries. By covering cities, the activities in its surrounding non-urban areas are partly captured as air quality in a city is influenced by its surroundings. For example, TERI-ARAI (2018) shows that 64% of PM2.5 concentrations in Delhi are contributed by sources outside the city.

In order to overcome the issues of limited area coverage of ground based monitoring, the second method can make use of satellite based AOD (aerosol optical depth) datasets.

AOD is also an indicator of air quality and is a measure of the extinction of the solar beam by dust and haze. In other words, particles in the atmosphere (dust, smoke, pollution) can block sunlight by absorbing or by scattering light. AOD is obtained from satellite observations and serves as a proxy to PM concentrations. However, the AOD datasets are not indigenously monitored currently. Moreover, AOD data are to be processed to estimate ground level PM2.5 concentrations through scientifically derived algorithms. In view of this, AOD has not been considered as the indicator for air quality in this assessment. However, in future with availability of indigenous or other acceptable satellite products, along with scientifically proven and accepted algorithms, this can be used as a better indicator to provide a comprehensive view of air quality across the country.

Both the methods discussed above cannot however ascertain the contributions received by a state from neighbouring states. In order to do that, the third methodology, which can be adopted by India in the longer run, could be based on emissions approach. This requires a clearly defined and consensus based methodology, which can be developed through participation of all the relevant stakeholders in order to attribute contributions of different states to air pollution across the country. This can be done using an air quality modelling based framework. This will require development of a high resolution database of air pollutant emissions, which can be fed into an accepted and suitable meteorological and air quality model for India. The model can be validated with ground based concentrations and validated models can be used to estimate state-wise contributions to India's pollution levels after accounting for trans-boundary issues.

Considering the enormity of the issue in the present scenario, where the methodology is there though not yet perfect, one cannot ignore the large volume of data to send the signals for incentivising efforts for air pollution control in India. In the present circumstances, AOD and emission datasets cannot be relied upon and hence, the most authentic, publically available, indigenous dataset is of ground based measurements of PM10, which can be used for the comparisons to start with. We attempted various ways by which PM10 concentrations can be used at state or city levels for comparisons and devolution of central funds. However, the current network covers about ~50% of urban population and does not cover the rural regions. Hence it can only be used to indicate urban air quality in the states. Accordingly, our final recommendation is to carry out analysis at the city level and provide grants to cities based on their air quality management needs and performance.

City level approach

This approach is targeted at air quality in Indian cities where PM10 concentrations are measured regularly under the National Air quality Monitoring Programme. There are two ways by which assessment can move forward – a) need based, b) performance based. While the need based assessment will identify the places with higher pollution levels which will require grants for air pollution control, the performance based approach will incentivise reductions in pollutant levels in the cities. We propose a hybrid approach, in which current state of air quality will be considered to determine the need of FC grants and the cities with higher pollution level will be granted 40% of the total grant in first two years for air pollution control. Thereafter the performance with respect to change in air pollution levels will dictate the amounts of grants to be given in the remaining three years.

Presently, CPCB has a wider network of manual air quality monitoring stations, while they have initiated more advanced real-time monitoring in some of the cities. In view of wider representation of cities through manual network, PM10 data from both manual and real-time monitoring stations have been collected for the year 2017, and 2018, respectively. It is to be noted that the data for 2018 for manual stations is yet to be received from CPCB and should finally be used for final analysis. However, for demonstrative purpose the latest real-time PM10 data of 60 cities have been retrieved from the CPCB website and for 253 cities (which are above the national annual average PM10 standard) it is adopted from CPCB's published data of 2017. The merged dataset of real-time and manual measurements has been used to identify the most polluted cities in India. Data of manual and real-time stations suggested that out of 313 cities, 243 (77%) violated the prescribed annual average standards. These cities have been used for further analysis based on population exposures. Total exposure caused by PM10 concentrations was estimated based on this equation.

