MANAGING REGIONAL AIR QUALITY

NEED FOR A FRAMEWORK

MANAGING REGIONAL AIR QUALITY

NEED FOR A FRAMEWORK

Research direction: Anumita Roychowdhury

Writers: Anumita Roychowdhury and Kalyani Tembhe

Research inputs: Vivek Chattopadhyaya

Editor: Archana Shankar

Cover: Ajit Bajaj

Layout: Kirpal Singh

Production: Rakesh Shrivastava and Gundhar Das

Maps used in this document are not to scale.

Citation: Anumita Roychowdhury and Kalyani Tembhe 2021, *Managing Regional Air Quality: Need for a Framework*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-40616000
Fax: 91-11-29955879
E-mail: sales@cseinida.org
Website: www.cseindia.org

Contents

1. Why this study?

Improving air quality to meet the clean-air benchmark across the country is one of the most urgent public health challenges today. While urban air quality management has taken root with varying level of action across cities in different geographical regions of the country, there is no framework to meet the clean air targets at a regional scale.

Air pollution has no boundaries. Nor is just a city problem. Both urban and rural limits merge in a given airshed that spans over a huge geographical tract with a nearly common air mass, geographical attributes and similar meteorology. This presents the challenge of achieving more harmonized action across multiple jurisdictions of states.

This framework needs to take shape quickly. Currently, the clean air policies are city-centric. The National Clean Air Programme (NCAP), the first-ever national framework to guide and influence clean air action in polluted cities, has set a target of a 20–30 per cent reduction in particulate levels from 2017 levels by 2024. About 132 cities have been identified under this programme as non-attainment cities that are implementing clean air action plans to meet this target.

Similarly, an additional opportunity has emerged from the funding programme for a million-plus cities for which the 15th Finance Commission has sanctioned a budget for 42 urban local bodies and agglomerations to mitigate air pollution within their respective municipal boundaries. This programme has also sought a 5 per cent reduction in particulate pollution annually over a period of five years.

To meet these targets both the programmes require multi-sector action plans that can reduce pollution from key sources effectively within the targeted geography and the administrative boundary of the city. Both the programmes have adopted a compliance monitoring strategy that requires cities to report on specific indicators of progress in each sector. Cities have to provide information on the current status of action as per each indicator, targets to be met in each sector, and funding planned for each action every quarter. This process is an opportunity to internalize several strategies in the system needed for systemic changes in cities.

While this process can be improved and strengthened to become more performance-oriented, the experience so far has raised several additional questions related to the adequacy of this city-based approach to mitigation of air pollution. The reason for this is the emerging science that has established that it is not possible to draw a hard line around the boundaries of cities or municipalities or even states to focus only on confined action. Wind and pollution blow across boundaries and geographies that can undercut local action in targeted cities.

The current approach of delineating the city boundary for supporting clean air action is cutting off large numbers of pollution sources within the larger influence area of the city and reducing the impact of action. The experience so far with the preparation of clean air action plans for the non-attainment cities show that a large number of power plants and big industrial sources are not within the orbit of planning as the cities have drawn a strict boundary of the municipal limit to keep them out.

Without a strategy it will be challenging to reduce regional influence on local pollution. When meteorology turns adverse in different airsheds due to winter inversion or any other meteorological event, even towns that otherwise may have reasonably lower annual pollution levels can experience high smog episodes. This comes to sharper focus every winter in the Indo-Gangetic Plain. This vast landlocked expanse experiences inversion and entrapment of pollution across the spread of this region. Even if targeted cities take action to reduce pollution overtime the effort can be overwhelmed by the regional buildup of smog.

Air quality analysis carried out by the Centre for Science and Environment (CSE) has shown that even smaller towns and cities in the Indo-Gangetic Plain with much lower annual average particulate level than Delhi and the National Capital Region (NCR) experience higher levels than Delhi during smog episodes. Regional inversion and entrapment of pollution make all habitats vulnerable to toxic risk.

The science of air pollution is slowly taking shape to estimate the direction and quantum of movement of pollution across regions and contribution to sub-regions. There is a clear gradient of influence from any epicentre in the region—from within cities, neighbouring regions, larger states, other parts of the country, and beyond. Such pollution can be from continuous sources such as industry, power plants and vehicles as well as episodic sources such as burning of waste, especially crop waste. To this is added rural pollution sources, including cooking on solid fuels, which is estimated to contribute about 25 per cent of the outdoor ambient particulate concetration in India, as well as non-road sources such as agricultural tractors and diesel generator sets for irrigation among others.

Such a wide gamut of clean air action has become necessary to meet the clean air targets and the National Ambient Air Quality Standards that are being further tightened by the Central Pollution Control Board. This demands a different approach to management of air quality and strengthening and alignment of hyperlocal-, urban- and regional-level action, with clear systems of responsibilities, targets and mitigation strategies to maximize the air quality gains.

India's NCAP has recognized the idea of a regional approach and inter-state coordination. It mentions that a comprehensive regional plan needs to be formulated, incorporating inputs from the regional source apportionment studies. It has listed a series of measures that cut across multiple jurisdictions and are regional in nature, including implementation of policies related to transport such as stringent norms for fuel and vehicles, shift from road to rail or waterways, fleet modernization, electric vehicle policies, clean fuels, bypasses, taxation policies, etc. The industrial sector includes stringent industrial standards, clean fuels, clean technology, enforcement and continuous monitoring. This needs enhanced LPG penetration and control of agricultural burning. These interventions need regional-level inter-state coordination specifically for the Indo-Gangetic Plain.

While the idea has been taken on board, the framework for a formal adoption of integrated management of airshed is not yet in place.

Such an approach has a legal underpinning. This framework requires delineation of the region for aligned and coordinated action. This itself is challenging as scientifically delineated airsheds may have several administrative and political overlaps in the real world and may be an impediment to establishing a legal framework to align regional action and responsibilities within a delineated zone. This will require an operative framework. Technically, identification of critically polluted areas is permitted within the existing provision of the Air (Prevention and Control of Pollution) Act, 1981, that can be leveraged for the purpose of airshed management. But this is currently applied with a very narrow scope to only the industrial areas and/or clusters. But this can be expanded to cover a larger region based on the principle of airshed- based action.

Such a precedent has not so far been set at an executive level in India. Only the ongoing public interest litigation on air pollution in the Supreme Court of India has established the principle of regional approach and integrated planning by encompassing Delhi and sub-regions of three other states in the NCR region.

This is an experiment that needs to be leveraged to create a framework. It is needed to establish upwind and downwind movement of pollution and its effect and assess how this science can inform regional action and planning. It will also require strong science to assess and model air quality transport within a region and identify region-wide pollution sources, impact of atmospheric conditions and factors on local build-up of pollution and regional transport to understand the downwind and upwind character of factors such as pollution movement. The science is in a nascent stage in India though some valuable evidences have begun to emerge.

This approach has gained credence and acceptance globally and several governments have framed rules and policies and set up institutional structures to address action at the airshed level and establish responsibilities for a compliance. It has also changed the way the air quality monitoring system is designed to capture trends across a wider jurisdiction. There are valuable lessons from the architecture of the Clean Air Act in the US that has provided for assessment and responsibility for transport of pollution from upwind to downwind states and adopted a good neighbour policy. The European Union (EU) has adopted the Convention on Long-Range Transboundary Air Pollution (CLRTAP), monitoring of long-range pollution, and an EU-wide air-quality policy that provides a template for aligned air-quality action. China has operationalized the framework for integrated air-quality management of super-regions like Beijing-Tianjin-Hebei region with 28 towns, the Yangtze River Delta and the Pearl River Delta. Appropriate legal, regulatory, action planning and compliance framework has been adopted for aligned implementation.

In South Asia, an additional strategy may also be required to develop a South Asia-level action to further reduce the transboundary effect. The Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia, signed by all South Asian countries in 1998, promotes good science and policy at the regional scale. This forum, however, needs reinvention and resources to become a more effective forum for regional dialogue and action.

Moreover, to operationalize multi-jurisdiction and multi-sector plans, a new institutional architecture is needed in India that will complement and support local institutions and actions and at the same time help to establish regional-level responsibility and accountability for harmonized action across the region.

The time has come to assess the legal and operational framework for introducing regional-level air-quality management in India. From this perspective CSE has taken this initiative to review the emerging science on regional movement of pollution, understand institutional arrangements for coordinated action, legal provisions and national and global good practices for regional air quality management. Globally, several structures and protocols have emerged to address transboundary movement of pollution within a country and between countries. It is necessary to understand these practices to tap the learning curve for India.

The way forward: Summary highlights

This review has established that the scope of the National Clean Air Programme (NCAP) needs to be expanded to go beyond cities to larger regions for an airshed approach and include strategies and framework for regional air-quality management in India. The most recent effort is the preparation of the state action plan that has created an opportunity for more harmonized action across districts. More steps are needed to develop regional monitoring strategies, legal framework, operative mechanism for integrated action and alignment of responsibilities of different authorities and compliance system within the region and the federal system. This strategy is needed to meet the clean air standards.

As the science has established, it is not possible for any local administrative unit to meet the clean-air benchmark without minimizing the regional influences, airshed-level control strategies become necessary to meet the clean-air targets.

Adopt regional-scale air-quality monitoring strategy and assessment of regional contribution to pollution: Air quality monitoring networks need to identify the spatial scale that is appropriate for capturing the areas or regions for profiling of pollution patterns and movement. There has to be a clear delineation of monitoring of micro scale, neighbourhood scale, urban scale and regional scale to characterize regional air-quality trends, geographic patterns and regional background and transport of pollution.

This is needed to address interstate pollution impact on downwind locations and account for it in mitigation strategy to meet the air quality standards. State-level action plans can be designed to reduce the effect on downwind states and tighten the action for additional reduction in the upwind states.

A parallel can be drawn with the Malé Declaration as part of which CPCB has identified 11 monitoring sites to assess regional pollution trends in the subcontinent. Likewise, similar action is needed within the country. The CPCB air-quality monitoring protocol requires identifying urban background sites. But this has not been implemented. This protocol will have to be further developed.

Provide for delineation of air-quality control regions: The scope of the Air Act, 1981 needs to be expanded to establish regions as air-quality-control regions and define the jurisdictional boundaries to meet the air quality standards. A set of responsibilities and relationships amongst national, state, and local agencies needs tobe established to mitigate air pollution. The state clean air action plan need to identify the regulations, programmes and roadmap to attain the standards within the delineated region. The scope of non-attainment areas needs to expand to include sub-regions like the Indo-Gangetic Plain. As in the US, upwind areas that significantly contribute to non-attainment areas in downwind states also need to be designated as non-attainment areas even if they have locally lowered pollution and have achieved the National Ambient Air Quality Standards (NAAQS) standards. Establishing upwind and downwind strategies will be critical for this framework to work efficiently.

Legal framework for regional air quality management: Regional air quality management will require a legal framework to be defined within the ambit of the Air Act, 1981 and Environment Protection Act 1986 and necessary amendment is needed to support this process. Technically, identification of critically polluted areas is possible within the existing provision of the Air Act, 1981 for the purpose of air quality management. CPCB is vested with the power to declare Critically Polluted Areas and Severely Polluted Areas. This approach is however now confined to the management of industrial clusters as per the Comprehensive Environmental Pollution Index (CEPI) Act. It is necessary to expand the scope of its application to include multiple jurisdictions in airsheds such as the Indo-Gangetic Plain to declare them as air pollution control areas and develop management plans for coordinated and collaborative action. This legal backup is important to establish the responsibilities of states and/or cities and vertical and horizontal accountability to meet the regional-level targets related to overall air quality as well as the sectoral targets. It also needs to fix downwind and upwind responsibilities and accountability within the region.

Establish responsibility in state and/or regional plans to account for contribution to air quality in downwind regions: The legal framework needs to regulate inter-region and/or state transport of pollution. For instance, the interstate transport provision of the US Clean Air Act—called the Good Neighbor Provision—addresses interstate transport of pollutants to downwind states. The clean air plans of states, regions and cities in India should include measures for the pollution sources within their jurisdiction to prevent significant contribution to nonattainment areas. The plans must be continually updated based on assessment. If states fail in this the CPCB and the Central Ministry of Environment needs to step in with its own regional plan for harmonized action and to regulate pollution from sources in upwind states and mandate time-bound implementation. This needs to be done pollutant-wise and can pave the way for capping pollution concentration and emissions budget at the regional scale to support compliance with the national ambient air quality standards. States need to be mandated to take additional steps to satisfy good neighbour provisions or prove why additional measures are not necessary as is done in the US. Ensure that downwind states meet the standards while minimizing contribution from the upwind states. High emitting states need to comply with the requirements.

Create regulatory and institutional framework for regional air quality management: Currently, air pollution control is aligned with existing municipal, city and state boundaries and their respective administrative jurisdictions. Once there is geographical delineation of air pollution control areas that may include multiple state governments as in Delhi-NCR, joint efforts of local, state and national bodies will be needed. This requires an intra-state approach as well as inter-state approach to control pollution in a larger landscape and needs to be reflected in attainment plans. The Central government needs to ensure that the multi-sector regulations are met in both upwind and downwind locations.

Need oversight for multi-jurisdiction action in the targeted regions: This will require a formal collaborative and integrated process for regional harmonization of action plans with adequate financial support and resource mobilization strategies and capacity building. The only precedence of multi-jurisdiction air pollution action is evident in Delhi-NCR that has its root in the ongoing public interest litigation in the Supreme Court that has treated Delhi NCR as an integrated unit for the purpose of issuing directions on pollution control. Only recently, an executive system in the form of an Air Commission has been created as a sub-regional institution for overseeing the pollution control action in this region. The Commission is empowered to take decisions and to enforce penal action in regions governed by different state governments. But this is not well aligned with the vertical and horizontal integration of line departments in each sector and alignment of the budget line that is needed in each state for an effective operational framework.

More institutional integration is needed. For instance, China has created administrative units like the Jing-Jin-Ji Regional Coordination Group for Air Pollution Prevention and Control in Beijing-Tianjin-Hebei region and surrounding areas. This is backed by the China's State Council. The Ministry of Environment Protection and the State Council has framed Jing-jin-ji and surrounding area Air Pollution Action Plan and enforcement regulation including air quality standards for the region. Regional measures and criteria for the coal, automobile and industrial sectors have been defined for regional collaboration and joint law enforcement. The Jing-Jin-Ji Ambient Environmental Bureau also facilitates the Central authority's power in managing cross-province air quality regulations. Such a framework needs to be developed for both vertical and horizontal integration.

Operationalize shared responsibility: A regional airshed air quality management based on the principles of shared responsibility, knowledge base and accountability is an important mechanism to regulate the air quality in a region. While outlining the framework, extra effort is needed to establish accountability. For a given non-attainment downwind state or city, the corresponding high contributing upwind state or city should also be regarded as responsible or non-attainment irrespective of their NAAQS status. There can be challenges as it is difficult to define percentage or concentration contributed by the upwind regions to the downwind region's non-attainment. The regulatory framework can complement existing city-centric measures and expand efforts to a regional level. Comprehensive stakeholder engagement is significant for the success of any regulatory framework.

Reinvent the Malé Declaration to re-energize regional cooperation in South Asia: A regional approach will increasingly require addressing pollution ingress from the larger subcontinent. Already estimates have emerged to show the relative contribution from outside India to local pollution. The Malé Declaration is already in place for regional cooperation on air pollution mitigation in South Asia. It needs to be strengthened with committed funding and an action plan with adequate technical and scientific support. The member states can define common monitoring goals and methods as well as information sharing systems, development of science for pollution source assessment and transboundary effects, and adopt interim targets for clean air to seek upward harmonization in policy action. This will require committed funding from the member states and multilateral agencies as well as work plan with a roadmap.

2. Regional imperatives of air pollution

National and regional approaches to air quality management is necessary to reduce public health risk equitably across all regions. The State of Global Air, 2020, has presented stark evidences on the public health impact of air pollution in India. Out of the total tally of 6,670,000 $PM_{2.5}$-attributable deaths globally, 980,000 deaths have occurred in India, recording 61 per cent increase since 2010. Even though the average annual population weighted $PM_{2.5}$ has reduced from 95.2 microgramme per cum in 2014 to 83.2 microgramme per cum in 2019, the levels are still too high.

While particulate pollution is responsible for these estimated deaths, other silent killers like ozone are also pacing up, recording an 84 per cent increase in ozone-related deaths since 2010. Ozone concentration in India has seen an increase of 17 per cent—from about 56.5 parts per billion (ppb) in 2010 to 66.2 ppb in 2019. India is facing a multi-pollutant crisis.

Reanalysis of state-level data from a 2017 *Lancet* study "The impact of air pollution on deaths, disease burden, and life extectancy across the states of Inida: The global burden of disease study" shows that even if there are wide variations in pollution concentrations across regions of India—with the Indo-Gangetic Plain showing the highest concentration—the health risk in terms of number of people dying per 100,000 population is fairly uniform across India. While 63 people are dying per 100,000 population in Delhi and 79 in Bihar, the number in Kerala is 79 and in Tamil Nadu 76. Health science has continually underscored the point that most of the health impact occurs at a level that are much lower than those measured in Indo-Gangetic Plain.

Climatic and geo-spatial attributes determine the intensity of pollution build up in different regions. The country's climate is significantly impacted by its numerous geographical features, including the Himalayas, Indo-Gangetic Plain, Thar Desert, Western Ghats and Deccan Plateau. Whereas the coastal winds disperse the pollution away from the coastal towns, the climate and meteorology of the Indo-Gangetic Plain trap pollution, especially during winters. The Indo-Gangetic Plain is more vulnerable as it is landlocked and its natural ventilation patterns are constrained. This increases overall pollution concentration in the region. According to a 2020 WHO report, 14 of the 20 most polluted cities of the world are in India, and except for Bhiwadi all of these cities are located in the Indo-Gangetic Plain. In contrast, the southern, western and eastern regions of the country show lower concentration of particulates. The regions with coastlines have an advantage of more efficient ventilation patterns. Therefore, cities with lower concentrations are in coastal region and in tropical wet and dry zones.

Air quality of any given region is a product of complex synergies between various factors: type, quantity, sources and intensities of anthropogenic activities, chemical and atmospheric transformations, regulations and, most importantly, meteorological and geographical conditions that aggravate or alleviate the pollution. Topography and weather affect an area's dispersion capacity, and the intensity of polluting activities within and outside a city influence local pollution, which is why despite the advantages of coastal environment Mumbai and Visakhapatnam often rank in the "poor" air quality index (AQI) category.

Even before India could comply with the current national ambient air quality standards for clean air, the World Health Organization (WHO) raised the bar and redefined the threshold of safe air in 2021. Currently, nearly everyone in India is breathing air that defies the current guidelines of the WHO.

As meeting the current air quality standards and WHO guidelines remains a challenge, questions have been raised regarding the feasibility of implementing the new WHO guidelines in different geo-climatic zones of India. The new WHO guidelines are tougher—a target of 5 $\mu g/m^3$ for annual average and 15 $\mu g/m^3$ for the 24-hour average of $PM_{2.5}$ for instance are eight to four times tighter respectively than the Indian standards. This region has challenging meteorological and climatic conditions, with the added challenge of haze columns, heat island effects and very high baseline pollution.

Even if polluting activities are eliminated, only biogenic or natural processes can create natural organic aerosols that can also be high. Within these constraints mitigation of emissions from different sources as well as survival emissions from cooking among others will have to be addressed.