Total exposure = Population of city (Census 2011) x Annual average PM10 concentrations in city

Thereafter, the cities are ranked in order of highest exposures, and the top 100 ones have been selected for the purpose of grants based on the need. 59 out of these 100 cities are also in the list of 102 non-attainment cities identified by the NCAP. The share of different cities in total exposure estimated in the 100 selected cities is calculated. The same shares have been recommended for distribution of finance commission grants to the cities. Table 12 shows the annual average PM10 concentrations, population, exposure and relative shares for different cities.

Table 12 : Annual average PM10 concentrations, population, exposure and relative shares for 100 selected cities.

	Type of monitoring	City	PM10 (2017-2018)	Pop. (Mun. corp. 2011)	Total Exposure	% share in the grant	Amount if the Grant is 10,000 Crores	Amount if the grant is 8,000 Crores
1	RT	Delhi	245	11402709	2789266516	15.0%	1505	1204
2	RT	Mumbai	100	12442373	1240986079	6.7%	670	536
3	MA	Lucknow	246	2817105	693007830	3.7%	374	299
4	MA	Ahmedabad	120	5577940	669972571	3.6%	361	289
5	RT	Hyderabad	96	6731790	644800651	3.5%	348	278
6	MA	Kanpur	224	2765348	620129289	3.3%	335	268
7	RT	Bengaluru	70	8443675	587191806	3.2%	317	253
8	RT	Kolkata	121	4496694	545482761	2.9%	294	235
9	MA	Surat	106	4467797	475075748	2.6%	256	205
10	RT	Ghaziabad	282	1648643	465348380	2.5%	251	201
11	RT	Jaipur	141	3046163	430180961	2.3%	232	186
12	MA	Agra	185	1585704	292562388	1.6%	158	126
13	MA	Chennai	62	4646732	287632711	1.6%	155	124
14	MA	Dhanbad	238	1162472	276668336	1.5%	149	119
15	MA	Patna	157	1684222	263580743	1.4%	142	114
16	RT	Varanasi	219	1198491	261939500	1.4%	141	113
17	RT	Pune	79	3124458	245796337	1.3%	133	106
18	RT	Jodhpur	224	1033756	231983682	1.3%	125	100
19	RT	Thane	125	1841488	230031717	1.2%	124	99
20	RT	Nagpur	89	2405665	214308567	1.2%	116	92
21	RT	Gurugram	241	876969	211746665	1.1%	114	91
22	RT	Visakhapatnam	117	1728128	201344793	1.1%	109	87
23	MA	Meerut	153	1305429	199077923	1.1%	107	86
24	RT	Ludhiana	114	1618879	184402716	1.0%	99	80
25	RT	Moradabad	205	887871	182288647	1.0%	98	79
26	MA	Vadodara	108	1670806	180781209	1.0%	98	78
27	MA	Bareilly	195	903668	176215260	1.0%	95	76
28	MA	Bhopal	93	1798218	166720497	0.9%	90	72
29	RT	Noida	253	637272	161286437	0.9%	87	70
30	MA	Indore	80	1964086	157126880	0.8%	85	68
31	MA	Allahabad	140	1112544	155978669	0.8%	84	67
32	MA	Ranchi	142	1073427	152426634	0.8%	82	66
33	RT	Howrah	135	1077075	144962438	0.8%	78	63
34	RT	Kota	143	1001694	143561030	0.8%	77	62
35	MA	Pimpri- Chinchwad	82	1727692	141670744	0.8%	76	61
36	MA	Dehradun	248	569578	141445203	0.8%	76	61
37	RT	Amritsar	124	1132383	139958807	0.8%	76	60
38	MA	Jharia	295	472952	139520840	0.8%	75	60
39	MA	Rajkot	107	1286678	137031207	0.7%	74	59
40	MA	Firozabad	220	604214	132725675	0.7%	72	57

	Type of monitoring	City	PM10 (2017-2018)	Pop. (Mun. corp. 2011)	Total Exposure	% share in the grant	Amount if the Grant is 10,000 Crores	Amount if the grant is 8,000 Crores
41	MA	Gorakpur	186	673446	125260956	0.7%	68	54
42	MA	Saharanpur	174	705478	122400433	0.7%	66	53
43	MA	Gwalior	110	1069276	117620360	0.6%	63	51
44	RT	Aurangabad	96	1175116	112272261	0.6%	61	48
45	RT	Nashik	75	1486053	111395579	0.6%	60	48
46	MA	Chandigarh	109	961587	104620666	0.6%	56	45
47	MA	Raipur	103	1010433	104074599	0.6%	56	45
48	RT	Navi Mumbai	91	1120547	102320386	0.6%	55	44
49	MA	Guwahati	106	957352	101160195	0.5%	55	44
50	RT	Durgapur	169	566517	95671390	0.5%	52	41
51	RT	Solapur	100	951558	95595389	0.5%	52	41
52	MA	Jamshedpur	131	631364	82393002	0.4%	44	36
53	RT	Jalandhar	93	862886	79888985	0.4%	43	34
54	MA	Jabalpur	74	1055525	78108850	0.4%	42	34
55	MA	Bhubneshwar	91	843402	76749582	0.4%	41	33
56	MA	Ulhasnagar	150	506098	75661651	0.4%	41	33
57	RT	Muzaffarnagar	191	392768	75109869	0.4%	41	32
58	MA	Jammu	149	502197	74659954	0.4%	40	32
59	RT	Hubballi	78	943788	74009725	0.4%	40	32
60	MA	Trichy	86	847387	73044759	0.4%	39	32
61	RT	Ujjain	135	515215	69714198	0.4%	38	30
62	MA	Amravati (Maharashtra)	106	647057	68393925	0.4%	37	30
63	MA	Madurai	67	1017865	68196955	0.4%	37	29
64	RT	Vijaywada	65	1034358	67637318	0.4%	36	29
65	RT	Bhatinda	107	625700	67257370	0.4%	36	29
66	MA	Hissar	220	301383	66304260	0.4%	36	29
67	RT	Udaipur	137	451100	61944107	0.3%	33	27
68	RT	Asansol	106	563917	59941871	0.3%	32	26
69	RT	Ajmer	110	542321	59481829	0.3%	32	26
70	MA	Muzaffarpur	167	354462	59195154	0.3%	32	26
71	MA	Jhansi	113	505693	57143309	0.3%	31	25
72	MA	Akola	127	425817	53936820	0.3%	29	23
73	MA	Mathura	154	349909	53885986	0.3%	29	23
74	RT	Siliguri	104	513264	53328222	0.3%	29	23
75	MA	Cuttack	87	610189	52883047	0.3%	29	23
76	MA	Jamnagar	104	479920	49911680	0.3%	27	22
77	MA	Kolhapur	90	549236	49614319	0.3%	27	21
78	RT	Bulandshahar	220	222519	49002743	0.3%	26	21
79	MA	Bhiwandi	68	709665	48257220	0.3%	26	21
80	MA	Belgaum	95	488157	46374915	0.3%	25	20
81	RT	Singrauli	206	220257	45475986	0.2%	25	20

	Type of monitoring	City	PM10 (2017-2018)	Pop. (Mun. corp. 2011)	Total Exposure	% share in the grant	Amount if the Grant is 10,000 Crores	Amount if the grant is 8,000 Crores
82	MA	Guntur	69	647508	44678052	0.2%	24	19
83	MA	Dombivali/Ambernath	176	253475	44611600	0.2%	24	19
84	MA	Bharatpur	177	252342	44538363	0.2%	24	19
85	RT	Thiruvananthapuram	58	743691	43465502	0.2%	23	19
86	MA	Warangal	70	615998	43119860	0.2%	23	19
87	RT	Satna	147	280222	41192634	0.2%	22	18
88	RT	Patiala	100	406192	40502454	0.2%	22	17
89	MA	Sangli	76	502793	38044670	0.2%	21	16
90	MA	Timukuru	125	302143	37767875	0.2%	20	16
91	MA	Devanagere	87	434971	37697487	0.2%	20	16
92	MA	Bhatinda	131	285788	37438228	0.2%	20	16
93	MA	Mangalore	75	488968	36672600	0.2%	20	16
94	RT	Dewas	123	289550	35577326	0.2%	19	15
95	MA	Jalgaon	77	460228	35437556	0.2%	19	15
96	MA	Kurnool	82	430214	35277548	0.2%	19	15
97	RT	Pali	149	230075	34281982	0.2%	18	15
98	RT	Chandrapur	104	320379	33239716	0.2%	18	14
99	RT	Bhiwadi	312	104921	32690711	0.2%	18	14
100	MA	Nellore	65	499575	32472375	0.2%	18	14