Background levels are very high in India. The lockdown phases during the pandemic restrictions, when the economy and transport had come to a near halt, showed how low pollution can become if pollution is controlled locally and regionally. In 2020, the citywide average in Delhi was below half of the standard on 50 days, of which 31 days were below 25 $\mu g/m^3$ in 2020. An assessment by

SAFAR of the Indian Institute of Tropical Meteorology under the Ministry of Earth Sciences has shown that the background levels for the Mumbai region, for instance, could be lower during the hard lockdown phases because of the reduced regional influence. An assessment by the Central Pollution Control Board showed that in several other regions the pollution could be reduced by more than half. Yet the levels were higher than the WHO guidelines. The current challenge in India is to meet its national ambient air quality standards in all the regions and move beyond to meet tighter interim target.

Overall, the cleanest cities are concentrated in Kerala and southern Karnataka and a few others in small pockets in the Bundelkhand-Bagelkhand region of Madhya Pradesh and Northeast India. Evidently, Eloor, close to Kochi in Kerela, has the lowest annual average for 2020 at 12ug/m^3, with 317 days of the 24-hour average lower than 25 µg/m^3. Similarly, Mysuru's annual average for 2020 stood at 17µg/m^3. The 24-hour average was lower than 25 µg/m^3 on 204 days. Ramnagara in Karnataka had 234 days when the 24-hour average level was below 25 µg/m^3 and its annual average at 21 µg/m^3. Satna in Madhya Pradesh had 321 days with the 24-hour average below 25 µg/m^3 and probably tops the list with the most number of clean days but its annual average is 18 µg/m^3.

Given the complex nature of air pollution, a one-size-fits-all regulatory framework for air quality management does not provide an optimum solution. Airshed-level coordinated actions and interim targets are needed to manage air pollution. The current system falls short of adopting airshed management and governance principles.

3. Airshed approach for air quality management

The new science emphasizes on taking an airshed approach to air quality management. Airshed is understood to be a geographic area with a unique air mass and common topography, meteorology and climate. It acts coherently in terms of pollution dispersion. A delineated zone has a unique air mass where emissions from the region are contained largely within its limits. It might range from a small area with fewer polluting sources to vast urban and rural areas with complicated air quality issues. While it may appear to be comparable to a watershed, an airshed is significantly more difficult due to the lack of physical or apparent dimensions and the possibility of vast area dispersion.

There is no singular or uniform definition of airshed approach to air quality management. There are different approximations and dimensions. Airshed boundaries can be defined differently for different situations.

- Studies show that an airshed can be defined as a remote geographic location, such as a small valley town, where the dispersion of air pollutants is limited by physical restrictions such as surrounding hills and waterbodies. During stable, stagnant and light wind conditions, these features can reduce the dispersion of pollutants emitted from local sources, resulting in degraded air quality. For example, experts point at the San Joaquin Valley air basin in California as an example of this type of airshed.
- An airshed can also be a large geographic area covering hundreds of square kilometres that experiences similar air quality due to similar types of pollutant emissions, topography and meteorology, as in the Indo-Gangetic Plain.
- An airshed's limits can also be based on jurisdictional concerns such as municipal, regional or governmental borders as in densely populated places such as Delhi, Montreal and Metro Vancouver. This can also happen in large, generally flat areas with no substantial variations in land elevation, such as in Alberta and Saskatchewan.

Delineation of an airshed has three basic steps: First, emission quantification to prepare a multi-pollutant emission inventory; second, analysis of meteorological data to evaluate variations and similarities at the local and regional levels; and third, performing air quality modelling to understand the pollution dispersion and transformation in the study area. But before delineation, there needs to be collective motivation and incentives to justify the need for airshed air quality management, as it requires a lot of time, resources and planning. This requires enhanced air quality monitoring, emissions inventory, dispersion modelling, source apportionment, and meteorological information to assess the region. The framework for airshed management planning is based on the principles of shared responsibility, sustainable development, integrated planning and management of resources, adaptive management and, last but not the least, continuous improvement without degrading the air quality of clean areas.

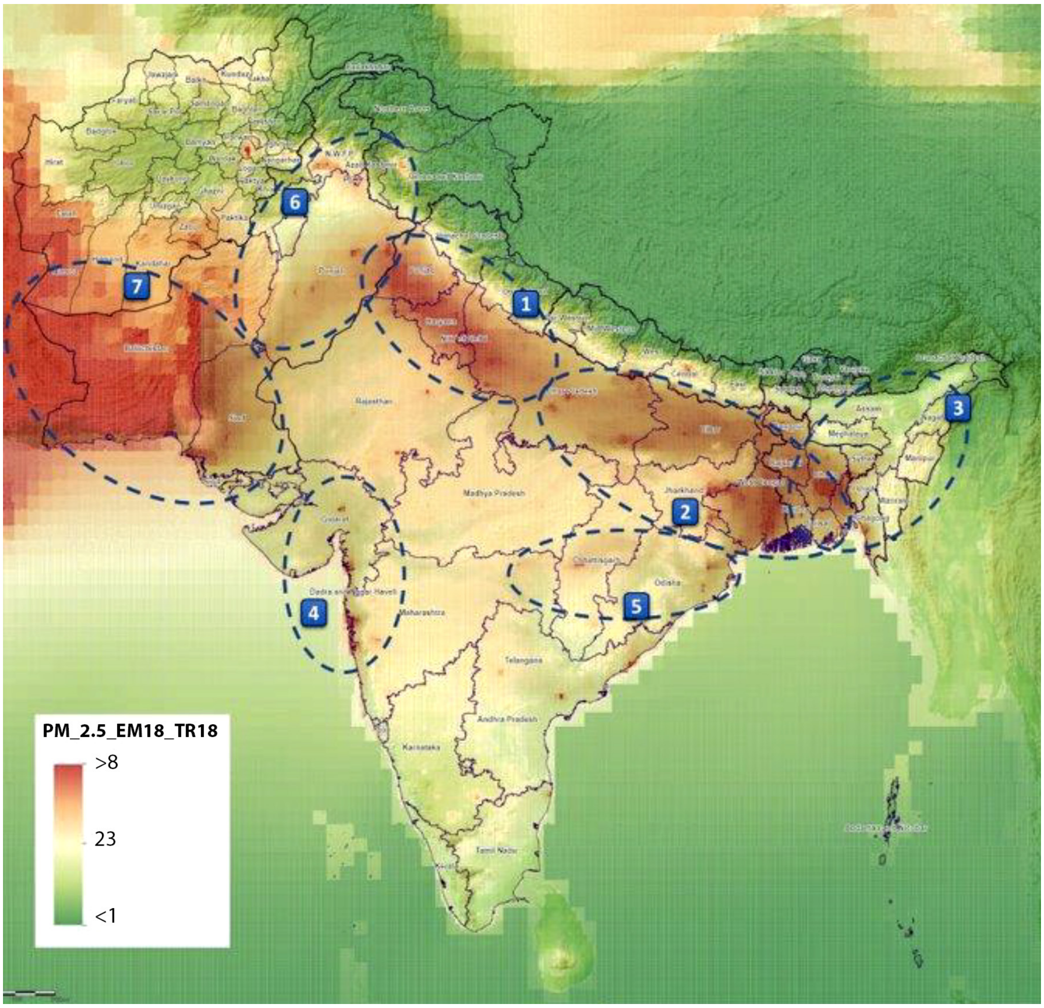
When Beijing reported alarmingly poor air quality, the country's officials drafted measures to relocate the polluting industries away from Beijing to the neighbouring province of Hebei. Due to this action, not only did Hebei's air quality take a toll, but due to the regional transport of air from Hebei to Beijing it proved ineffective, following which an air quality management comparable to airshed management was drafted for the Beijing-Tianjin-Hebei region.

A World Bank assessment has identified several critical airsheds with high $PM_{2.5}$ concentrations in India. The areas include the western and central Indo-Gangetic Plain that extends into Pakistan; central and eastern Indo-Gangetic Plain that extends into Nepal and Bangladesh; the Brahmaputra airshed covering Bangladesh and India; middle India including east Gujarat, west Maharashtra, Odisha and Chhattisgarh; northern and central including Pakistan (Punjab), India (Punjab), and part of Afghanistan; south Pakistan; and west Afghanistan extending into east Iran. The geographic spread of the extent of these regions determines the airshed and brings out significant overlap in jurisdictions (see *Map 1: Critical airsheds of India*).

The rapid increase in anthropogenic emissions in several of these regions over the past decades have significantly deteriorated the region's air quality. High levels of unhealthy air pollution occur in the Indo-Gangetic Plain and the Indus River Plain. Transboundary pollution and non-transboundary pollution get trapped by the high-altitude Himalayan range and form a valley effect somewhat similar to Kathmandu in Nepal or the San Joaquin Valley in USA.

This entrapment worsens during winter, when the Indo-Gangetic Plain is affected by the Western Disturbances (a series of alternating low and high-pressure systems that travel from west to east, causing heavy haze and fog). A low-pressure system generates increased moisture content in the boundary layer, strong winds and clouds, which is then replaced by a high-pressure system, which causes clear skies, low winds, radiative cooling of the ground and temperature inversions. During

Map 1: Critical airsheds of India



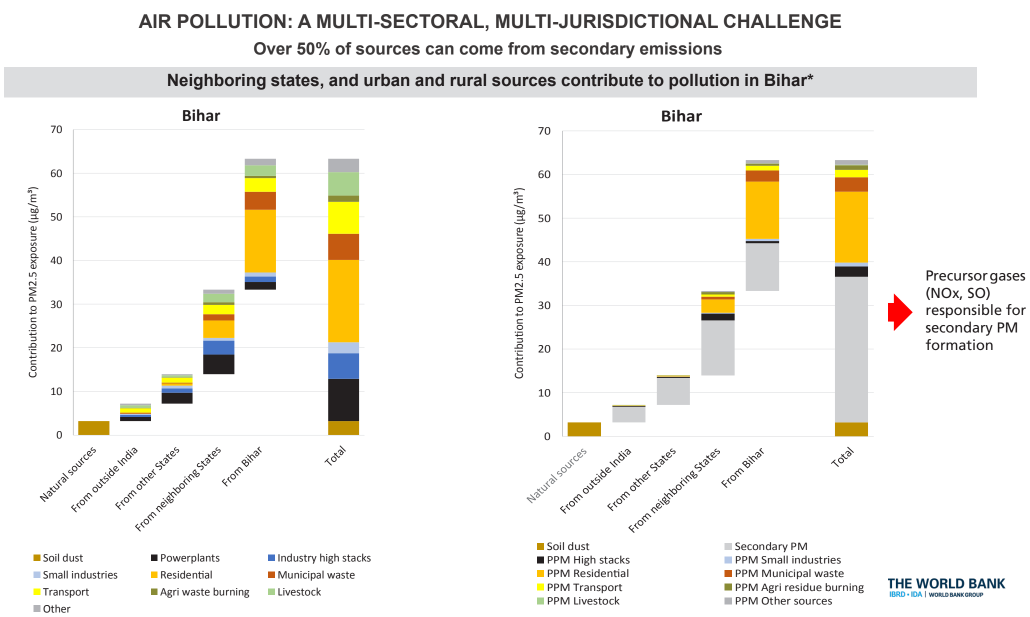
Source: Karin Shepardson, 2020, World Bank Engagement on Air Quality Management, Asia Development Bank Workshop on Scaling Support-Discussion with MDBs

this time, the temperature also hits its yearly lows, accompanied by increase in the frequency of Western Disturbances. These circumstances are perfect for the buildup of pollutants inside the boundary layer, which frequently results in fog and haze over the Indo-Gangetic Plain. Despite strict local action, the air quality in this region continues to be alarming, the reason for this being the transboundary flux of pollution over the plain.

The World Bank has further estimated the influx of pollution from sub-regions to targeted states to demonstrate the transport of pollution from outside India, from other states, and from within the state. This can be made even more granular for cities. Such a modelling has been done for the state of Bihar. There is a clear gradient in which the share of regions depends on proximity within the state to neighbouring states and outside India; the highest contribution can come from within the state. This further captures the source-wise contribution to the concentration of total pollution, including from soil dust, power plants, industry high stacks, small industries, residential, municipal waste, transport, agricultural waste burning, livestock and others. Also, depending on the origin of the pollution, the relative contribution of the sources can vary (see *Graph 1: Relative contribution of sub-regions to the local air pollution*).

For instance, in Bihar, the contribution of power plants dominates pollution from other states. But closer home the relative contribution of residential biomass burning increases. This provides insight into the nature of interventions needed region-wide to be able to make an effective impact.

Graph 1: Relative contribution of sub-regions to local air pollution



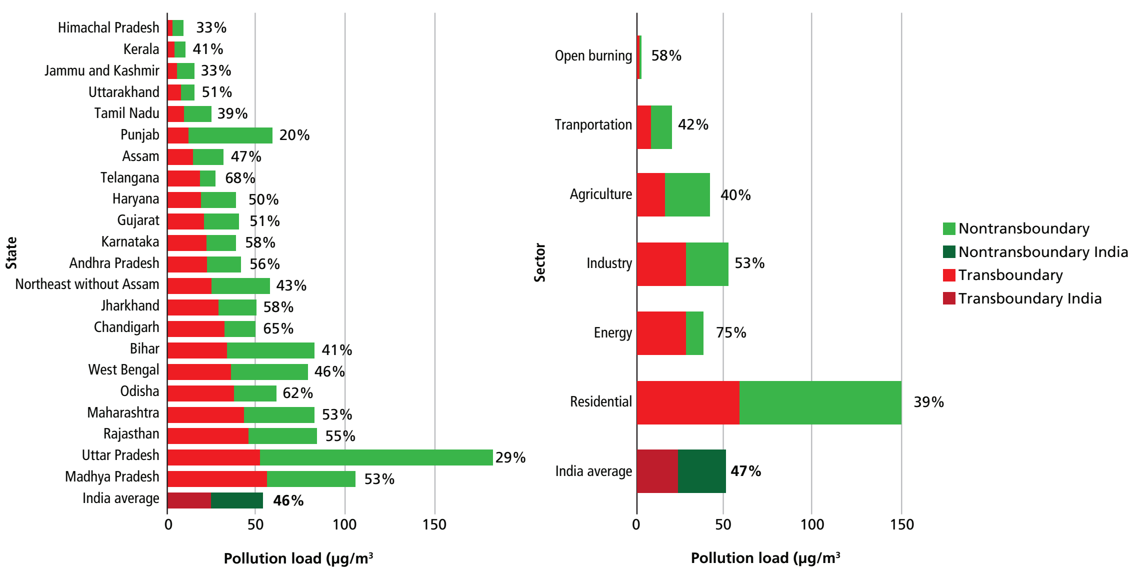
Source: Karin Shepardson, 2020, World Bank Engagement on Air Quality Management, Asia Development Bank Workshop on Scaling Support-Discussion with MDBs

The literature shows that in India, when all states and sectors are combined, transboundary air pollution flux contributes to around 46 per cent of the overall air pollution burden, according to 2015 data. This high fraction demonstrates that state-level policymakers are incentivized to regulate just half of the widespread air pollution while the other half is outside their jurisdiction. The Indo-Gangetic Plain, where the pollution levels are highest and occasionally becomes "severe", creates a large amount of pollution. Still, most of it is either transferred to neighbouring states within the plain or outside the plain. In particular, the upwind states of Haryana, Punjab and Uttar Pradesh stand out as net exporters of emissions while the central and eastern states, particularly Odisha, Telangana, Chhattisgarh and Rajasthan, are major recipients of the pollution from the Indo-Gangetic Plain due to wind patterns (see *Graph 2: Statistics of transboundary and non-transboundary pollution load received by (a) 22 Indian sub-national jurisdictions and (b) six sectors*).

The relatively wealthy and lesser populated states of Haryana and Punjab export much of their industrial, agricultural and residential pollution to the neighbouring relatively poor and densely populated states.

The externalities and lack of jurisdictional power arising due to transboundary air pollution cannot be addressed unilaterally. Externalities allow polluters to profit from the economic output that causes pollution, but recipients have no power in decisions on sources that contribute to air pollution. The need for regional airshed delineation for air quality management and inter-state transboundary regulations in the country has become more pressing in light of this regulatory dissonance.

Graph 2: Statistics of transboundary and non-transboundary pollution load received by (a) 22 Indian sub-national jurisdictions and (b) six sectors



Source: Xinming Du et al. 2020, *Cross-state air pollution transport calls for more centralization in India's environmental federalism*, Atmospheric Pollution Research.

Several studies have thrown up evidences on long-range transport of pollution, which affect distant sites and are influenced by different atmospheric processes. The South Asian region is severely affected by long-range transport and transboundary pollution. Studies have shown that this can also originate in Europe, the Middle East, Africa, Southeast Asia etc. The transported mineral dust in West and South Asia contributes to high particulate loadings in the region. Also forest fires in Southeast Asia lead to long-term climate implications. The transport of polluted continental air masses up to the Indian Ocean has implications for Indian summer monsoons (ISM) and also affects sensitive ecosystems such as the Himalayan region and Western Ghats. It is also said that South Asian region receives air masses from Europe, the Middle East, Africa, the Indian Ocean and so forth, depending upon the season. Air masses also coming from Europe and the Middle East and carry high concentration of acidic pollutants that affect the Himalayan ranges. Acidic pollutants from continental anthropogenic sources are transported to an eco-sensitive site in the Western Ghats in India and the outward fluxes of anthropogenic activities of the Indo-Gangetic region are transported towards the Bay of Bengal. Transboundary and long-range transport of pollutants need immediate attention.

There is yet another set of studies emerging around the assessment of the impact of the short-lived climate forcers that are local pollutants such as black carbon— a fraction of particulate matter, but being heat trappers are also acceleratorsof global warming. South Asia has been investigated for atmospheric "brown clouds", caused by pollution from carbon aerosols. Satellite images of atmospheric haze over South Asia have been studied. Short-lived climate forcers have also been investigated in the context of biomass burning in the region. Open residue burning is common here. Air pollution in the Indo-Gangetic Plain largely comprised carbon (organic, black), dust, nitrates and sulphates largely caused by forest fires, vehicles, coal-based power plants and industries.

Impact in smaller sub-regions: Science is also estimating the movement of pollution between smaller sub-regions and its role in the regional pollution load. The sub-regions that have drawn attention include Delhi-NCR, which comprises jurisdictions of four state governments: Delhi, Haryana, Uttar Pradesh and Rajasthan.

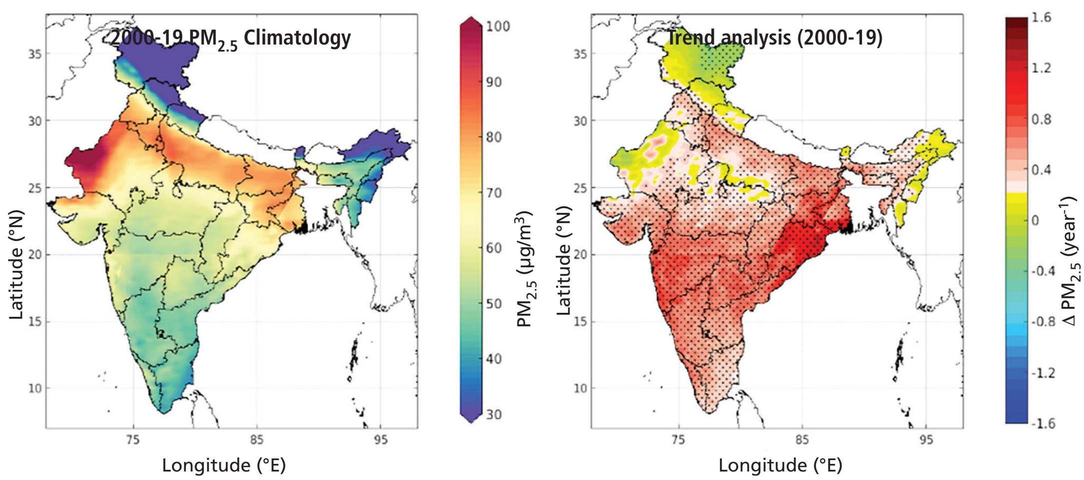
A 2018 joint study by Energy and Resources Institute (TERI) and Automotive Research Association of India (ARAI) study estimated the contribution of sources from within Delhi and also from 19 districts of the NCR to Delhi's air quality. This shows that Delhi's own contribution to $PM_{2.5}$ concentration in 2018 was 36 per cent in winter and 26 per cent in summer. But contribution of NCR to

Delhi's pollution was about 23–24 per cent of $PM_{2.5}$ and 26 per cent of PM_{10}. In all, Delhi's air quality is influenced by sources within NCR by 70 per cent in winter and 50 per cent in summer.