While the shares in the grant have been mentioned above, the total grant recommended is the range of Rs.10,000-8,000 Crores, so as to ensure that the largest recipient Delhi will get Rs.1505-1200.4 Crores. Over a 5 year period and the smallest recipient Nellore will get at least 18 Crores - 14 Crores over the same period. The grant would therefore, be targeted and would have the potential to make a difference in the air quality in these 100 cities.

RT : Real time (2018), MA: Manual (2017)

Cities like Bhiwadi, Jharia tops the list of cities with high air pollution levels, but due to relatively lesser population exposure, they will receive only 0.2% and 0.8%, respectively, of the total grants. Delhi being seventh highest in pollution and second highest in population will receive the maximum 15.1% share in the grant. Based on the calculations, Delhi (15.0%) Mumbai (6.7%), Lucknow (3.7%), Ahmedabad (3.6%), Hyderabad (3.5%), Kanpur (3.3%), and Bangalore (3.2%) are the other cities having somewhat higher shares than the rest, which will receive <3% of the total grant.

In the first two years, the grant is proposed to be distributed based on the above stated calculations. For the next three years, the performance of the cities in terms of reduction of air pollution levels needs to be evaluated. This can be calculated using the following formulae

$$S_i = \left(\frac{C - P}{P}\right)_i$$

Where C is the concentration in year t+2, and P is the PM10 concentration in base year t.

Conditionality of use

It is recommended that the amount should be earmarked for the selected most polluted 100 cities in the form of yearly grants. For the first two years, grants can be given on the basis of pollutant levels in the year 2017 as discussed above, while for the next three years the grants can be given on a yearly basis based on the change in PM10 concentrations in last 2 years. This grant should be earmarked for activities directly and indirectly related to improving air quality. The sectors where these resources can be recommended for investments for improving the air quality of the state are shown in Table 2 below.

Table 13 : Sectoral strategies recommended for use of FC grants

Sector	Strategy
Vehicles	▪ Public transport procurement based on electric buses modes, Metro rail etc. ▪ Development of old vehicle scrappage program ▪ Regional mobility infrastructure ▪ Incentives for retrofitment of pre BS-IV vehicle with diesel particulate filters
Industries	▪ Development of automated industrial pollution vigilance and control centres
Agricultural residue burning	▪ Development of in-situ and ex-situ programs for control and management of agricultural residue burning
Municipal waste burning	▪ Development of in-situ and ex-situ programs for control and management of municipal residue burning o Methane recovery from STPs and landfills o Composting o Waste to energy
Construction dust	▪ Enforcement of C&D rules within the municipal limits through incentivised use of construction dust control equipments by both public and private agencies
Road dust	▪ Vacuum cleaning of major arterial roads
Others	▪ Augmenting the air quality monitoring network ▪ Conducting studies on state-wise or city scale source apportionment

The States should be requested to draw up specific action plans choosing all/any of the following sectors in the first year of the FC award and for the year remaining four years the release of funds will be dictated by the progress in the execution of the action plans.