On the other hand, in this upwind to downwind movement, Delhi also contributes to NCR pollution. During summer the contribution from Delhi to downwind Noida can be 28 per cent during summer and 40 per cent during winter. But to upwind Panipat the contribution is about 1 per cent. The report by IIT Kanpur (2015) also shows more than 50 per cent of secondary particulates associated with coal and biomass burning outside Delhi (see *Box: Evidence on transboundary movement of pollution in Delhi-NCR*).

Independent studies have adopted more advanced techniques, including satellite imaging of pollution, which has enabled better understanding of the spread and intensity of pollution. Scientists in the Indian Institute of Technology (IIT), Delhi, have assessed a high-resolution (1 km) ambient $PM_{2.5}$ database spanning two decades (2000–19) for India. They have converted aerosol optical depth from a Moderate Resolution Imaging Spectroradiometer (MODIS) to surface $PM_{2.5}$. The satellite-derived daily (24-hour average) and annual $PM_{2.5}$ were derived. and correlated with surface measurements from the CPCB's monitoring network. The assessment concludes that the poor air quality across the urban–rural landscape indicates that this is a regional-scale problem (see *Map 2: Spatial patterns of (a) annual $PM_{2.5}$ and (b) annual aerosol optical depth (AOD) averaged for 20-year (2000–2019) period over India*).

Map 2: Spatial patterns of (a) annual $PM_{2.5}$ and (b) annual aerosol optical depth (AOD) averaged for 20-year (2000–2019) period over India



Source: Sagnik Dey et al., 2020, *A Satellite-Based High-Resolution (1-km) Ambient $PM_{2.5}$ Database for India over Two Decades (2000–2019): Applications for Air Quality Management*, MDPI, Remote Sens. 2020, 12, 3872; doi:10.3390/rs12233872

EVIDENCE ON TRANSBOUNDARY MOVEMENT OF POLLUTION IN DELHI-NCR

The contribution of pollution sources in different regions of Delhi and NCR sub-region was reported in a joint study by TERI and ARAI (2018) on pollution source assessment. The average contribution of $PM_{2.5}$ in Delhi and other NCR towns (Ghaziabad, Noida, Gurgaon, Faridabad and Panipat) during winter and summer was estimated. The report captured inter-boundary movement of pollution—from upwind to downwind regions—to indicate how pollution management needs to be done at the regional scale. The following is a snapshot of this evidence.

Delhi: The contribution of $PM_{2.5}$ to Delhi's air quality was 24 per cent, 17 per cent, and 33 per cent from NCR, upwind NCR states, and upwind regions outside India, respectively. Significant contributions of $PM_{2.5}$ is from outside Delhi. An IIT Kanpur (2015) study has reported a 56 per cent contribution of $PM_{2.5}$ from outside of Delhi. In summer, the contribution of $PM_{2.5}$ is also high due to higher wind speed and enhanced atmospheric transport of pollutants.

Ghaziabad: Among NCR towns, Ghaziabad is downwind of Delhi and received 10 per cent of $PM_{2.5}$ from Delhi during winter. Upwind NCR states, and upwind regions outside India contributed about 11 and 9 per cent of $PM_{2.5}$. Ghaziabad received 61–70 per cent of $PM_{2.5}$ from NCR in summer and winter. In summer, 33 per cent of the contribution of $PM_{2.5}$ was from regions outside India and only 5 per cent of the contribution of $PM_{2.5}$ was from Delhi.

Noida: Noida is also located downwind of Delhi, and the prevailing wind direction is north-west, especially in early winter (or autumn) and winter season. Noida received 40 per cent of $PM_{2.5}$ from Delhi in winter, while upwind NCR states and regions outside India both constituted 14 per cent of $PM_{2.5}$. The 24–32 per cent contribution of $PM_{2.5}$ from NCR in summer and winter is evident. In summer, 43 and 28 per cent of contribution to $PM_{2.5}$ was from upwind regions outside India and from Delhi, respectively.

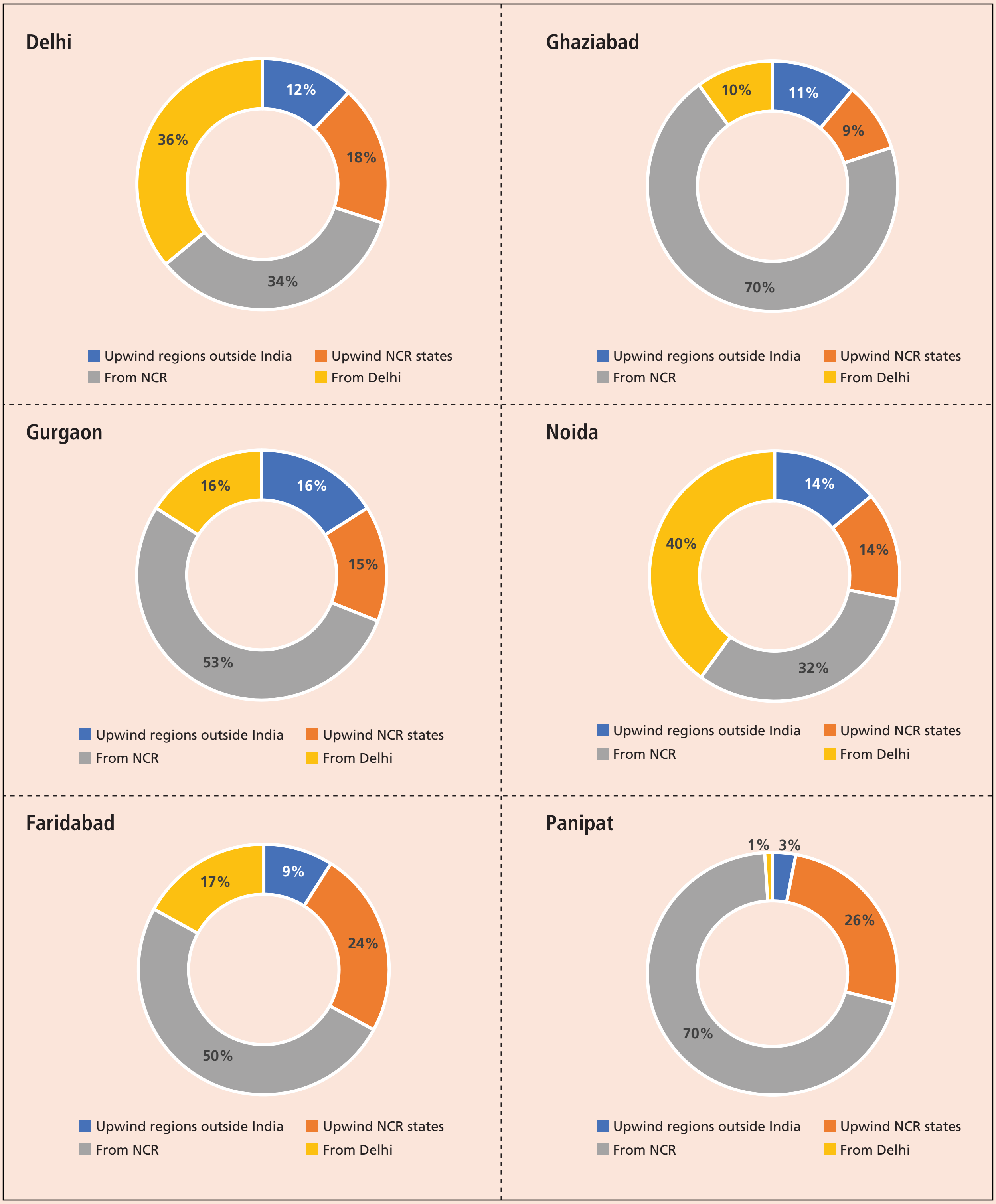
Gurgaon: Gurgaon receives 12–15 per cent of $PM_{2.5}$ from Delhi in summer and winter seasons. The upwind NCR states and regions outside India contribute 15–16 per cent of $PM_{2.5}$ in winter, while 53 per cent of $PM_{2.5}$ in summer is from upwind regions outside India. Gurgaon also gets 35–53 per cent of $PM_{2.5}$ from NCR in summer and winter.

Faridabad: Faridabad gets 13–15 per cent of the contribution of $PM_{2.5}$ from Delhi in summer and winter. The upwind NCR states and regions outside India contribute 9–24 per cent of $PM_{2.5}$ in winter, while 50 per cent of $PM_{2.5}$ is from regions outside India in summer. Faridabad also gets 30–50 per cent of $PM_{2.5}$ from NCR in summer and winter.

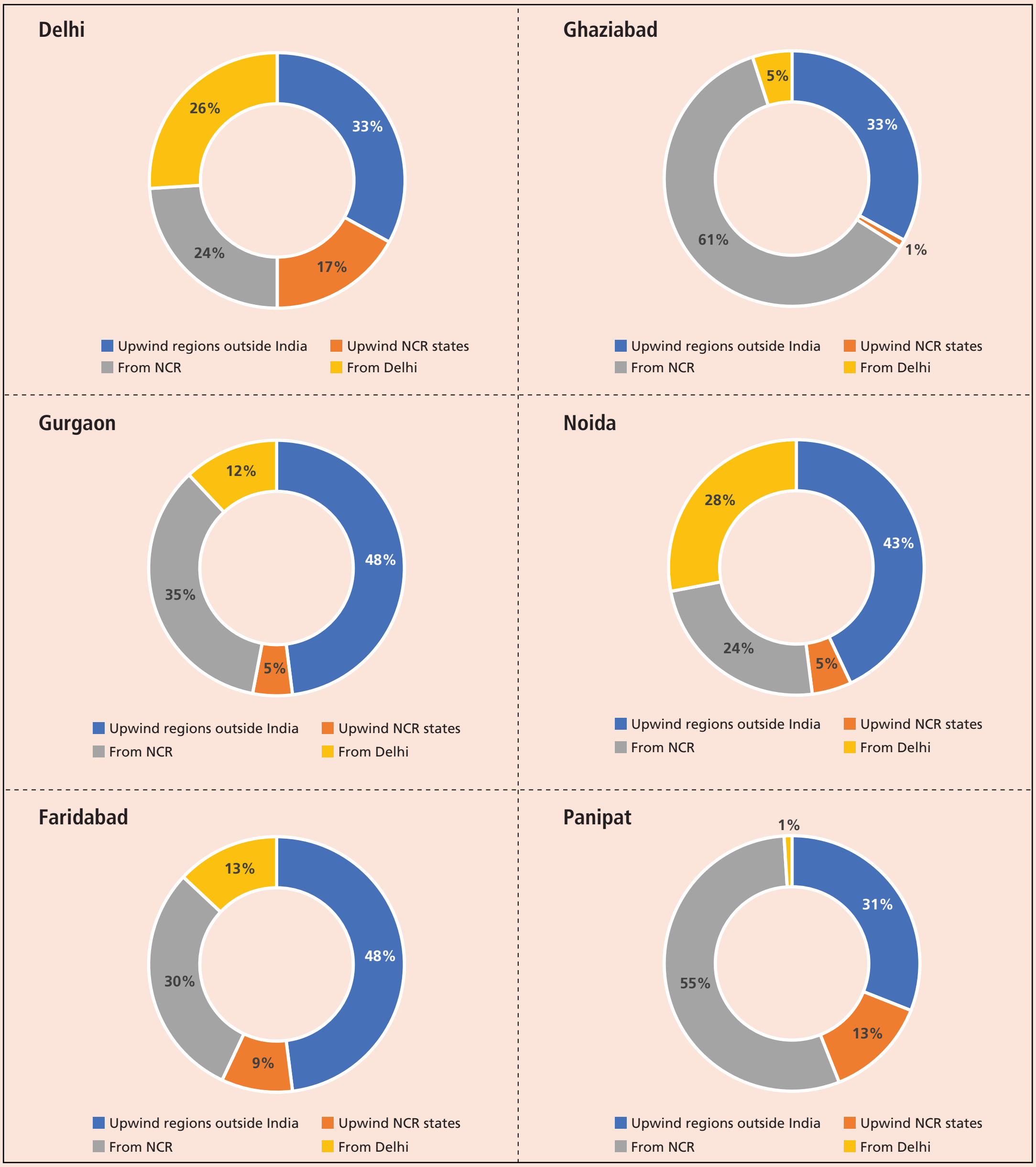
Panipat: Panipat is located in the upwind direction of Delhi, and received 1 per cent of $PM_{2.5}$ from Delhi. Upwind NCR states and regions outside India contributed 4–26 per cent of $PM_{2.5}$ in winter, while 31 per cent of $PM_{2.5}$ was from upwind regions outside India in summer. Panipat received 56–70 per cent of its $PM_{2.5}$ from NCR in summer and winter.

Overall, the assessment of both source apportionment studies revealed that secondary particles, vehicle, biomass burning and industries were the major sources of $PM_{2.5}$ in Delhi and NCR towns during winter. In summer, the contributions of dust from inside and outside of India increased. High contribution of dust sources in $PM_{2.5}$ can be attributed to dry conditions and higher wind velocities in summer. Local sources such as vehicles and their contribution to $PM_{2.5}$ is higher in winter (23–25 per cent in Delhi city and NCR towns) compared to summer (9–20 per cent).

Graph 1: The percentage contribution of $PM_{2.5}$ from different regions during winter season

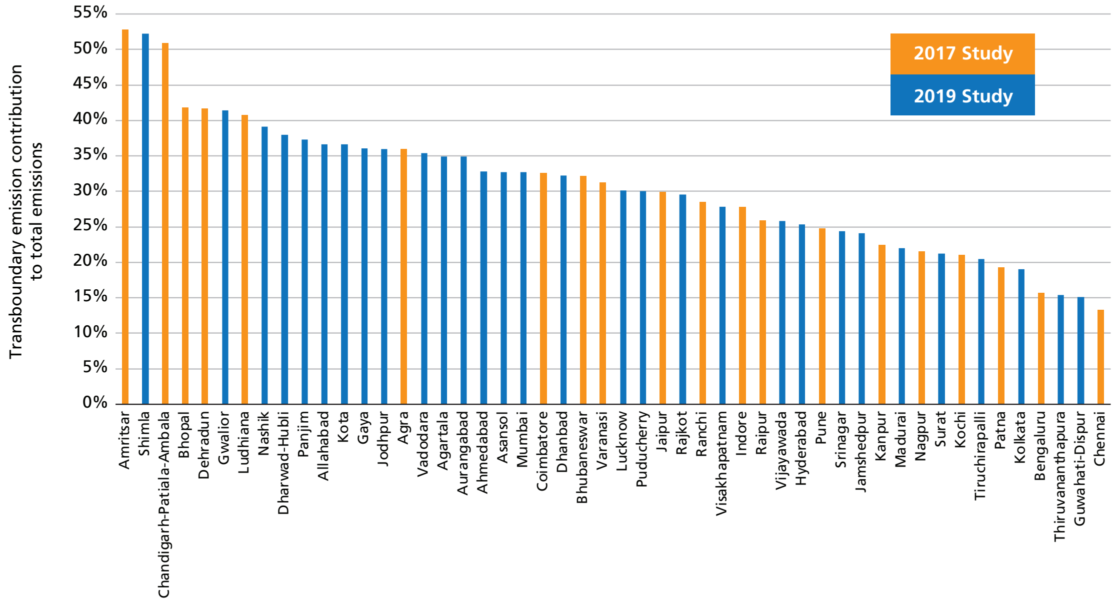


Graph 2: The percentage contribution of $PM_{2.5}$ from different location during summer season



Other independent assessments have followed. According to the air pollution knowledge assessment reports for fifty cities released by UEinfo in 2017 and 2019, for 29 out of 50 cities, over 30 per cent of the total emissions is sourced outside the city's jurisdiction (see *Graph 3: Percentage of total emission sourced outside the city boundaries*).

Graph 3: Percentage of total emission sourced outside the city boundaries



Source: Compiled by CSE from Urban Emission Info

The implicit logic in this science is that air pollution mitigation is not possible if a large share of pollution sources remain outside the orbit of the control area. Air pollution is a multi-sector crisis and cannot be addressed if a large part of industrial units, power plants, small industrial units, household energy and waste streams remain outside the limits of the municipal boundaries of cities.

Winter pollution and regional transport of pollution: Winter pollution is a direct evidence of the regional scale buildup of pollution. Winter inversion, cool and calm conditions and other atmospheric disturbances aids in rapid buildup of pollution concentration.

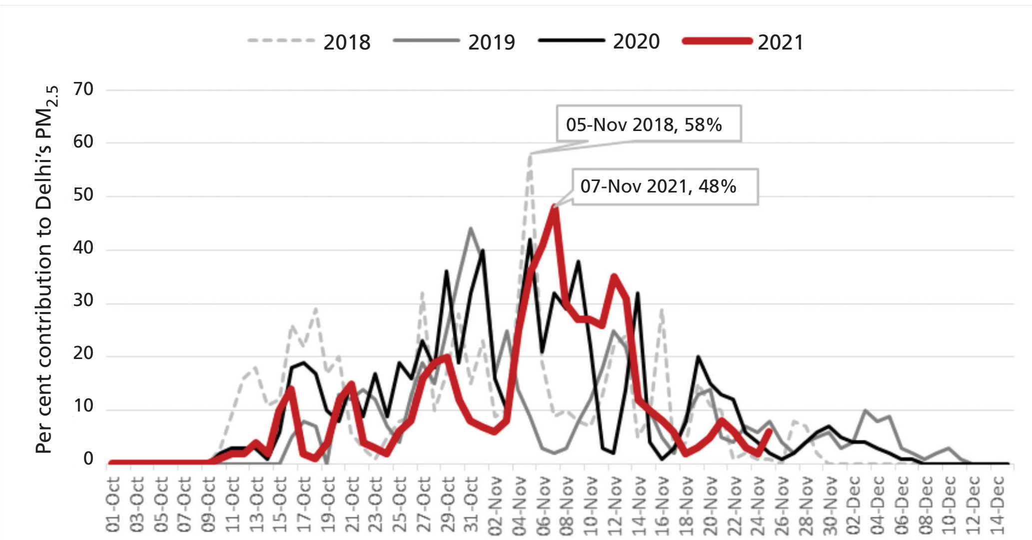
CSE has tracked all the 67 monitored cities in the Indo-Gangetic Plain. It shows air quality dips to "poor", "very poor" and "severe" categories as the monsoon retreats. For most of the northern plains from Punjab to central Uttar Pradesh (UP), the start of bad air quality days is almost perfectly synchronized. The Eastern Plains witness the onset of pollution almost three to four weeks later. The air cleans up in Punjab much earlier than in the rest of Indo-Gangetic Plain, while pollution lingers longer in NCR and adjoining western UP. In the lower Indo-Gangetic Plain (Bihar and West Bengal), the air begins to clean up earlier than in NCR. The Northern Plains (up to central UP) are severely impacted by farm stubble fire smoke during the start of winter season, but the high levels seen later in the season are due to inversion and local pollution. Meanwhile, winter buildup in the Eastern

Plains is driven almost by inversion and local pollution with limited impact of smoke from farm stubble fires and intrusion from the larger Indo-Gangetic Plain.

Contribution from episodic events: In Delhi-NCR it has become possible to estimate the contribution of smoke from crop burning in the neighboring states to Delhi's air quality. SAFAR (System of Air Quality and Weather Forecasting And Research), a research-based initiative of integrating air quality with health advisories and food security, now routinely predicts and estimates the daily contribution of stubble burning to the pollution in Delhi. This depends on the direction and speed of the transport wind and intensity of burning in a given day.

CSE analysed the data provided by SAFAR on daily percentage contribution of the stubble burning to the $PM_{2.5}$ concentration in Delhi-NCR depending on the direction and speed of the wind. The review of the data for the winter period October–December (2018–21) shows that depending on speed and direction of wind and intensity of fire incidents this contribution can be as low as 0–4 per cent per day to a peak contribution of over 30–40 per cent per day on a few days. There is high variability. During 2021, due to prolonged rain in October, a significant amount of burning was deferred and therefore the contribution during October was minimal. But this increased significantly post Diwali due to concentrated burning and a spike in peak levels. After November 12, the share declined significantly. Data from previous winters shows that the influence of stubble burning is eliminated during the later part of the winter (see *Graph 4: Contribution of farm fires to Delhi's air quality*).

Graph 4: Contribution of farm fires to Delhi's air quality



Source: CSE analysis of SAFAR data, 2021

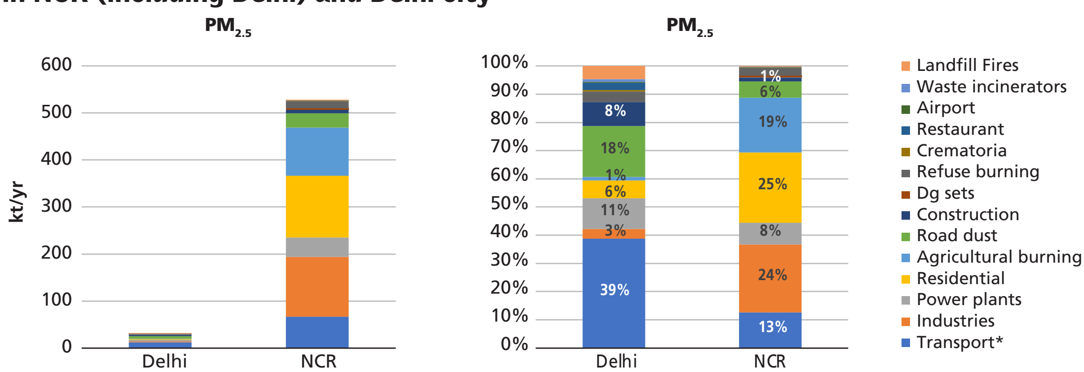
It is important to emphasis that while Delhi's example is illustrative of regional influence, such episodic events have significant impact on the larger Indo-Gangetic Plain.

Understanding pollution sources in sub-regions: Regional action needs proper profiling of pollution sources across the region for developing integrated regional plan of action. The conventional approach of carrying out the source inventory of emissions and source apportionment studies that estimate the pollution load from the inventory of pollution sources and assesses relative contribution of sources to the ambient concentration respectively have just about begun in cities. While some of the early studies have been carried out in Delhi-NCR, the other 132 cities under NCAP have just been mandated to do similar studies and are in varying level of progress. Most of these studies barring a few in Delhi-NCR are city-centric and do not include regional scale of assessment.

The 2018 joint study by TERI-ARAI carried out a source inventory in NCR to assess the major sectors that include residential, open agricultural residue burning, tailpipe emissions from vehicles, construction, industries (including bricks and stone crushers), power plant stacks, coal-handling units and fly-ash ponds, road dust, diesel generators, refuse burning, crematoria, restaurants, airports, landfills, waste incinerators, solvents, ammonia emission sources, etc.

There is great variance between the pollution inventory profile and relative contribution of sources to the pollution load in Delhi and NCR region. While vehicles contribute about 39 per cent of the $PM_{2.5}$ load in Delhi it is about 13 per cent in NCR. But contribution of industry (24 per cent) and agricultural burning (19 per cent) are higher in NCR. There is relative difference between overall $PM_{2.5}$ load between Delhi and NCR (see *Graph 5: Absolute and percentage share of different sectors in overall inventory in NCR (including Delhi) and Delhi city*).

Graph 5: Absolute and percentage share of different sectors in overall inventory in NCR (including Delhi) and Delhi city



Source: ARAI-Teri, 2018, Source Apportionment of $PM_{2.5}$ & PM_{10} of Delhi NCR for Identification of Major Sources

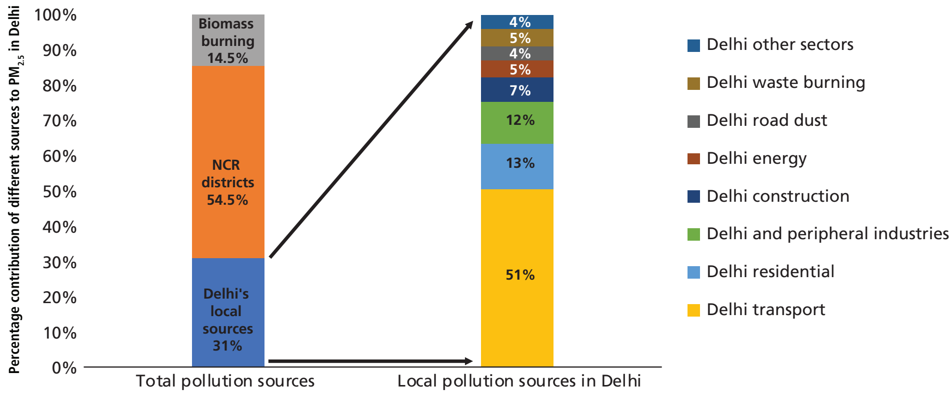
Yet another emerging science has made it possible to estimate change in the relative contribution of different pollution sources to the concentration of $PM_{2.5}$ in Delhi. In 2021, the Indian Institute of Tropical Meteorology (IITM) under the guidance of Ministry of Sciences developed a decision support system (DSS) for air quality management in Delhi. DSS uses the online chemistry transport model Weather Research and Forecasting with Chemistry (WRF-Chem) and is linked to emissions inventory prepared by TERI-ARAI for Delhi and its surrounding 19 districts. Based on data from the CPCB and satellite-based aerosol optical depth data as well as active fire count data it generates near-real-time emissions estimates. DSS thus provides information on contribution of emissions from Delhi and the surrounding 19 districts to the air quality in Delhi, the contribution of emissions from 8 different emission sectors in Delhi to the air quality Delhi, contribution from biomass-burning activities in the neighbouring states to the degradation of air quality in Delhi, and the effects of possible emission source-level interventions on the forecast severe air-quality event in Delhi. The system provides percentage contribution to $PM_{2.5}$ in Delhi from 29 sources and eight out of 29 sources are reported Delhi's local sources. The contribution of local sources of $PM_{2.5}$ include transport, industry, construction, waste burning, energy, residential source, road dust and other.

This dynamic trend is expected to change according to season, change in weather patterns and intensity of polluting activities among others. CSE examined hourly data on the relative contribution of different pollution sources to Delhi's air quality put out by IITM for the early winter phase of 2021, i.e. October 24–November 8. This analysis has considered local sources of Delhi and contribution of districts of NCR and that of the agricultural stubble burning to Delhi's air quality. Additionally, it has also assessed only local sources of pollution in Delhi and different source fractions among them.

Overall, during the early phase of 2021 winter, the overall contribution of NCR districts was as high as 54.5 per cent and that from stubble burning about 14.5 per cent on average. But if only local sources of Delhi are considered and the total and contribution from outside sources are excluded, the contribution of the transport sector to Delhi's air quality is around 50 per cent of $PM_{2.5}$ in Delhi, followed by Delhi's household pollution, which is in the range of 12.5–13.5 per cent; industry, which is 9.9-13.7 per cent; construction, 6.7–7.9 per cent; and waste burning and road dust each were in the range of 4.6–4.9 per cent and 3.6–4.1 per cent respectively. This is an indicative trend for this period and will keep changing with seasons and relative changes in air polluting activities (see *Graph 6: Average percentage contribution of sources of $PM_{2.5}$ in Delhi for early winter period October 24–November 8, 2021*).

While annual source inventory and apportionment studies provide the overall estimates in a given year, this method estimates the dynamic changes. While the 2018 TERI-ARAI source apportionment study showed that winter contribution of vehicles can be close to 25 per cent, the dynamic estimation now indicates that in certain phases contribution can be as high as half.

Graph 6: Average percentage contribution of sources of $PM_{2.5}$ in Delhi for early winter period October 24–November 8, 2021)



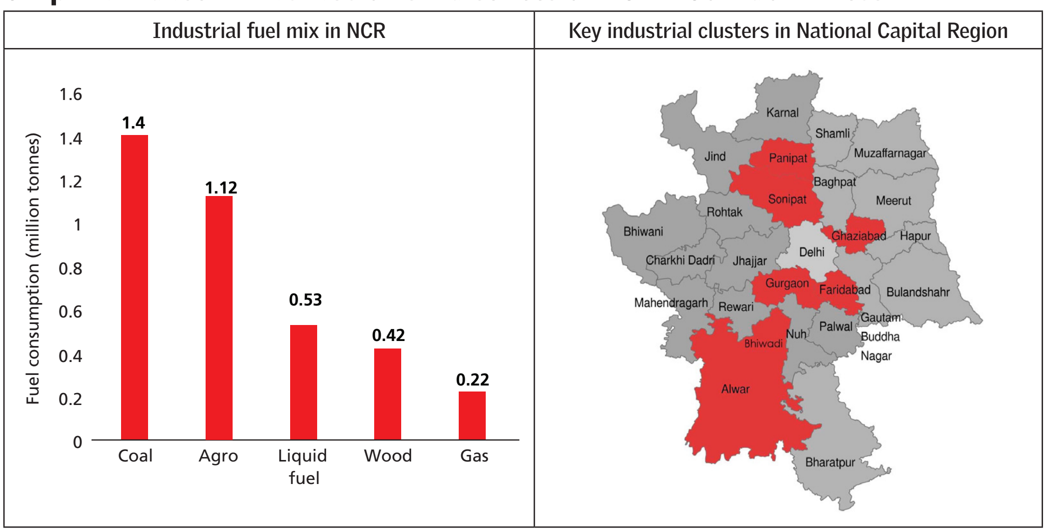
Source: CSE analysis of data from Decision Support System of IITM

Reality check on pollution sources in Delhi-NCR: CSE carried out an assessment of action on pollution sources in NCR for insight into the regional scale of the problem, which showed significant asymmetry in action across different sectors in the region.

In the thermal power plant sector, Delhi city has shut down all coal power plants and the remaining plants run on natural gas. As a result, combustion of estimated more than 2 million tonne of coal per year has been stopped. Next steps in Delhi have to target proper remediation of fly ash in Badarpur. However, within 300 km radius of Delhi there are 11 thermal power plants of 13.5 GW (five in Haryana, four in Punjab and two in Uttar Pradesh). These are still contaminating the airshed. Regional contribution from these plants cannot be addressed if the revised emissions standards are not implemented urgently in all the plants by 2022. As of 2020, two plants were complying with sulphur dioxide (SO_2) norms, and work is in progress in three plants that are likely to comply. The remaining plants are lagging. All the stations are however complying with particulate matter (PM) standards. The 2015 emissions standards that were to be met by 2019 have not been met and now the deadlines have been further extended to 2024. It is now cheaper to pay penalty than to comply. Of the total capacity of old plants (commissioned before 1990) 1,720 MW need to be retired. Other plants need to be reviewed/closed or modified. Both fiscal and regulatory strategies are needed for all the plants to clean up quickly in the region. This will have to be supported by overall reforms in the power distribution sector for reliable supply of quality electricity to all users—i.e. residential and commercial—and to also eliminate diesel generator sets in the region.

Similarly, in the industry sector, pollution control action in Delhi has shifted big industrial units to the NCR but these continue to operate within the airshed. And NCR itself has several industrial areas and clusters that are also designated as critically polluted areas. Additionally, there are large number small and informal industrial units. While Delhi has notified clean fuels that can be used in the city and has banned coal and other dirty fuels, coal combustion dominates the industry sector of NCR. CSE survey of fuel use in the industry sector has brought out that coal dominates NCR industry with the total combustion of 1.41 million tonne of coal in six NCR districts as of 2020. This contributes massively to the pollution load (see *Graph 7: Industrial fuel use on six districts of NCR—Coal dominates*).

Graph 7: Industrial fuel use on six districts of NCR—Coal dominates



Source Centre for Science and Environment, 2021, *Capital Gains Clean Air Action in Delhi-NCR: What Next?*

The pattern of fuel mix in the region shows that coal is in the lead, followed by agro residues, liquid fuel gas and wood. Maximum annual coal consumption has been noted in Sonipat district of Haryana, followed by Bhiwadi in Rajasthan. Sonipat also consumes highest amount of gas fuel among all districts in NCR. Alwar district is the biggest consumer of agro-based fuel. Use of natural gas is very low. Interestingly, the growing pressure of emergency smog action in Delhi-NCR that compels emergency action to temporarily close down industries running on coal in

NCR during smog episodes has catalysed fuel switch promoting wider use of agro-residue-based fuels. However, emissions impact of this fuel switch is not available.

The industry sector in Delhi-NCR is dominated by small- and medium-scale industries that rely on numerous small boilers without pollution control systems. The particulate standards for boilers (capacity <2 TPH) is as high as 1,200 mg/Nm^3. They are difficult to monitor and they continue to contaminate the airshed**.** Revised standards for boilers has been pending with the Ministry of Environment and Forest and Climate Change (MOEF&CC) for many months. This region is characterized by high coal consumption, manual coal feeding, no automation, and poor housekeeping practices. The transition to natural gas has not been possible at a scale in NCR due to higher prices of gas; tax burden on gas is higher than coal.

In the transport sector, the region is already in grip of rapid motorization, high use of diesel vehicles and old legacy vehicles. Availability of public transport service for the given population is extremely inadequate. Even Delhi has not been able to meet the target of a minimum of 10,000 buses and full integration of the metro and bus service. The public transport service availability in NCR is much less. Most cities and towns in NCR do not have a dedicated bus service. Only Gurugram, Noida and Ghaziabad have made a nascent beginning. Network of walking and cycling is extremely inadequate. Only a few streets in Delhi, including Ajmal Khan Road and Shahajanabad, have been pedestrianized. While some network development has started in Delhi, Gurugram and Noida, this is largely a non-starter in the rest of NCR. Similarly, the Supreme Court mandated parking policy as a demand management measure has not been implemented in Delhi and NCR. As a result, it is also not possible to apply vehicle restraint measures.

Waste and dust management in smaller municipalities in the region are even weaker. Areas outside the municipalities are not within the ambit of air quality governance. Even Delhi is able to process only 47 per cent of its solid waste management while the rest is dumped in landfill sites. The situation is worse in the rest of NCR. Landfills in the region, including Bhalsawa, Ghazipur, Okhla and Bandhwari landfill for Gurugram and Faridabad are oversaturated and prone to catching fire. Delhi has amended its municipal bylaws as per the Central Solid Waste Rules and Regulations 2016, but is yet to implement it fully. On the other hand, Delhi has set up adequate processing plants for construction and demolition waste. But due to inadequate collection capacity, the existing capacity remains underutilized. The NCR towns and districts on the other hand have not been able to scale up action on collection and processing of C&D waste.

Overall clean energy access in the region is still limited and a large number of households are still using solid fuels for cooking. Unreliable and erratic electricity supply due to lack of reforms in electricity distribution and pricing have led to overdependence on diesel generator sets in NCR. This snapshot from NCR also demonstrates the importance of intensification of local action across all sectors in the region. Regional action will require addressing each of these aspects in all the 24 districts of NCR and beyond and in Delhi.

4. Policy levers for regional pollution management

Does India have the policy levers to promote regional action? The Ministry of Environment, Forest, and Climate Change (MoEFCC) established the National Clean Air Programme (NCAP) in January 2019. From the initial target of 102 non-attainment cities the list has expanded to include a total of 132 cities. The Central Pollution Control Board (CPCB) has issued a notification under the Air (Prevention and Control of Pollution) Act of 1981 and directed for clean air action plans to reduce PM2.5 pollution by 20–30 per cent by 2024 from 2017 levels. Maharashtra continues to host the most cities (19), followed by Uttar Pradesh (17) and Andhra Pradesh (13). The first stage of NCAP operations plans to improve the ability of CPCB and the State Pollution Control Boards (SPCBs) to monitor, analyse and control air pollution.

The 2018 National Green Tribunal (NGT) order, O.A No. 681, directed SPCBs to prepare city Clean Air Action Plans. The 2017 Clean Air Action Plan of Delhi NCR was prepared under the direction of the Supreme Court. As of June 2021, 129 city Action Plans have been approved by CPCB.

India's NCAP has recognized the idea of regional approach and inter-state coordination. It mentions that a comprehensive regional plan needs to be formulated incorporating the inputs from the regional source apportionment studies. It has listed series of measures that cut across multiple jurisdictions and are regional in nature. These include implementation of policies related to transport like auto fuel policy for stringent norms for fuel and vehicles, shift from road to rail and/or waterways, fleet modernization, electric vehicle policies, clean fuels, by-passes, taxation policies, etc. In industrial sector stringent industrial standards, clean fuels, clean technology, and enforcement (continuous monitoring). Also enhanced LPG penetration, agricultural burning control and management that need regional level inter-state coordination specifically for the Indo-Gangetic Plain.

Moreover, a grant of Rs 4,400 crore to urban local bodies for air pollution mitigation is also limited to 42 cities. This is also city-centric except where urban agglomerations have been adopted very specifically.

There is no framework to enable its implementation. On the contrary, most non-compliant cities have been very rigid about adhering to the administrative boundary of the city municipality or the legal urban limits. As a result, a large number of pollution sources including industries and power plants that are outside the city limit were excluded from the action plans, thus defeating the purpose of air quality management. It is not possible to improve the air quality of a city if the polluters in the airshed are not controlled.

As of now, the only instance of integrated regional plan is that of Comprehensive Action Plan for air pollution control in Delhi and NCR that the Supreme Court had initiated with the onset of the public interest litigation decades ago. Under its direction the Environment Protection (Pollution and Control) Authority (EPCA) was constituted by the Ministry of Environment, Forest and Climate Change under Section 3 and 5 of the Environment Protection Act, 1986 in 1998. Even though the original focus was on Delhi, over the years several measures have been directed for the entire NCR region. Eventually under the direction of the Supreme Court a comprehensive clean air action plan was notified for Delhi and NCR in 2018. This single integrated plan is legally binding. This requires uniform implementation of all strategies across the region. But there is quite an asymmetry in scale of action across the region.

Despite the expectation of coordinated action across states, the bottom up preparedness for harmonized and inter-state cooperation for coordinated action is still weak and not legally articulated. There is no legal or institutional framework for regional air quality management to enable this process.