Vehicular Sub-sector

a) Public transport

Growth of private vehicles has led to tremendous increase in congestion on roads. This has further aggravated the problem as congestion leads to enhanced fuel combustion and higher emissions. One of the prime reasons for growth of private vehicles is the lack of adequate public transportation systems. The FC grants should be used (as per the requirements in the cities) for strengthening of public transport through procurement of electric buses modes, or Metro rail etc. In this regard, it is also important to improve the city-to-city connectivity through improvements in the regional mobility infrastructure. This will reduce the need for long distance use of private vehicles. Incentives in the form of subsidies can be suggested for intra-city transportation. It is suggested that any city wanting to fast-track its metro/regional connectivity should be considered for grant of FC funds.

b) Scrappage and retrofitment of old vehicles

As newer BS-VI compliant vehicles with diesel particulate filters from 01.04.2020 will increase the overall stock of vehicles every year, huge numbers of vehicles are also becoming old and obsolete. Ill maintained, used and obsolete vehicles worsen public health risk. The exposure from such vehicles increases as such vehicles emit toxic gases and particulate matter close to the breathing zone.

Old vehicles with uncontrolled emissions can emit 16 times more particulate matter. Intergovernmental Panel on Climate Change (IPCC) has estimated that the Global Warming Potential (GWP) of black carbon emitted from vehicles is 900 times higher than CO_2 in a comparable time frame of 100 years. Also, the International Agency for Research on Cancer (IARC) of the WHO has reclassified diesel exhaust as a Group 1 carcinogenic.

Therefore, there is an immediate need for a strategy and action plan for scrapping such used vehicles, especially in metropolitan cities. Identification, end of life de-registration and recycling of such vehicles needs support in collaboration with the manufacturers. Therefore, it is recommended that state of the art scrapping centres for old de-registered vehicles are set up in at least in 6-7 metropolitan cities. For the not so old vehicles (e.g. BS-III, BS-IV), FC grants can be used for providing incentives for retrofitment of vehicles with diesel particulate filters (DPFs). This can lead to significant reductions from these old vehicles also. Since, DPFs are expensive devices and hence can be made popularised with the fiscal incentives.

Industries Sub-sector

Industrial pollution is the most dominant source which emerges out of the national scale emission inventories. While there are emission control standards in place but their enforcement is a major concern. Regulatory authorities lack in their capacities (in terms of manpower, skill, and finances) to adequate enforcement of the law and hence need technological support. FC grants can be used for development of automated industrial pollution vigilance and control centres, which can remotely access and monitor the

industrial stacks and detect any violations. An automated industrial pollution vigilance and control centre is already operational in the Uttar Pradesh PCB for monitoring of River Ganga.

Agriculture Sub-sector

a. Reducing agricultural residue burning

Although, there is an existing government scheme to provide subsides on the machinery required for in-situ management of agricultural residues, but that is not found to be adequate enough as agricultural burning was still found to be prevalent in Punjab and Haryana. There is a need for further enhancement of support in this direction. Not just in-situ, but ex-situ management of agricultural waste also needs to be promoted. Hence, the FC grants should be used, wherever is required, for development of in-situ and ex-situ programs for control and management of agricultural residue burning. In the similar manner, FC grants should also be used for development of in-situ and ex-situ programs for control and management of municipal wastes and its burning. For this, decentralised/or centralised composting and waste to energy plants can be supported. Additionally, methane recovery from STPs and landfills can also be explored.

Municipal Sub-sector

a. Municipal solid waste, construction, and road dust

Waste to energy (WTE) plants with proven technology may be encouraged with FC grants at least in the top ten polluted cities. Dust generated from construction and roads is an important factor adding to the PM10 concentrations. FC grants should be used for enforcement of C&D rules within the municipal limits through incentivised use of construction dust control equipments by both public and private agencies. The grants should also be spent for procurement of Vacuum cleaning machines which can be employed for cleaning of major arterial roads.

b. Research activities

It is utmost important to understand the dynamically changing sources and their contributions towards prevailing air pollutant levels. FC grants should be used for augmenting the air quality monitoring network in the cities and also for conducting studies on state-wise or city scale source apportionment.

Conclusions

The FC can play an important role in signalling the importance of environmental quality in the developmental agenda of States. The proposed approach for determining the shares of cities takes into account existing air quality status in cities but also creates a strong outcome based incentive by placing a higher weight on the change in air quality in the last 5 years, in a dynamic manner. It is proposed to assess air quality using PM10, which is a pollutant of concern and is also most widely being monitored across States. While the grant can be disbursed to states or cities, it may be more effective in making a change in air quality by supporting specific interventions at the city level.