The cross-sectoral and cross-regional character of air pollution necessitates cross-state and cross-departmental engagement and coordination. While Chennai and Mumbai have the advantage of having the most of their influential areas within their own states, Delhi requires significant regional cooperation with state governments of Haryana, Punjab, Uttar Pradesh and Rajasthan. With limited coordination mechanisms between sectoral ministries at the national and city levels and overlapping state jurisdictions in an airshed, delineation of accountability becomes critical for ensuring timely and effective implementation of the plans and achieving the overall target in all cities.

The term of EPCA, which was part of the judicial process, ended in October 2020. Thereafter the Clean Air Commission was established. This is a new statutory authority that was formed after both houses of the Parliament approved the Commission for Air Quality Management in National Capital Region and Adjoining Areas Bill, 2021. It is responsible for managing and monitoring air quality in the NCR and its neighbouring areas.

The new Act has empowered the Commission "to take all such measures, issue directions and entertain complaints, as it deems necessary or expedient, for the purpose of protecting and improving the quality of the air in the National Capital Region and adjoining areas". This has defined a geographical area that is multi-jurisdictional and includes several state governments in the air quality management zone.

The Act has specifically provided for "co-ordination of actions by the Governments of the National Capital Territory of Delhi and the States of Punjab, Haryana, Rajasthan and Uttar Pradesh, officers and other authorities under this Act or the rules". This coordination will aim for "planning and execution of a programme for the region".

At the regional scale the Commission is expected to look at pollution abatement measures, including restricting polluting activities in areas and ensuring adequate environmental safeguards, carrying out inspection, and taking steps necessary for prevention, control and abatement of air pollution in the region, and enforce penal action among others. The Commission has the power to wield the Code of Criminal Procedure, 1973 as applicable.

This overarching body is expected to consolidate multi-state monitoring from one platform so that air quality management can be comprehensive in the entire region. The commission has overriding powers over other bodies in matters of air pollution and can take measures, issue directions and entertain complaints. It also has penal authority. This is a supra-regional body that is expected to direct and coordinate action of all state governments in the region. This move has reduced the pressure on the judiciary and creates a supra-centralized executive framework for air-quality management in the region. How this will play out in harmonizing the stringent action across the region with several state governments remains to be seen.

The key challenge is to operationalize the framework within a federal system in which the state governments have to respond within this centralized framework. Power and authority at the top cannot work in isolation from the framework at the state, city, and/or local levels. Sector strategy is needed for all the districts of the region with mapping of sector-specific reforms, targets and resource requirement along with the responsibility of the line departments. But the capacity in states as is evident in the process of implementation of Clean Air Action Plans under NCAP and the 15th Finance Commission funding for the ULBs is weak and even after preparing the action plans the scope of action is not always clear to the departments and they tend to remain business as usual. A much stronger framework is needed to address institutional inertia, push back from lobbies, and lack of capacity and systems for accountability. Unless a proper institutional arrangement in terms of inter-departmental cooperation, system alignment, process development and enforcement is worked out in detail at the local level in each city and state, internalizing and mainstreaming action can remain a challenge. This integrated regional framework will have to be developed quickly.

In the past the various measures that were implemented to control pollution from vehicles, industry, waste and other sectors were backed by the directives from the Supreme Court. The Clean Air Commission will have to rely on the executive system and processes to establish responsibility and accountability within the federal system of the NCR.

Legalizing regional approach: Technically, there is no legal hurdle to introducing the regional approach to air quality management of this scale. Under the Air (Prevention and Control) Act, 1981, Article 19 confers power to declare air pollution control areas. According to the Article 19 of the Act, the state government in consultation with the SPCB is vested with power to declare, alter or merge the "Air Pollution Control Area" wherein the provisions of the Act will be applicable. Currently, a very narrow view is taken of this provision and declaration of such control areas are confined to only critically polluted industrial areas. The scope and ambit of this provision can be broadened to include more jurisdictions for integrated planning and compliance, geographical coverage and pollution source coverage while defining air pollution control areas or critically polluted area within the ambit of the Air Act, 1981. This is needed to strengthen the governance framework and inter-state cooperation to tackle the persistent air pollution crisis. It is time to make the change in traditional governance approach to allow wider and more effective participation of state governments for harmonized regional action.

The Air Pollution Control Areas are provisionally similar to the Air Quality Control Regions in the Clean Air Act (1967 Amendment) of USA. The CPCB is vested with power to declare Critically Polluted Areas (CPAs) and Severely Polluted Areas (SPAs). However, this approach is now confined to only management of industrial clusters as per the Comprehensive Environmental Pollution Index (CEPI) Act.
It is necessary to develop a cohesive framework for regional management with a legal framework and carry out the necessary amendments. However, comprehensive regional air quality management will also require strong scientific support for assessment of pollution sources in the region in terms of source apportionment and source inventory studies. This will also require institutional alignments for coordinated action and accountability and resource mobilization for funding the regional-level strategies.

5. Global learning curve

Globally, several regions and/or countries have taken the lead to address regional air quality management. A template for regional action has evolved in different regions of the world that present an important learning curve for India.

The following are the two key approaches:

i) Regional framework within the country to align action across multiple jurisdiction of states and cities; and
ii) Regional framework for addressing transboundary movement of pollution between countries in a given region.

India needs to examine and adopt a similar framework.

The United States of America

The most explicit initiative is that of the USA where the approaches to regional management of air quality within the country has matured considerably. The Clean Air Act (CAA) that is the legal foundation of clean air action in the US has integrated several provisions that provide the legal basis for regional air quality management. There are several elements to this approach.

Delineation of Air Quality Control Regions: The Clean Air Act (CAA), enacted and incorporated into the United States Codes as Title 42 and Chapter 85 in 1963, is the key step towards air quality management in the USA. Compared to its predecessor—the Air Pollution Control Act of 1955, where the Department of Health, Education Welfare (HEW) was the only governing and responsible body—the CAA increased the federal involvement. It gave HEW the authority to set air quality standards. But, these criteria were optional; the U.S. states were free to apply them as they saw appropriate. In 1967, Congress amended the act, and the states were mandated to establish atmospheric areas and federal Air Quality Control Regions (AQCR) in consultation with HEW.

Before setting the AQCR, Section 107 (a) (I) of the amendment required the HEW secretary to delineate the broad atmospheric areas or air basins in the US based on climatic, topographical and meteorological factors that influence the transport and dispersion of air pollutants. HEW designated about eight areas: the Great Lakes (northeast); Mid-Atlantic Coastal; Appalachia; South Florida; Great Plains; Rocky Mountains; California Oregon Coastal; and Washington Coastal.

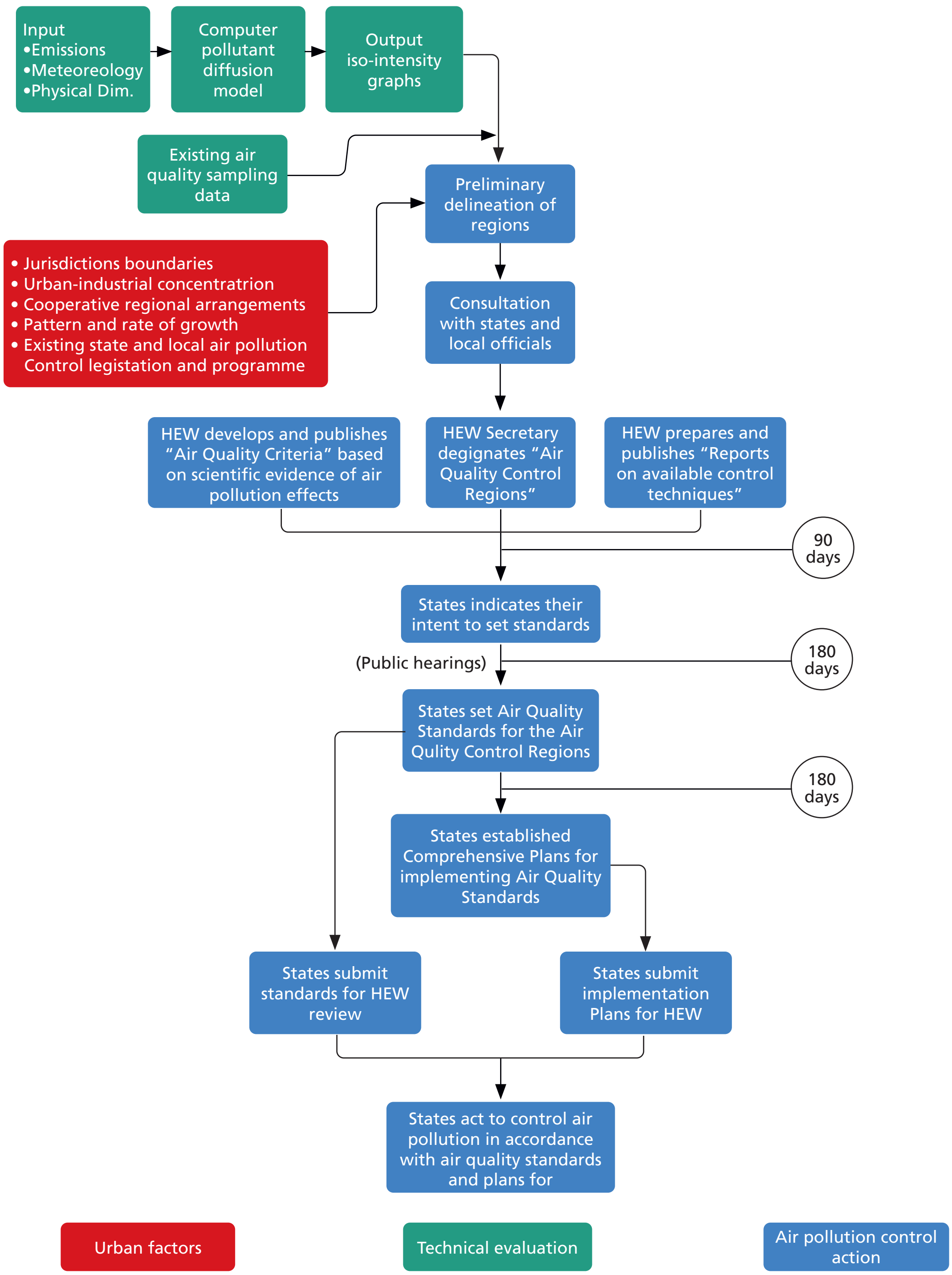
Section 107 (a) (2) of the 1967 amendment held the secretary of HEW responsible to "designate Air Quality Control Regions based on jurisdictional boundaries, urban-industrial concentrations, and other factors, including atmospheric areas, necessary to provide adequate implementation of air quality standards".

The proposed boundary-setting operations in areas were coordinated by members of the Federal air pollution control programme and engaged the relevant officials and residents of the proposed regions. Citizens' input was evaluated after the consultation, and the borders were set (see *Graph 7: Designation of AQCR and flow diagram for action to control air pollution on a regional basis under the 1967 Clean Air Act Amendment*). These boundaries were published in the Federal Register after being authorized by the secretary, and the region was formally designated. By the end of 1970, about 91 AQCR were designated, which covered all of the high-polluting centres but not the whole territorial territory of the nation.

The 1970 Clean Air Act Amendments (CAAAs) gave the EPA administrator the prerogative to designate the regions, and the administrator had 90 days to designate any new interstate or major intrastate area that they considered necessary or suitable for the attainment and maintenance of ambient air quality requirements. This resulted in 247 AQCRs officially designated in Title 40, part 81 of the Code of Federal Regulations.

There was no federal advice on decreasing emissions at individual sources in the 1967 act, and federal air quality guidelines were not obligatory on states. Many states could only force abatement if they could show that a particular source was causing a public nuisance. This form of a largely decentralized national air pollution control plan was ineffective. States were hesitant to take harsh measures for fear of losing business to their neighbours. Because there were so many sources contributing to urban air pollution, and it was so difficult to quantify the size of each source's proportional impact, air quality regulations were nearly impossible to implement directly. After the 1970 Clean Air Act Amendments (CAAAs) and the US Environmental Protection Agency (EPA or Agency) formation, Congress developed a new federal framework for air pollution management, which was intended to address these flaws. Air quality control regions were not new in 1970 CAAA, but the pollution control mechanisms applied in them [16 ELR 10043] was (see *Figure 1: Designation of AQCR and flow diagram for action to control air pollution on a regional basis under the 1967 Clean Air Act Amendment*).

Figure 1: Designation of AQCR and flow diagram for action to control air pollution on a regional basis under the 1967 Clean Air Act Amendment



Note: HEW = Department of Health, Education Welfare

Source: Compiled by CSE from various sources. Clark L. Gaulding 1968, "Definition of air quality control regions: Approach and experience to date", *Journal of the Air Pollution Control Association, 18:9, 591-595, DOI: 10.1080/00022470.1968.10469172*

The 1970 amendments (CAAAs), accompanied by the creation of the US Environmental Protection Agency (EPA or Agency), marked the federal government's foray into air quality management and established a command-and-control approach to federal environmental legislation. It entailed a complicated set of responsibilities and relationships amongst federal, state, tribal and local agencies to mitigate an array of air pollution issues through different air programmes and ensure public health and welfare. The act required EPA to establish minimum National Ambient Air Quality Standards (NAAQS) for criteria pollutants at levels that will safeguard public health, and the states to submit State Implementation Plans (SIPs) to the EPA within three years with regulations and roadmaps to attain these standards within its jurisdictions, including the AQCRs.

EPA quickly realized the complexities of regulating the areas not complying with the standards due to the multiple pollution sources, barring of constructions of major new sources coupled with urban economic stagnation. In response to this, the EPA devised an offset programme that permitted new development within an AQCR that would not meet the deadline as long as the emissions were carefully regulated and offset by higher emission reductions at existing sources in the region. Congress created the nonattainment area programme in 1977, codifying and expanding on the offset policy. The 1967 AQCRs were functionally and geographically comparable to the 1977 nonattainment areas in two ways: functionally, they were places with severely polluted air that were to be the main target of pollution control efforts; and geographically, they centred on the nation's largest cities.

Even though the Federal AQCRs does not explicitly outline a framework for an inter-jurisdictional regulation of long-range transport of pollutants across an airshed, they provide a framework for regulating the nonattainment areas. They provided a geographic foundation for programmes to abate metropolitan smog. EPA's legal victories in the *Ohio v. Ruckelshaus* and *Illinois State Chamber of Commerce v. United States Environmental Protection Agency* litigations ensured that the upwind areas that significantly contribute to the nonattainment in the downwind states would also be designated as "non-attainment" areas even if they have locally achieved the NAAQS standards. The 1970 CAAAs also addressed the interstate transport of ozone and fine particulate matter ($PM_{2.5}$) through its Good Neighbor provision. Pursuant to this provision, EPA established a series of market-based cap-and-trade programmes.

The Good Neighbor Provision: The 1970 CAAAs' air quality management is not limited to addressing local air pollution. It has programmes to regulate interstate and intercontinental air pollution transport. The Interstate transport provisions of the act, also called the Good Neighbour policy, made provision to address interstate transport of pollutants to the downwind states. To ensure compliance with the Good Neighbor clause, CAAA establishes two separate statutory authorities: (1) the SIPs process under Section 110 and (2) a petition process under Section 126(b). According to Section 110 (a)(2)(D)(i)(I) of the act, the states' SIPs are required to include measures precluding any source of emission within their jurisdiction from contributing significantly to nonattainment or interfering with maintenance of the NAAQS in any another state. If the EPA determines that an existing SIP is insufficient, it must order the state to update the SIP.

This technique, known as SIP call, can be sent to many states at once. If a state fails to submit a good neighbour SIP or if the EPA disapproves of the ones proposed by them, EPA is required to promulgate Federal Implementation Plans (FIPs) to backstop the state actions. The 1990 amendments to the act provided EPA and the states with further provisions to address interstate transport. Under section 126 of the act, the states affected by inter-state pollution can file petitions with EPA to regulate pollution from sources in upwind states. Under section 126(b), EPA needs to make decisions within sixty days. And if the EPA administrator approves the petition, the petitioned sources must stop operations within three months unless they comply with EPA-mandated emission controls and compliance timelines.

While Section 126(b) and a SIP call both enforce the Good Neighbor provision, they do so differently. First, a state or political subdivision must initiate the 126(b) petition, whereas the EPA initiates the SIP call. Second, unlike a SIP call, a 126(b) petition may only target a "major source or group of stationary sources" and cannot be used to address small or mobile sources. Third, when it grants a 126(b) petition, the EPA may directly regulate upwind sources, but a SIP call results in direct EPA regulation only if the EPA issues a FIP in response to a state's failure to react sufficiently to the SIP call. The EPA's examination of 126(b) petitions has occasionally overlapped with the agency's SIP call procedure.

When it issued a SIP call in 1998, the EPA coordinated its consideration of eight 126(b) petitions. The EPA recognized the distinction between the CAA authority for the 126(b) petition procedure and the SIP call but coordinated the two measures because they were both intended to minimize ozone transport in the eastern United States. States have also filed 126(b) applications ahead of the Good Neighbor SIP deadlines. In 2011, the EPA approved a 126(b) petition from New

Jersey, concluding that a coal-fired generating station in Pennsylvania significantly contributed to New Jersey's nonattainment with the SO2 NAAQS. Some saw the EPA's approval of this petition as a more liberal reading of Section 126, in which 126(b) petitions are not necessarily confined to the time period of Good Neighbor SIP updates.

Previously, EPA would consider 126(b) petitions several years after revising a NAAQS and making attainment and nonattainment designations for revised standards; however, EPA approved New Jersey's 126(b) petition before Pennsylvania was required to complete its Good Neighbor SIP for the 2010 revision to the SO2 NAAQS. The EPA issued an emissions restriction for the generating station that would cut SO2 emissions by 81 per cent and imposed a three-year compliance deadline. The U.S. Court of Appeals for the Third Circuit affirmed the EPA's interpretation of Section 126 in 2013, stating that the CAA enables the EPA to make a Section 126 determination outside of the Section 110 SIP process.

In addition, Section 176 A of the Act gives EPA the prerogative to form a transport region to address regional pollution problems. Along with the transport region, the EPA administrator may also establish an associated transport commission to assess the extent of interstate pollution transport and devise control strategies to mitigate it. For example, Section 184 of the act was formulated explicitly to establish a single transport region for ozone—the Ozone Transport Region (OTR)—which covers portions of the northeast and mid-Atlantic (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, certain counties in Northern Virginia and Washington, DC). The CAA required states in the OTR to implement limitations on sources in all specified areas, regardless of attainment status.

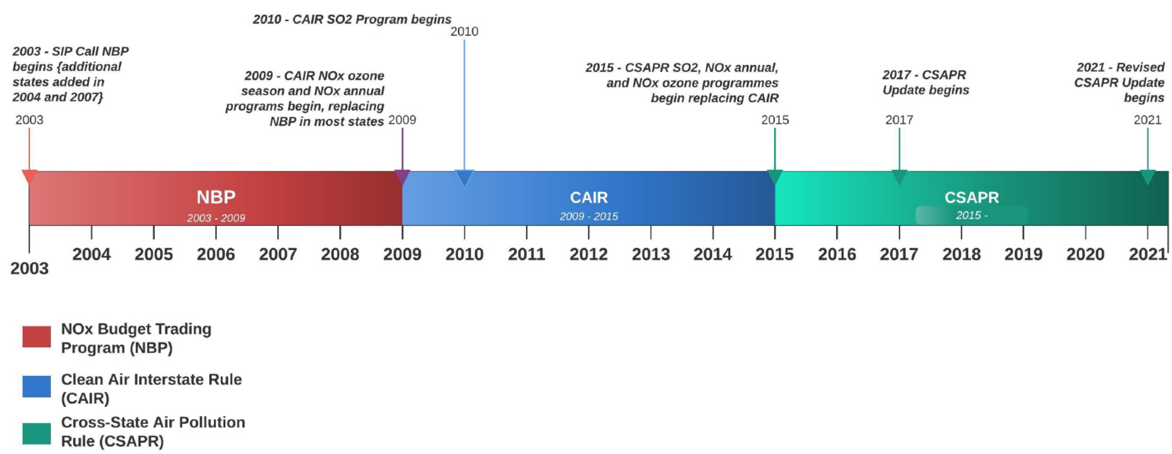
Regional pollution budget: In 1994, the Ozone Transport Commission (OTC) created the NOx Budget Program, and virtually all of the OTR states signed a Memorandum of Understanding (MOU). The programme was implemented in 1999–2002. The OTC NOx Budget Program established a regional budget (i.e. cap) on NOx emissions from electric utilities and big industrial boilers during the "ozone season" (May–September). According to the MOU, states were responsible for adopting rules, identifying sources, distributing NOx allowances, and enforcing compliance. The EPA was in charge of approving the states' regulations and tracking allowances and emissions. In 2002, EPA found that certain regions covered by this promulgation had failed to meet the required deadline, owing mostly to ozone transfer from upwind areas. Following this, the NOx Budget Trading Program (NBP) essentially superseded the OTC NOx Budget Program in 2003–09.

The NBP covered a larger geographic region than the OTC NOx Budget Program and focused on NOx reductions from both electric utilities and nonutility sources (e.g. large industrial boilers). The EPA created the NBP as part of the NOx SIP Call, which required a number of eastern and Midwestern states and the District of Columbia to modify their SIPs to address regional ozone transport. The NOx SIP Call established a NOx ozone season budget for each state and required upwind states to implement SIPs to decrease NOx emissions to levels that would match the budgets. The NBP concluded in 2008.

The EPA found in 2005 that interstate movement of SO2 and NOx significantly contributed to ozone and $PM_{2.5}$ nonattainment. Specifically, EPA discovered that (1) interstate transport of NOx from 25 states and the District of Columbia significantly contributed to nonattainment, or interfered with maintenance, of the 1997 eight-hour ozone NAAQS; and (2) interstate transport of SO2 and NOx from 23 states and the District of Columbia significantly contributed to nonattainment, or interfered with maintenance, of the 1997 $PM_{2.5}$ NAQS. In response to these results, the EPA issued the Clean Air Interstate Rule regulation that applied to 28 eastern states and the District of Columbia.

All these regulations promulgated under the Good Neighbor provision served as a blueprint to the current Cross-State Air Pollution Rule (CSAPR) program, which focuses on limiting interstate transport of power sector SO_2 and NOx emissions to eastern states (see *Figure 2: Environmental Protection Agency's actions under the Good Neighbor provision*).

Figure 2: Environmental Protection Agency's actions under the Good Neighbor provision



Source: US EPA

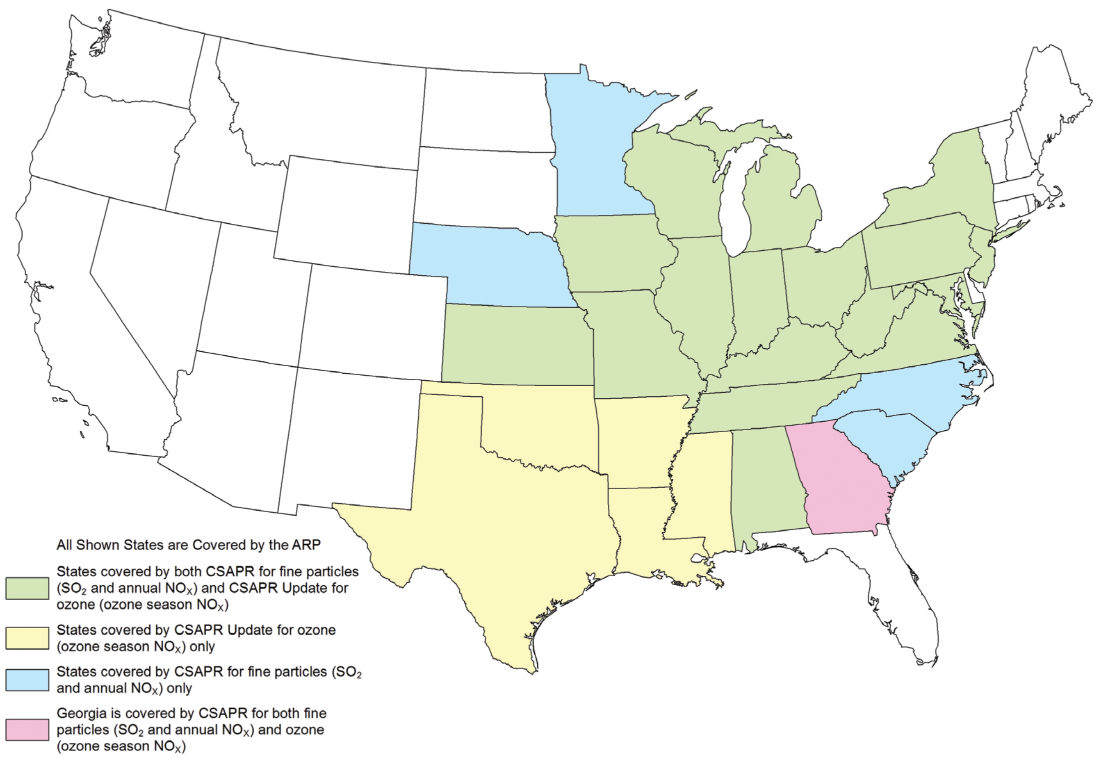
Cross-State Air Pollution Rule (CSAPR) programme: As the Clean Air Interstate Rule (CAIR) did not sufficiently address interstate pollution's impact on downwind air quality, the DC Circuit invalidated the rule in 2008. The primary issue in this litigation was the ambiguity of the term "contribute significantly". To promulgate the CAIR regulation, the EPA had to determine what amount of emissions constitutes a "significant contribution" to another state's nonattainment problem. In response to this, the EPA promulgated the Cross-State Air Pollution Rule (CSAPR) in July 2011. In CSAPR and the CSAPR Update, EPA uses a contribution screening threshold of one per cent of the NAAQS to identify upwind states that may significantly contribute to downwind nonattainment and maintenance problems.

It requires 28 states in the eastern half of the country to reduce fossil fuel-fired power plant emissions that cross state lines and contribute to fine particulate and summertime ozone pollution in downwind states. This rule required 23 states to mitigate annual SO_2 and NO_x emissions to enable the downwind states to attain both or either of the 1997 and 2006 $PM_{2.5}$ NAAQS. It also required 25 states to reduce summertime NO_x to help the downwind states attain the 1997 ozone NAAQs. The CSAPR divided the states that must reduce SO_2 emissions into two categories (Group 1 and Group 2). In Phase I, both groups were obligated to minimize their SO_2 emissions. To minimize their considerable contribution to air quality concerns in downwind areas, all Group 1 states and certain Group 2 states were obliged to undertake additional reductions in SO_2 emissions in Phase II.

Since then, the CSPAR criteria were promulgated for the 2006 24-hour fine particulate NAAQS, 1997 annual fine particulate NAAQS, 1997 8-hour ozone NAAQS, and the 2008 ozone NAAQS. These promulgations resulted in the formation of five air quality-assured trading programmes for states in the CSAPR region: SO_2 Group 1 trading programme, SO_2 Group 2 trading programme, NOX annual trading programme, NOX ozone season Group 1 trading programme and NOX ozone season Group 2 trading programme. The rule requires 27 states in the eastern half of the US to improve air quality by reducing emissions (see *Map 3: US states covered under the CSAPR and CSAPR Update for Ozone and $PM_{2.5}$*).

For each of the states covered under CSAPR, EPA establishes a pollution limit (emission budget). Allowances or permissions to emit pollutants are assigned to affected sources based on these state emissions budgets. The guideline gives impacted sources a lot of leeway, allowing them to choose their compliance approach in each condition. Sources can buy, sell and save allowances for future use as long as they have enough allowances to account for their emissions at the end of the compliance period.

Map 3: US states covered under CSAPR and CSAPR Update for Ozone and $PM_{2.5}$



Source: USEPA

CSAPR is modelled according to the previous rules and provides a four-step process to address the requirements of the Good Neighbour provision for ozone or $PM_{2.5}$ standards. For every promulgat98ion of the rule, EPA adhered to the following steps and took corresponding actions:

- **Step 1:** Identifying downwind receptors that are expected to have problems attaining or maintaining clean air standards (i.e. NAAQS);
- **Step 2:** Determining which upwind states contribute to these identified problems in amounts sufficient to "link" them to the downwind air quality problems;
- **Step 3:** Identifying upwind emissions that significantly contribute to nonattainment or interfere with maintenance of a standard by quantifying appropriate upwind emission reductions and assigning upwind responsibility among linked states; and
- **Step 4:** Reduce the identified upwind emissions via permanent and enforceable requirements (e.g. regional allowance trading programmes).

CSAPR, like any other rule, itself went through a lot of litigation, including but not limited to *EPA vs EME Homer Generation*, Docket no.12-1182 (D.C. Cir.); *Wisconsin v. EPA*, No. 16-406 (D.C. Cir.); *New York v. EPA*, No. 19-1019 etc. The Bureaucratic process and the innate reluctance to commit to the emission reductions lead to decades of litigations and stagnation. Climate change rules have always been victims of the powerful lobby of fossil fuel in the nation and the presidential cycles. Most recently, in 2016, the "close-out" rule issued by President Trump with respect to CSAPR not only stymied any relevant progress in the direction of transboundary pollution control but also caused a lot of litigations. In 2016 when EPA issued an update to the rule to help the downwind states meet the 2008 ozone NAAQS, the agency found that while the rule would result in significant near-term reductions in cross-state ozone emissions, it may not be enough to completely meet Good Neighbor obligations under the 2008 ozone NAAQS of all affected states.

With further analysis after the issuance of the rule, in December 2018, EPA released a conclusion that the emission reductions needed by the CSAPR Update will adequately meet all covered states' Good Neighbor duties regarding this NAAQS. The DC Circuit affirmed the CSAPR Update in most aspects in September 2019 but remanded the rule to EPA to remedy the court's finding that the rule unlawfully permitted upwind states' major contributions to downstream air quality problems to persist beyond downwind states' NAAQS deadlines. In October 2019, the court invalidated EPA's December 2018 conclusion. Only recently, in March 2021, the EPA finalized the revised CSAPR update to resolve 21 states' pending interstate transport obligations. The agency determined that additional reductions with respect to the update were required for twelve of the twenty-one states covered by the rule (see *Table 1: History of the Cross-State Air Pollution Rule [CSAPR]*).

Table 1: History of the Cross-State Air Pollution Rule (CSAPR)*

Date	*Litigation concerning the Cross-State Air Pollution Rule*	*Summary*
April 29, 2014	*EPA v. EME Homer City Generation*	
October 26, 2016 EPA releases the 2016 CSAPR Update, which took effect on December 26, 2016.		For states that have not included CSAPR into their State Implementation Plans (SIPs), this regulation establishes Federal Implementation Plans (FIPs). It mandates power plants in the affected states to reduce their emissions. Some of the Phase 2 NOx limits have also been adjusted by the EPA.
November 22, 2016	*Wisconsin v. EPA*, No. 16-406 (D.C. Cir.)	The upwind areas filed sixteen to challenge the CSAPR Update.
January 19, 2017		In *Wisconsin v. EPA*, the states of New York, Rhode Island, New Hampshire, Vermont, Massachusetts, and Maryland filed a motion to intervene in support of the 2016 CSAPR Update.
Trump Era		
February 24, 2017	President Trump signed the Regulatory Reform Executive Order	The D.C. circuit ordered EPA to reevaluate CSAPR.
July 10, 2018		EPA determined that the CSAPR Update fully addresses upwind states' "good neighbour" obligations for the 2008 NAAQS.
December 6, 2018		The EPA issues a final rule stating that the 2016 CSAPR Update fully satisfies the 2008 ground-level ozone NAAQS' "good neighbour" responsibilities. Because the EPA will not demand further emissions reductions from upwind states, this is known as the "Close-Out" Rule. According to the EPA, downwind states will not be able to achieve the 2008 ozone NAAQS requirements until 2023, two years after the NAAQS deadline.
January 30, 2019	*New York v. EPA*, No. 19-1019 (D.C. Cir.) *Downwinders at Risk v. EPA*, No. 19-1020 (D.C. Cir)	All the downwind states to coal plants such as Homer City Generation in Pennsylvania—New York, Maryland, Connecticut, New Jersey, Massachusetts and Delaware, all downwind states—file lawsuit review the CSAPR Close-Out Rule. A coalition of environmental groups also filed a petition for review.
September 13, 2019	*Wisconsin v. EPA*, No. 16-1406 (D.C. Cir.)	Except for a provision that allows upwind states to continue polluting downwind states after the statutory deadline for downwind states to comply with the NAAQS, the DC Circuit upheld the 2016 CSAPR Update. This section of the rule was sent back to the DC Circuit for review.
October 1, 2019	*New York v. EPA*, No. 19-1019 (D.C. Cir.)	The EPA's CSAPR Close-Out Rule is dismissed by the DC Circuit, which finds that the agency has not implemented strict enough rules to address cross-state air pollution that affects downwind states.
October 28, 2019	*New York v. EPA*, No. 19-1019 and *Wisconsin v. EPA*, No. 16-1406 (D.C. Cir.)	The deadline for EPA to appeal two D.C. Circuit decisions from September and October 2019 ordering the agency to reconsider its Cross-State Air Pollution Rule update and Close-Out Rule has passed. This means that the EPA has accepted the decisions and will have to change the rules.

Date	***Litigation concerning the Cross-State Air Pollution Rule***	***Summary***
October 29, 2019	*New Jersey v. Wheeler*, No. 1:19-cv-03247 (DDC)	New Jersey and Connecticut sued EPA for failing to meet its April 1, 2019 deadline to take action on Pennsylvania and Virginia for their failure to file Good Neighbor State Implementation Plans.
January 16, 2020	*New York v. Wheeler*, No. 1:20-cv-00419 (SDNY)	New York and Connecticut filed a lawsuit against the Environmental Protection Agency (EPA), requesting that the agency issue federal implementation plans for sources in five upwind states (Illinois, Michigan, Pennsylvania, Virginia, and West Virginia) whose state plans did not fully comply with the Good Neighbor provision.
February 7, 2020	*Downwinders at Risk v. Wheeler*, No. 1:20-cv-00349 (DDC)	A group of environmental organizations filed a lawsuit against EPA, requesting that the agency adopt federal Good Neighbor plans for 20 upwind states.
February 19, 2020	New Jersey v. Wheeler, No. 20-cv-1425 (SDNY). The lawsuit is similar to New York v. Wheeler, No. 1:20-cv-00419 (SDNY)	New Jersey, Connecticut, Delaware, New York, Massachusetts and New York City filed a lawsuit in the United States District Court for the District of Columbia, requesting that the Environmental Protection Agency (EPA) adopt federal Good Neighbor plans for seven upwind states (Illinois, Indiana, Michigan, Ohio, Pennsylvania, Virginia and West Virginia).
September 15, 2020	In his Public Health and Environment Executive Order, President Biden directed *EPA to consider promulgating a Federal Implementation Plan for states that have failed to submit state implementation plans satisfying the 2008 ozone NAAQS, specifically California, Connecticut, New York, Pennsylvania and Texas.*	
January 12, 2021	*State of New York et al. v. Wheeler*, No. 1:21-cv-252 (SDNY)	A coalition of Northeastern states sued EPA over the agency's failure to "timely act" within the required 12-month timeframe on upwind states' plans to comply with the 2015 ozone NAAQS under the Clean Air Act's Good Neighbor Provision.
Early Biden Actions		
January 20, 2021	EPA sent the proposed CSAPR update rule revisions to the White House Office of Information and Regulatory Affairs for review. The DC Circuit's decision in Wisconsin v. EPA, No. 16-1406, prompted this proposal.	
April 8, 2021	*WildEarth Guardians v. Regan*, No. 21-994 (D. Colo.)	WildEarth Guardians sued the EPA for for failing to determine that Colorado had missed an August 2020 deadline for submitting an air pollution plan for the Denver Metro/North Front Range area. The area has "serious" ozone NAAQS nonattainment.
June 25, 2021	Midwest Ozone Group v. EPA, No. 21-01146 (D.C. Cir.)	The Midwest Ozone Group files a petition for review of EPA's 2021 CSAPR Update with the D.C. Circuit

*All the information is taken directly from the Environmental and Energy Law Program's Regulatory Tracker at Harvard Law School

Source: Environmental and Energy Law Program Staff, Cross-State Air Pollution Rule regulatory tracker. Available at https://eelp.law.harvard.edu/2017/09/cross-state-air-pollution-rule-and-section-126-petitions/, as accessed on July 10, 2021

Regional approach to air quality monitoring network design: Air quality monitoring networks in the USA are driven by scientific studies and analysis rather than jurisdictional boundaries. The selection process of monitoring sites encompasses four major activities, including:

- Creating and comprehending the monitoring aim as well as the relevant data quality objectives;
- Identifying the spatial scale that is best appropriate for the site's monitoring aim;
- Identifying the general areas where the monitoring station should be located; and
- Identifying specific monitoring locations

According to the document of the California Air Resources Board, "Annual Network Plan Covering Monitoring Operations in 25 California Air Districts July 2021", the spatial scales of the network are decided on the basis of the monitoring objective. At the micro-scale, measured concentrations are expected to be similar for an area ranging from several metres up to about 100 metre. At the middle scale, the measured concentrations are expected to be similar for areas up to several city blocks in size with dimensions ranging from about 100 metre to 0.5 kilometre. At the neighborhood scale, measured concentrations are expected to be similar within some extended area of the city that has relatively uniform land use with dimensions in the 0.5–4.0 kilometre range. At the urban scale, measured concentrations are expected to be similar within an area of city-like dimensions, on the order of 4–50 kilometre. At the regional scale, measured concentrations are expected to be similar within a rural area of reasonably homogeneous geography without large sources, and extend from tens to hundreds of kilometres. National and global scales are therefore at a much broader level.

The number and range of monitoring sites is established to characterize national and regional air quality trends and geographic patterns that can vary in complexity from place to place. Within each state, federal regulations require at least one site measuring concentrations representative of regional background and at least one site representative of regional transport.

For monitoring regional fluxes of emission, the network is based in a rural area of reasonably homogeneous geography, and the network extends from tens to hundreds of kilometres. The process of selecting sampling sites also involves several considerations such as economics, security, logistics, atmospheric conditions, topography and the pollutant in consideration.

USEPA document “Ambient Air Monitoring Strategy for State, Local, and Tribal Air Agencies Office of Air Quality Planning and Standards Research Triangle Park, NC December 2008” states, “as many air quality control solutions move toward large-scale regional, multi-pollutant control strategies, there is an increasing need for coordinating various urban oriented networks with the regional/rural monitoring networks, given that the changes in regional background atmospheric conditions critical to understanding how to reduce urban air pollution are typically observed at the regional/rural monitoring stations”.

EPA’s IMPROVE programme is a cooperative measurement effort that is coordinated by the federal, regional and state organizations. The IMPROVE network presently comprises 110 regionally representative monitoring sites, seven sites operated collaboratively with the Clean Air Status and Trends Network (CASTNET) and 34 sites within the CSN operating according to IMPROVE protocols.