While the present assessment appears the best option given available data, it is important to recognize limitations that are posed due to deficiencies in the existing monitoring system. First, some states do not have any monitoring stations under NAMP- Arunachal Pradesh, did not have data reported from any monitoring stations in 2017. Second, there are an insufficient number of monitoring stations to adequately represent the cities, which can affect the representativeness of the data. Third, the current monitoring network only covers urban locations. There is clearly a need for augmenting PM_{10} and $PM_{2.5}$ monitoring in both urban and rural areas. Simultaneously, Aerosol Optical Depth (AOD) should be explored as a parameter which can be used for capturing air quality in future. As discussed earlier, AOD can provide more widespread spatial coverage, including in rural areas, thus making the analysis more representative.

The proposed approach does not take into account trans-boundary issues related to air pollution and in the long run a clearly defined and consensus based approach needs to be developed in order to attribute contributions of different states to air pollution across the country. This will require an air quality modelling based approach. The MoEFCC should take the lead in developing such a framework. This type of attributive system will require

a) development of a high resolution database of air pollutant emissions
b) adoption and validation of a reliable meteorological and air quality model for India
c) use of validated models to estimate state-wise contributions to India's pollution levels after accounting for trans-boundary issues

In the recently launched National Clean Air Program (NCAP), MoEFCC has set a target of 20-30% reduction in pollution levels by 2024. NCAP proposes various strategies towards this objective but does not provide any specific financial resources. The Finance Commission grant can contribute to the funding of some of the measures envisaged in NCAP. Enhancement of public transport, promotion of electric vehicles, control of agricultural residue burning, strengthening of SPCBs are some of the measures for which FC grants can support existing efforts of MoEFCC under NCAP. Particularly, an outcome-based grant can provide an incentive to States to put in efforts for control of air quality and achieve the target set in NCAP. Such a framework can also lead to a healthy competition among the states to improve their environmental image.

The FC grants should be dove-tailed with NCAP grants so as to ensure synergy between grants coming from both sources with the common objectives.

Reference

Amelsfort, D. (2015). Introduction to Congestion Charging: A Guide for Practitioners in Developing Cities, Asian Development Bank and GIZ. Available online at: https://www.adb.org/sites/default/files/publication/159940/introduction-congestion-charging.pdf

All India installed capacity (in MW) of power stations (2018). Revised as on 31.03.2018 url http://www.cea.nic.in/reports/monthly/installedcapacity/2018/installed_capacity-03.pdf

Central Pollution Control Board (CPCB), (2012a), Health effects of chronic exposure to smoke from biomass fuel burning in rural households, Delhi: CPCB.

Central Pollution Control Board (CPCB), (2012b), Epidemiological Study on Effect of Air Pollution on Human Health (Adults) in Delhi, Delhi: CPCB.

Central Pollution Control Board (CPCB), (2018), Consolidated Annual Report 2016-17 on Implementation of Solid Waste Management Rules, 2016 (April 2018), Delhi: Central Pollution Control Board, Ministry of Environment, Forests & Climate Change, Government of India.

Chakrabarti et al, (2019). Risk of acute respiratory infection from crop burning in India: estimating disease burden and economic welfare from satellite and national health survey data for 250 000 persons. International Journal of Epidemiology, dyz022, https://doi.org/10.1093/ije/dyz022

Chandrasekharan I., etal (2013), Construction of Environmental Performance Index and Ranking of States; *Current Science,* Vol. 104, No.4, 25 Feb. 2013; Pg.435-439.

Danish National Environment Research Institute and Centre for Clean air policy, (2004). Comparison of the EU and US air quality standards and planning requirement, URL : http://ec.europa.eu/environment/archives/cafe/activities/pdf/case_study2.pdf

Danish National Environmental Research Institute and the Center for Clean Air Policy (2004). Assessment of the effectiveness of European Air Quality Policies and Measures, http://ec.europa.eu/environment/archives/cafe/activities/pdf/database_report.pdf

Droste N., Lima G R., May P H., Ring I. (2015). Municipal Responses to Ecological Fiscal Transfers in Brazil: A microeconometric panel data approach. Environmental Policy and Governance 27(4): 378-393

European Commission, (2018) Communication "A Europe that protects: Clean air for all" Dated 17 May 2018

Finance Commission of India (2004), Report of the Twelfth Finance Commission: 2005-2010. http://fincom{India}.nic.in/writereaddata/html_en_files/oldcommission_html/fcreport/Report_of_12th_Finance_Commission/12fcreng.pdf

Finance Commission of India (2015). Report of the Fourteenth Finance Commission: 2015-2020. http://finmin.nic.in/14fincomm/14thFinanceCommission.htm

Gupta, M. and Sengupta, R., (2012). Fiscal & Monetary Policy aspects under Framework for Energy Efficient Economic Development (FEED) Mechanism of National Mission for

Enhanced Energy Efficiency (NMEEE). New Delhi: NIPFP. Available online at: https://www.nipfp.org.in/media/medialibrary/2013/08/BEE_draft_report.pdf

HEI & IITM, 2018, Burden of Disease Attributable to Major Air Pollution Sources in India, url: https://www.healtheffects.org/system/files/GBD-MAPS-SpecRep21-India-revised_0.pdf

Jha, D. (2017). Modi's pet Ujjawala scheme wobbles as many beneficiaries drop out after their first LPG cylinder. Retrieved April 4, 2018, from Scroll: https://scroll.in/article/839961/modispet-ujjawala-scheme-wobbles-as-many-beneficiaries-drop-out-after-their-first-lpg-cylinder

Kaladharan. M, (2016), Renewable Energy in India: An Analysis of the Regulatory Environment and Evolving Policy Trends, Centre for Policy Research India url http://www.cprindia.org/research/papers/renewable-energy-india-analysis-regulatory-environment-and-evolving-policy-trends

Kishore, R. (2017). India's poor are not using LPG cylinders they got under Ujjwala scheme. Retrieved August 4, 2018, from Mint: https://www.livemint.com/Politics/oqLQDFKNuMdbmLEVL88krN/Indias-poor-are-not-usingLPG-cylinders-they-got-under-Ujjw.html

Malhotra, S. (2017). December 14). Prime Minister Modi's LPG scheme for poor running out of gas. Retrieved August 4, 2018, from Hindustan Times: https://www.hindustantimes.com/indianews/lpg-scheme-for-poor-running-out-of-gas/story-t4SSXDV9tkDWCYoyKURtKP.html

Ministry of Drinking Water and Sanitation (MDWS), (2018) ,"Arsenic and Fluoride Contaminated Water", http://164.100.47.190/loksabhaquestions/annex/16/AU2671.pdf

Ministry of Environment Forest and Climate Change (MOEFCC), (2014), "Study on Industrial Pollution", URL: http://164.100.47.193/Annexture_New/lsq16/2/au5026.htm

Ministry of Environment Forest and Climate Change (MOEFCC), (2016), http://pib.nic.in/newsite/PrintRelease.aspx?relid=137373

Ministry of Environment Forest and Climate Change (MOEFCC), (2016a), "Solid Waste Management Rules Revised after 16 Years; Rules Now Extend to Urban and Industrial Areas", Press Information Bureau, New Delhi: MOEFCC, Government of India, URL: http://pib.nic.in/newsite/PrintRelease.aspx?relid=138591, Last accessed on 4th January 2019

Ministry of Environment Forest and Climate Change (MOEFCC), (2016), "Marine Ecosystems", http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=45334&lsno=16

Ministry of Environment Forest and Climate Change (MOEFCC), (2018), "Air Pollution due to Stubble Burning", http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=74024&lsno=16

Ministry of Environment Forest and Climate Change (MOEFCC), (2018), "Effect of Pollution on Marine Life", http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=61261&lsno=16