EPA collaborates on site selection with states and through multistate organizations. This includes selection of sites that are representative of urban (about 50 sites) and rural or regional (about 20 sites) locations throughout the country to characterize urban- and regional-scale patterns of air pollution. In fact, the national-level health assessments and air quality model evaluations require data that is representative of broad urban (e.g. 4–50 km) and regional/rural (> 50 km) spatial scales.

EPA also has regional haze rules and standards. Also measurement of pollutants such as HNO_3, NH_3 and ozone are necessary at urban and regional-scale locations.

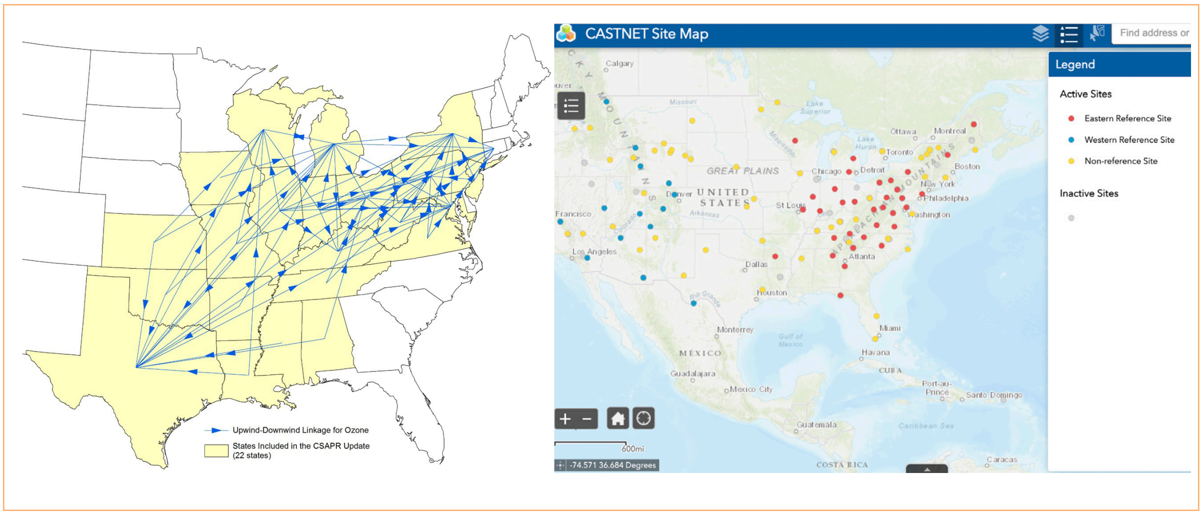
Interstate air pollution transport is monitored through Clean Air Status and Trends Network (CASTNET), which was designed using the above-mentioned principles (see *Graph 9: (a) Interconnected nature of regional pollution transport (b); CASTNET site locations*).

Federal regulations note that the spatial scale of representativeness of a monitor should be consistent with the stated site type. The spatial scale of representativeness is a measure of the physical dimensions of the air mass through which pollutant concentrations are expected to be relatively homogeneous. The scales of representativeness that are most relevant to ambient air monitoring are defined as follows:

- Micro-scale: Measured concentrations are expected to be similar for an area ranging from several meters up to about 100 metre. This area is expected to have the highest concentration.

- Middle scale: Measured concentrations are expected to be similar for areas up to several city blocks in size with dimensions ranging from about 100 metre to 0.5 kilometre.
- Neighborhood scale: Measured concentrations are expected to be similar within some extended area of the city that has relatively uniform land use with dimensions in the range of 0.5–4.0 kilometre.
- Urban scale: Measured concentrations are expected to be similar within an area of city-like dimensions, on the order of 4–50 kilometre.
- Regional scale: This is a multi-jurisdiction scale that also reflects general background, and regional transport of pollution.

Figure 3: (a) Interconnected nature of regional pollution transport; (b) CASTNET site locations



Source: US EPA

State and local district-level regulatory framework—California case study

The state of California is well known for its stringent air quality regulations and near successful air quality management. The primary body that regulates air quality management in the state is the California Air Resources Board (CARB), which is a part of California EPA. California EPA reports directly to the Governor's Office in the Executive Branch of California State Government. For effective air quality management, CARB partners with US EPA and 35 local air pollution control districts (APCD).

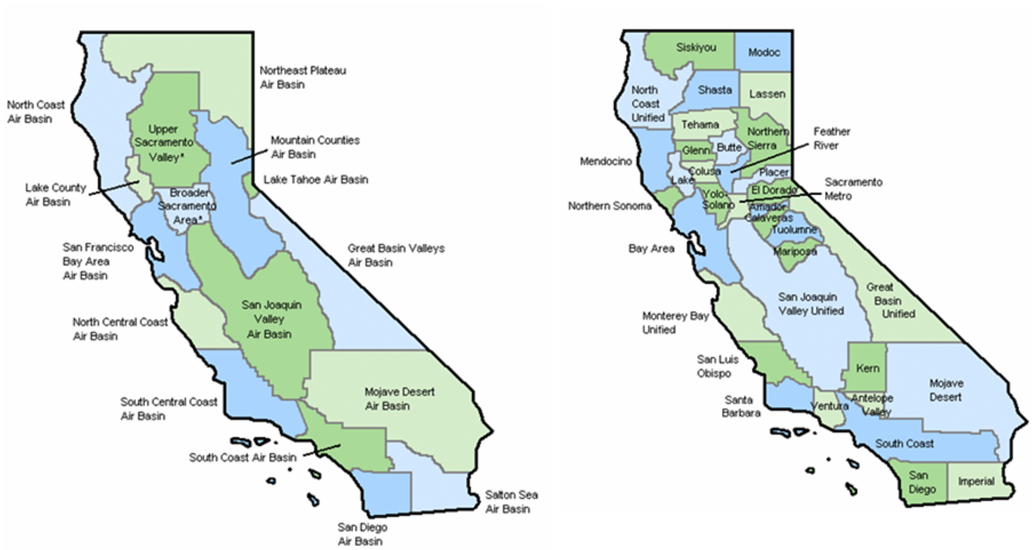
Geographically, California is divided into 15 air basins for regional management of the state's air resources and into 35 Air Districts (Air Pollution Control

District and Air Quality Management District) for regulatory enforcement and compliance. The districts were formed taking into account the air basins in the state (see *Figure 8: Air Basins and Air Districts in* California*)*. The state is not new to regional air pollution, and the air pollution episodes are largely responsible for the stringent and committed air quality management approach the state follows. A lot of downwind basins—San Diego Air Basin, South Coast Air Basin, San Joaquin Valley Basin etc.—are affected by ozone transportation (see *Figure 9: Downwind areas impacted by upwind emissions*).

Air quality management in California is a joint effort including local, state and federal bodies. The Air Resources Board adopts statewide regulations to decrease emissions from motor vehicles and fuels, off-road equipment, and consumer products. Stationary sources are generally the responsibility of districts. Preempted mobile sources and national transportation sources, such as ships, trains, and aircraft, can only be regulated by the federal government.

The California Clean Air Act (CCAA or Act; Stats.1988, Ch.1568) requires Air Pollution Control Districts (APCD or districts) that have been designated as nonattainment for the State ozone level to prepare an air quality plan that aims to meet the criteria as soon as practicable (California Health and Safety Code (H&SC)section 40910 et seq.).

Figure 4: Air basins and air districts in California



California Air Basins

California Air Districts

Source: California Air Resources Board (CARB)

Table 2: Downwind areas impacted by upwind emissions

Upwind area	Downwind Areas Impacted											
	Mountain Counties	San Joaquin Valley	Bay Area	Broader Sacramento	Upper Sacramento	North Central Coast	North Coast	South Central Coast	Great Basin Valleys	South Coast	San Diago	Mojave Desert
Broader Sacramento	X	X	X		X							
Bay Area	X	X		X		X	X	X				
San Joaquin Valley	X			X		X		X	X			X
South Central Coast										X		
South Coast								X			X	X

Source: CARB

In the attainment plan, there are particular requirements that must be met. This includes the implementation of emission control measures for both existing stationary sources and new or increasing stationary sources. Further, suppose the district contains an area with a population of 50,000 people. In that case, as specified in Section 40918(a) et seq. of the H&SC, districts with a moderate, serious, severe or extreme nonattainment classification must use reasonably available transportation control measures sufficient to reduce the rate of increase in passenger vehicle trips substantially, and miles travelled per trip. In addition, these districts must include provisions in their attainment plans for the development of area-wide source and indirect source management programmes.

District measurements and state, national and other local strategies are all included in one cohesive plan in each district's attainment plan. Every three years, the attainment plans are reviewed and amended to integrate new information and evaluate the success of the adopted control method. If a district cannot demonstrate a 5 per cent annual decrease in ozone precursor emissions as required by H&SC section 40914, the district may instead commit to adopting all feasible measures. As of 2003, no district has met the 5 per cent yearly emission reduction goal, and all have chosen to implement all viable measures. The efficacy, technological feasibility, social and economic concerns all play a role in how districts prioritize their rule adoption timelines. The ARB assists districts in designing their attainment plans by providing technical help.

Downwind locations where transportation has a substantial impact surpass both state and federal ozone air quality criteria. In many circumstances, meeting federal and state air quality criteria in the downwind area is a joint effort. Transportation within state borders is not subject to any specific mitigation standards under federal law. When it comes to intrastate transportation, governments must develop a way to assure federal regulations are met in both upwind and downwind locations. In California, the mechanism given by ARB's transport mitigation regulations is used to set mitigation obligations for upwind districts. Emission reductions achieved through this technique are incorporated in federal ozone attainment plans for downwind areas (State Implementation Plans [SIPs]). Air quality modelling is used to better understand the relative transport contribution and the air quality advantages of actions taken by upwind locations as the new attainment plans are produced. Information from air quality modelling studies and regional transportation models aid local agencies in developing effective regional air quality plans.

Enforcing regional framework: Enforcement of regional framework can be challenging as is evident from the regulatory documents of the USEPA. States are expected to take additional steps to satisfy Good Neighbor provisions or prove why additional measures are not necessary. This can also lead to litigation if states claim that the standards cannot be met because of pollution coming in from another upwind state. For instance, it is reported that in *North Carolina v. EPA case in the District Court* in 2008, held that EPA must "coordinate interstate transport compliance deadlines with downwind attainment deadlines. Emissions reduction required by the Good Neighbor provisions should be evaluated considering relevant attainment dates of downwind non-attainment areas impacted by pollution outside".

In September 2019, the Sierra Club filed complaint in the US District Court for Columbia alleging that the "EPA had not fulfilled its mandatory duty to make findings of failure to submit interstate transport of pollutants plans with respect to 12 states". EPA is therefore taking action for all states that have failed to submit the plans.

In 2008 EPA had promulgated federal implementation plans for 22 states by requiring power plants in those states to participate in an allowance trading programme to address the requirement of Good Neighbor provision to meet ozone targets. Upwind states are linked to downwind ozone problems and makes attainment with standards more uncertain. To enable this process EPA also uses national modelling to develop plans to meet the requirements of good neighbor provisions.

Observers also point out that despite the legal back up of the Clean Air Act for addressing the interstate movement of pollution, it does not quite work in practice unless the high emitting states are willing to cooperate. Downwind states face problems due to NOx, ozone and $PM_{2.5}$ coming from upwind power plants, for instance. Sometime legal cases get tied up in courts for decade. California adopted its own transport provisions in the California Clean Air Act for upwind district that contribute significantly to downwind air pollution concentrations. Catherine Witherspoon, formerly with the California Air Resources Board, says that until the California Clean Air Act was passed, the Bay Area Air Quality Management District refused to install selective catalytic reducing system for NOx control on its power plants and refineries. Once it was passed the battle was over but only after it was proven that San Francisco sources affected both the San Joaquin and Sacramento Valleys.

Europe

Convention on Long-range Transboundary Air Pollution (LRTAP or Air Convention): In the 1960s, while investigating the causes of acidification in the Scandinavian lakes, scientists recognized the causal relationship between the long-range transboundary air pollution and the local air pollution episodes. To address this issue, 32 countries in the pan-European region signed the Convention on Long-range Transboundary Air Pollution (LRTAP or Air Convention) within the framework of UNECE (United Nations Economic Commission for Europe) in 1979. The Convention is one of the first and most successful international air pollution management treaties signed to address air pollution on a broad regional basis. It came into effect in 1983 and currently has 51 signatories, including virtually all UNECE member nations. The UNECE region encompasses all the European countries, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan in Central Asia, Israel in Western Asia and the United States of America and Canada in North America.

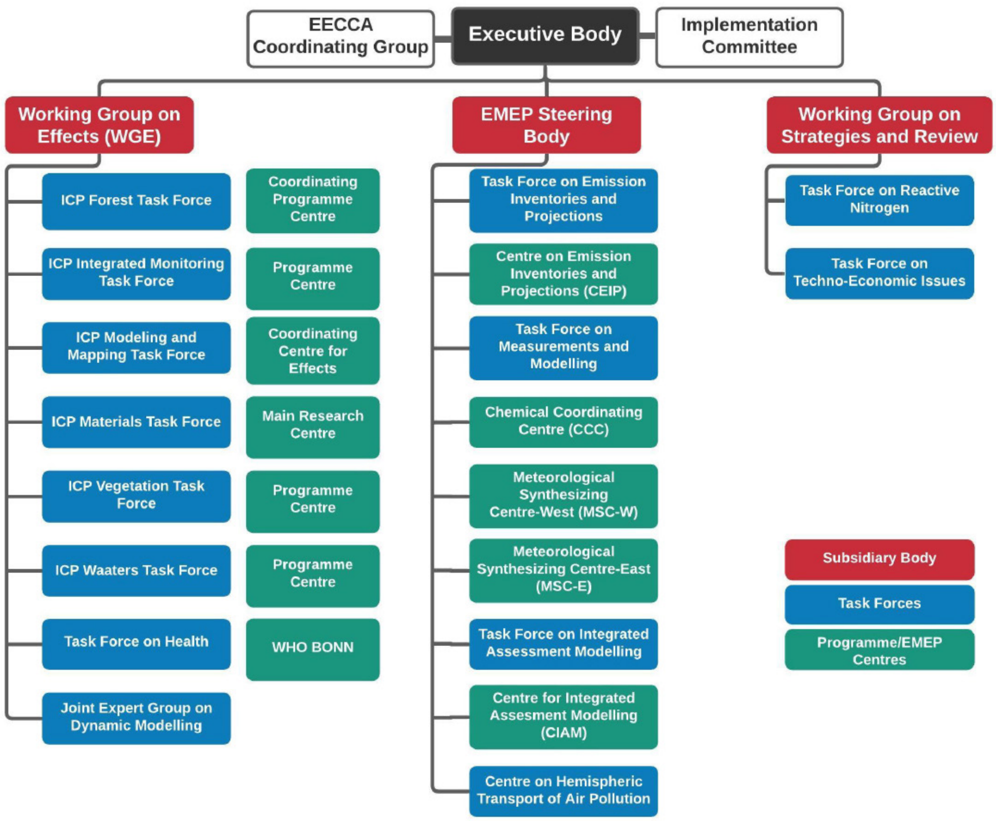
Along with the general principles for international cooperation to abate transboundary air pollution, the Convention laid down an institutional framework for integrating science and policy. Since its enforcement in 1983, eight protocols have been added (seven addressing air pollution control and one financing protocol) to the aegis of the Convention.

The Convention initially drafted protocols focusing on technologies to reduce emissions. However later in the 1990s the Convention negotiated protocols that followed an “effect-oriented” approach in addressing air pollution. The signatory parties agree to reduce emissions to the levels set based on their current exposure, available technologies, cost of implementation, and economic constraints. The most recent Protocol, the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, and its 2012 amended version implements the multi-pollutants or multi-effects approach and simultaneously integrates multiple strategies to reduce several pollutants. It was the first time the Convention established such a multi-action approach.

The Gothenburg Protocol (in its 2012 amended version) established national emission ceilings for ozone precursors and fine particulate matter ($PM_{2.5}$) for each country in the EMEP (European Monitoring Evaluation Programme) region. Every year, the Parties submitted their existing emissions and also their projections for future years. In case new sources or scientific insights are likely to change emission projections and the corresponding reduction targets, the reporting mechanisms provides the parties with some flexibility and allows them to declare adjustments in the emissions or projections. Emission limits for sulphur dioxide, nitrogen oxides, VOCs and ammonia, and limit values for mobile sources and VOC content in particular products are also defined. Finally, the Protocol calls for using the best available technology (BAT) for mobile and stationary sources, as specified in the relevant guidance documents.

The organizational structure of the Air Convention: The Convention laid down a complex framework involving scientific, policy and compliance coordination amongst the signatory parties to mitigate transboundary air pollution (see *Figure 2: Institutional framework* of the Convention on Long-Range Transboundary Air Pollution). CLRTAP is supported by a multi-tiered institutional architecture that addresses scientific and technical research, air pollution monitoring, policy formulation, and implementation oversight. A significant component of this architecture is the separation of scientific and technical activity from the political negotiation process, which has allowed to insulate the scientific work. The Executive Body of the Convention is backed by two scientific and technical bodies—the EMEP Steering Body and the Working Group on Effects. The Working Group on Strategies and Review is a policy and negotiating group that advises the Executive Body, while the Implementation Committee is in charge of compliance. A number of task groups and research centres are also part of the organization. UNECE functions as the Executive Body's and its subsidiary bodies' secretariat.

Figure 5: Institutional framework of the Convention on Long-Range Transboundary Air Pollution



Source: UNECE

The Executive Body (EB), composed of the Convention's Parties, is the decision-making body and generally meets annually to discuss the Parties' statuses. The Parties also use the EB meetings to make decisions on issues such as protocol assessments and protocol modifications. The Executive Body is assisted by the Implementation Committee, which comprises a legal experts group selected by the EB. The Committee evaluates the Parties' compliance with the protocols and reports them to EB and follows a cooperative and facilitative approach for compliance instead of a confrontational approach. The Convention is administered by the UNECE secretariat that oversees the sessions and their documentation and assists the organizations in carrying out their Convention-related tasks.

The Working Group on Effects (WGE), the EMEP Steering Body, and the Working Group on Strategies and Review (WGSR) are the three primary subsidiary entities reporting to the Executive Body. The first two bodies are responsible for giving scientific justification for the strategy group's actions. The WGE is made of six International Cooperative Programmes (ICPs). Through long-term monitoring, these programs synergistically assess the extent of the impacts of major air pollutants on the ecosystem. The EMEP Steering Body, through a unified monitoring network, provides the atmospheric modelling and air quality data. EMEP operation is coordinated by five programme centres and four task forces. The centres and task forces report annually to the EMEP Steering Body, which in turn reports to the Executive Body of the Convention. WGSR is the policymaking body; it negotiates the development and review of protocols. The EECCA Coordinating Group supports and promotes the implementation of the Convention in Eastern Europe, the Caucasus and Central Asia (EECCA) regions.

Decision-making in the Convention is formally by majority vote unless the Convention or its protocols stipulate that consensus is required as in, for example, to adopt protocol modifications. Despite its proclivity for diluting and delaying action on significant environmental problems, consensus decision-making is 'efficient' since Parties are more likely to respect an Executive Body decision if they subscribe to its terms rather than being coerced into compliance through a majority vote. Consensus decision-making has been demonstrated to function, but it works only if the Parties use it to reach agreements. This frequently necessitates the development of novel and adaptable solutions. However, Parties occasionally use it as a veto to stymie progress.