Ministry of Environment Forest and Climate Change (MOEFCC), (undated), Vision Statement on Environment and Human Health, http://www.moef.nic.in/sites/default/files/visenvhealth.pdf

Ministry of Power, (2018), GoI, Long term growth trajectory of Renewable Purchase Obligations for solar and non-solar for a period of three years url https://powermin.nic.in/sites/default/files/webform/notices/RPO_trajectory_2019-22_Order_dated_14_June_2018.pdf

Ministry of Power, GoI., (2018). State Distribution Utilities, Sixth Annual Integrated Rating, http://pfcindia.com/DocumentRepository/ckfinder/files/GoI_Initiatives/Annual_Integrated_Ratings_of_State_DISCOMs/6th_rating_booklet.pdf.

Ministry of Power, Government of India (2018). Central Electricity Authority, New Delhi Power Sector, March-2018. url http://www.cea.nic.in/reports/monthly/executivesummary/2018/exe_summary-03.pdf

Ministry of Statistics and Programme Implementation (MOSPI), (2018), Sustainable Development Goals (SDGs) - National Indicator Framework, http://www.mospi.gov.in/sites/default/files/National_Indicator_Framework_6nov18.pdf

NITI Aayog, (2018), SDG India Index: Baseline Report, 2018, New Delhi: NITI Aayog, Government of India.

N. Chandiramani, Environmental Federalism: An Indian Viewpoint, ICFAI Journal of Environmental Law, 3(2), 2004.

Pandey, K., Jitendra, Sahu, P., & Thakur, P. (2017). August 31). Ujjwala scheme: Are cleaner cooking fuels affordable and accessible? Retrieved August 4, 2018, from Down To Earth: http://www.downtoearth.org.in/coverage/india-steps-on-the-gas-58502

Pike, E. (2010). Congestion Charging: Challenges and Opportunities, International Council on Clean Transportation. Available online at: https://www.theicct.org/sites/default/files/publications/congestion_apr10.pdf

Ring I., (2008). Integrating local ecological services into intergovernmental fiscal transfers: the case of the ecological ICMS in Brazil. Land Use Policy 25, 485–497

Space Applications Centre (SAC), (2016), Desertification and Land Degradation Atlas of India (Based on IRS AWiFS data of 2011-13 and 2003-05), Ahmedabad: SAC, Indian Space Research Organization.

Tentative State-wise break-up of Renewable Power target to be achieved by the year 2022 So that cumulative achievement is 1,75,000 MW https://mnre.gov.in/file-manager/UserFiles/Tentative-State-wise-break-up-of-Renewable-Power-by-2022.pdf

The Energy and Resources Institute (TERI), (2018), "Source Apportionment of PM2.5 & PM10 of Delhi NCR for Identification of Major Sources", http://www.teriin.org/sites/default/files/2018-08/AQM-SA_0.pdf.

The Energy and Resources Institute (TERI), (2018b), Economics of Desertification, Land Degradation and Drought in India (Commissioned by MOEFCC). Vol I: Macroeconomic Assessment of the Costs of Land Degradation in India, New Delhi: TERI Press.

United Nations (2017), Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%20refinement_Eng.pdf

United Nations, (2015), *Transforming our world: the 2030 Agenda for Sustainable Development*, Resolution adopted by the General Assembly on 25 September 2015, General Assembly, Seventieth session, Agenda items 15 and 116.

UNDP (2016) Ecological Fiscal Transfers, Available at URL https://www.sdfinance.undp.org/content/sdfinance/en/home/solutions/ecological-fiscal-transfer.html#mst-1 ; Last accessed on 30 April 2019

USEPA (2016). Grant Guidance for Multipurpose Grants to States and Tribes. Available online at: https://www.epa.gov/sites/production/files/2016-04/documents/final_ multipurpose_grant_guidance_0.pdf

World Economic Forum (WEF), "90% of plastic polluting our oceans comes from just 10 rivers", URL: https://www.weforum.org/agenda/2018/06/90-of-plastic-polluting-our-oceans-comes-from-just-10-rivers/

The Energy and Resources Institute
www. teriin.org