One important factor in intergovernmental cooperation is the motivation of the Parties and the individuals who take the initiative and lead the necessary work. Annually, the Executive Body discusses and adopts the work plans of all working groups, task forces, expert groups, and centres. Generally, the work of the groups and task forces is led by one or two Parties, which frequently contribute considerably to its work, both manpower-wise and monetarily. Additionally, Parties that host centres typically provide additional workforce and financial resources. One may argue that the Convention is truly bottom-up. Typically, Parties' initiatives are incorporated into scientific programmes and policies (protocols, guidelines etc.). Active Parties are awarded for their influence on the direction the Convention takes.

Transboundary air pollution monitoring: The Convention's scientific infrastructure for unified monitoring and modelling programmes plays an important role in a scientific assessment. In pursuant to Article 10 of the Convention, the Executive Body needs to coordinate with the cooperative programme for monitoring and evaluation of long-range transmission of air pollutants in Europe (also called European Monitoring Evaluation Programme or EMEP) for data collection and scientific cooperation. EMEP clearly defines the monitoring strategies of the Convention. The primary goals of EMEP monitoring are to ensure:

- Enough long-term monitoring of concentrations and deposition fluxes to assess exposure and implications on health, ecosystems, plants, materials and climate;
- Adequate spatial coverage in EMEP's geographical scope, as well as increased access to information from previously underserved locations;
- Sufficient temporal resolution to investigate atmospheric processes driving pollution transport and transformation, to lead model improvements, and to analyse specific pollution episodes.
- Co-located and concurrent monitoring of important atmospheric variables, as well as the adoption and application of the standardized methodology and suitable quality assurance procedures; and
- A degree of ambition that is affordable to all Parties while also capitalizing on scientific advances and new capabilities.

The EMEP network is regarded as one of the most resilient and relevant in terms of its ability to detect trends in air pollution patterns across Europe and the length of its high-quality historical datasets (more than 20 years in some cases).

Dispute resolution: Article 14 of the 1979 Convention lacks a formal procedure for resolving conflicts arising from the interpretation or application of the document, instead of requiring parties to seek resolution through dialogue or any other dispute resolution mechanisms acceptable to them. The text of the three first Protocols to the Convention is identical. In addition to this procedure, the 1994 Sulphur Protocol and the three succeeding protocols state that if Parties want to negotiate and fail to achieve an agreement, the dispute will be resolved by a conciliation commission expressly established to recommend an award. These protocols also include a provision that allows Parties to submit a declaration acknowledging the International Court of Justice's jurisdiction or arbitration to resolve disagreements relating to the interpretation or application of the instrument. However, no official conflicts have arisen as a result of the Convention and its protocols yet. Furthermore, the Implementation Committee oversees a non-contentious submissions and referral procedure that permits parties to deal with non-compliance under the Convention. Submissions or self-submissions by Parties, as well as referrals by the Secretariat, may activate this procedure.

Key takeaways from the Convention: Science-policy interactions and inter-governmental capacity building

The Convention is considered one of the most successful frameworks for international transboundary air pollution reduction. Its success is primarily attributed to the strong interlinkages between its scientific and policy bodies and intergovernmental cooperation and conviction. The Convention's decision and regulation processes are two-way trips between scientific subsidiary bodies (EMEP and WGE) and policy entities (WGSR, EB).

The following are the key features of the Convention:

- The strategy is driven by scientific knowledge and studies. The assessment of the effects of transboundary air pollution on humans and ecosystems, which pollutants should be regulated and what variables and parameters are needed to characterize air pollution trends form the basis of the informative policy decisions.
- The policy framework enables countries to create monitoring networks with uniform technological rules to assure quality and comparability. It establishes national emission ceilings for regulating and minimizing the adverse impacts of air pollution, as well as reporting requirements for emissions, airborne concentrations, and deposition in order to track progress toward this goal.
- Science also aids in the understanding of trends and possibly unexpected behaviours (for example, if the impact of emission reductions on air pollution concentrations is less than projected) as well as new stakes.
- Policy framework takes such issues into account and proposes appropriate legislative or strategy evolutions: for example, reducing PM exposure was included in the revised Gothenburg Protocol in 2012 but not in the previous one; the need for greater collaboration with the climate community to develop control strategies and a focus on short-term climate forcers (SLCFs) was raised quite recently.

On the regulatory forefront, through their capacity building programme, the Convention provides a good example of intergovernmental efforts to address the challenges in transboundary air pollution abatement. The Convention faces a significant challenge in encouraging Eastern and South-Eastern European countries to participate. These countries have emerged from the fall of the Soviet Union, and their current geopolitical situation is vastly different from that of the Convention's first ten years. These new countries have had to deal with major economic issues as well as political unrest. As a result, they are behind in implementing and ratifying the Convention's protocols. The Convention is addressing this challenge in a variety of ways, including projects, bilateral cooperation, capacity building, meetings in these countries and, most importantly, the EECCA (Eastern Europe, Caucasus and Central Asia) action plan.

In 2007, a programme was created to encourage five SEE (South-Eastern Europe) countries to ratify the three most recent agreements. Another key move to encourage EECCA and SEE countries to sign up for the protocols is to give the three most recent protocols, which are now being amended, more flexibility (for example, more time to establish Emission Limit Values (ELVs) for existing installations).

The Convention functions in a dense regulatory landscape that comprises a slew of international, regional and domestic players and frameworks addressing cross-border air pollution or air quality challenges. The European Union (EU) air pollution rules, which are intimately linked to the CLRTAP framework, are the most noteworthy of these frameworks. A number of States that are Parties to the Convention have also negotiated bilateral agreements addressing transboundary air pollution. Because of the multiplicity of frameworks, there are some commonalities, particularly in their geographical reach, membership and commitments. In light of this, Article 3 of the Convention calls on Parties to create policies and plans to reduce air pollution while "taking into account efforts already made at national and international levels". Taking that into consideration, some Protocols include references to other international agreements, such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal and the Canada–United States Air Quality Agreement.

The European Union and the Convention

Since the Convention's inception, the EU has grown from six to twenty-seven countries, all of which are signatories to the Convention and its protocols. As the European Union is a signatory to the Convention and its protocols, the Commission ensures that all protocol provisions are implemented by all EU member states. The operation of the Convention is clearly influenced by the EU's rising size. With half of the total number of Parties, the EU has a significant influence on what happens in the Convention. The majority of initiatives in the Convention are taken by individual EU countries, which must first persuade the other EU members and the European Commission before the EU as a whole can submit, say, an amendment to a protocol. This trend has resulted in extensive pre-work and cooperation between the EU Member States and the European Commission in recent years. Nonetheless, the Convention is heavily reliant on the EU This is because the countries in the east and southeast of the EU have had severe economic problems and have had difficulty establishing environmental laws and regulations; the United States and Canada frequently find it challenging to agree to international regulations; and Norway and Switzerland, the largest of the rest of the ECE countries, already follow the Ambient Air Quality Directives and regulation of the EU related to the environment.

The European Commission is increasingly questioning the Convention's additional value. The Commission believes that the current conventions should be implemented and ratified as a first priority, particularly by the EECCA and SEE members. Many EU countries agree that more ratifications are necessary, but they also believe that the Convention has a significant role to play in the development of policy and science under the Convention.

The scientific instruments created under the Convention have been crucial in the formulation of EU air pollution policies, such as the Clean Air for Europe (CAFE) initiative, the 2005 Thematic Strategy on Air Pollution, and the implementation of national emission caps, among other things. Among these scientific tools are EMEP data, the critical loads approach and the Regional Air Pollution Information and Simulation (RAINS) model (and its extension, the model on Greenhouse Gases Air Pollution Interactions and Synergies model [GAINS]), an integrated assessment model that deals with air quality and its effects in Europe. The establishment of national emission ceilings (NECs) for EU Member States and the expansion process via which CLRTAP parties have become members of the EU have also contributed to improved interactions between the CLRTAP and the EU frameworks. The EU introduced new NECs in 2016 with promises to reduce emissions of five major air pollutants: NOx, non-methane VOCs, SO_2, NH_3, and $PM_{2.5}$ (Directive 2016/2284).

The new directive transposes the reduction commitments for 2020 agreed upon in the Gothenburg Protocol Amendment in 2012. Overall, EU air pollution laws have helped to mobilize the parties' commitments under the Convention and its protocols. Finally, EU regulations include a Directive on Environmental Impact Assessment that was amended in 2014 (Directive 2014/52/E.U.), which is aligned with the Espoo Convention commitments and includes provisions for cases where projects implemented in one Member State are likely to have significant effects on the environment of another Member State, including air pollution.

EU air quality policy

Air quality improvement has been on the EU agenda for decades, owing to the significant cross-border nature of air pollution. The 2013 clean air programme for Europe is currently the major EU strategic document with a specific focus on air quality. Its main goal is to reduce the number of premature deaths caused by ground-level ozone and fine particulate matter ($PM_{2.5}$) exposure by half by 2030 compared to 2005 levels. Recently, the European Green Deal called for the development of a zero-pollution action plan, with one of its primary goals being to improve air quality across the EU. Legal regulation is a significant policy instrument used by the EU and its Member States to achieve the aforementioned operational objectives, with specific action done within the context of three policy cornerstones. The first one consists of the two Ambient Air Quality Directives (AAQDs), which establish standards for a variety of air pollutants, harmonized criteria for monitoring and assessing air pollution across the Member States, and an obligation to take pollution-avoidance, prevention, and reduction measures. The second pillar expands on the directive on reducing national emissions of certain air pollutants (the NEC Directive), which established national emission reduction commitments for major pollutants such as SO_2, NO_x, VOCs, NH_3, and $PM_{2.5}$. It translates the EU's commitments under the amended Gothenburg Protocol into EU law. The third pillar covers a number of EU legislative acts that govern air pollution from specific sources in various sectors.

The legal framework established by the two Ambient Air Quality Directives (AAQDs) is based on four main goals: defining common methods for monitoring and assessing air quality; setting standards to be met across the EU; ensuring that air quality information is made available to the public; and maintaining good air quality and improving it where it is inadequate.

The AAQDs require the Member States to establish a network of measurement stations and sampling points in accordance with a set of common criteria for determining minimum sampling point numbers, data quality, unacceptable uncertainty in monitoring and modelling, and sampling point micro-scale and micro-scale siting. As a result, the AAQDs harmonize standard techniques and criteria for assessing air quality in all Member States in a comparable and trustworthy manner. Member States have to create air quality zones and agglomerations throughout their territories, as well as monitor and assess the concentration of air pollutants in all zones and agglomeration. Furthermore, Member States must categorize zones and agglomerations based on specific evaluation thresholds and utilize reference measurement methods based on international standards or equivalent procedures to assess air quality and must ensure measurement accuracy.

Over the last decade, both the number and size of exceedances have reduced for the majority of pollutants and in the majority of Member States. Despite this general improving trend, the intervals of exceedance have not been kept as short as possible in all cases, as required by the two AAQDs. The Commission's 2019 fitness check of the two AAQDs reveals a picture of partially effective implementation of the instructions.

Noncompliance has resulted in a large number of infringement processes initiated by the Commission against a significant number of Member States. More specifically, at the end of 2019, of the 327 open infringement procedures in the field of environment, 61 concerned failures (including problems with transposition and compliance) under all three pillars of E.U. air quality policy, with 12 and a few more following in the course of 2020. However, infringement processes, in addition to being time-consuming, do not always work in enforcing compliance with E.U. air quality standards to the extent that, in certain situations, Member States do not comply with decisions of the European Union's Court of Justice (CJEU). Such cases demonstrate that both compliance with existing EU air quality regulations at the national and, in particular, zone and/or agglomeration levels, as well as enforcement of compliance at both the national and EU levels, are significant challenges.

Zone and/or agglomeration-specific air quality plans and measurements are a vital tool on which the two AAQDs rely for the reduction and prevention of air pollution above the defined values. However, in certain circumstances, these plans and their implementation represent a barrier to meeting EU air quality criteria. Action for improvement should concentrate on the quality of the plans and, more particularly, on the nature of the measures included in the plans, which may jeopardize their implementation in practice. As a priority, such action should be conducted at the zone/agglomeration level affected by exceedances to ensure that local conditions are adequately taken into consideration when measures are devised and implemented. This procedure could benefit from EU-level direction. Furthermore, the implementation of air quality plans must be adequately monitored and reviewed as a basis for changes in their design and implementation commensurate with the pollution problem they were established to solve.

In some cases, air quality plans suffer from deficiencies in the EU legal framework, such as the absence of an obligation for the Member States to report to the Commission on implementing their Plans or update them when new measures are adopted or progress has not been sufficient. The European Court of Auditors also backs this proposal, which adds that the legal framework should include a requirement that air quality plans be results-oriented and that their number per zone or agglomeration be limited.

China

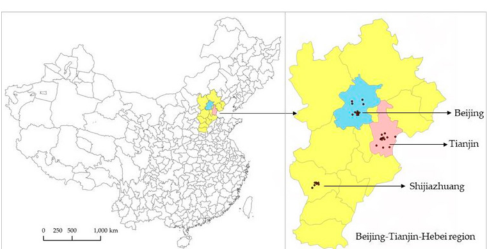
China's rapid industrialization, urbanization and motorization have created huge environmental pressures and air pollution with public health consequences. Smog has been widespread for days since 2000, and urban conglomerates, as well as economic clusters such as Jing-jin-ji (Beijing-Tianjin-Hebei region (BTH) with 28 towns, including Beijing), the Yangtze River Delta (south Shanghai) and the Pearl River Delta (south Guangzhou and Shenzhen) have been shrouded nearly three-thirds of the year with persistent haze between 2010 and 2013. This provoked a wave of wrath from the people, leading the government to declare the 13th Air Pollution Prevention and Control Action Plan, with drastic steps to close down polluting industries, speed up the transfer to cleaner energy sources, limit urban traffic and revise the governing system. For the purpose of this report, we will delve into the Jing-jin-ji air pollution management framework.

Jing-Jin-Ji Regional Coordination Group: The Third Plenary Session of the 18th Central Committee of the Party held in November 2013 stated that a regional coordination mechanism for ecosystem protection and restoration as well as pollution prevention and control are required. The Coordination Group for Air Pollution Prevention and Control in BHT and surrounding areas was founded at the end of 2013 with the backing of China's State Council. The Coordination Group was led by the Beijing Municipal Government and included seven ministries: the National Development and Reform Commission (NDRC), the Ministry of Finance (MOF), the former Ministry of Environmental Protection (MEP), the Ministry of Industry and Information Technology (MIIT), the Ministry of Housing and Urban-Rural Development (MOHURD), the China Meteorology Administration, and the National Energy Administration (NEA). Henan Province and the Ministry of Transport joined the Coordination group in May 2015, bringing the total number of members to eight ministries and seven provinces. MEP identified Beijing, Tianjin and another 26 cities in Hebei, Shanxi, Shandong and Henan provinces (collectively referred to as 2+26 cities) as key cities along the air pollution transport channels in Beijing-Tianjin-Hebei and Surrounding Areas in 2017, and prioritized these cities for the purpose of air pollution control. After five years of operation, the Coordination Group was revamped to a leading group led by the Vice-Premier of the State Council in 2018. As a result of this development, the combined air pollution prevention and control efforts in the BTH region and nearby areas now have greater authority and impact.

Regional cooperation Mechanism in Beijing-Tianjin-Hebei region: The 2008 Olympic Games were held in Beijing, and a month prior to and during the games air pollution was lowered through the integrated regional preventive and control strategy in the BTH region. Only a few years later, in 2011, however, the US Embassy in Beijing revealed data that indicated that PM 2.5 in Beijing had a "beyond index" in the air quality index of the US EPA, which raised global and national public concerns over severe air pollution in China, public awareness of air pollution and the need for efficient air pollution control. Since then, the political agenda has become significant in long-term integrated regional prevention and control of air pollution. In 2013 the State Council released the Jing-jin-ji and surrounding area Air Pollution Action Plan and enforcement regulation that mandated the Beijing-Tianjin-Hebei region to reduce their 2012 levels of $PM_{2.5}$ by 25 per cent by 2017.

In 2015, a twinning-based collaboration mechanism for controlling air pollution was formed. Beijing was twinned with the Hebei province cities of Baoding and Langfang. Beijing provided financial and technical assistance for eradicating small coal-fired boilers and controlling large coal-fired boilers, setting a precedent for regional cooperation on air pollution control. A collaborative forecasting and early warning mechanism was also built to motivate and guide each province (autonomous region and municipality) in improving their heavy pollution emergency response plans as part of the unified heavy pollution episode response. The alarm thresholds for severe air pollution crises were harmonized across Beijing, Tianjin and Hebei in 2016. This planning also assures that when heavy pollution days develop on a regional scale, provinces and municipalities within the region can adopt synchronized emergency measures (see *Figure 11: (a) Geolocation of Beijing-Tianjin-Hebei (BTH) region and air quality monitoring stations in the region; (b) Unified Heavy Pollution Grading Standards for 2+26 cities in the BTH region)*. In December 2016, there were several days with high levels of air pollution throughout a vast geographic area. In response, 60 cities in the BTH region and

Figure 6: (a) Geolocation of Beijing-Tianjin-Hebei (BTH) region and air quality monitoring stations in the region; (b) Unified Heavy Pollution Grading Standards for 2+26 cities in the BTH region



(a)

Blue Alert	Yellow Alert	Orange Alert	Red Alert
Predicted daily mean AQI (24-hour average, the same below) is above 200, but below the higher-level alert conditions.	Predicted daily mean AQI is above 200, which will continue for two consecutive days (48 hours) or more, but below the higher-level alert conditions.	Predicted daily mean AQI is above 200, which will continue for three consecutive days (72 hours) or more, and predicted daily mean AQI is above 300, but below then higher-level alert conditions.	Predicted daily mean AQI is above 200, which will continue for four consecutive days (96 hours) or more, and predicted daily mean AQI is above 300, which will continue for two consecutive days (48 hours) or more; or predicted daily mean AQI reaches 500.

(b)

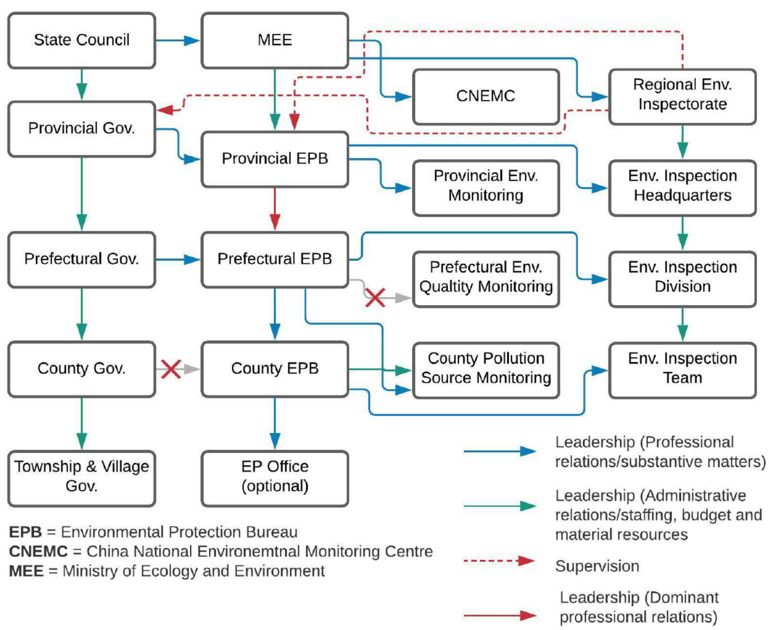
Sources: Wang, Li et al. 2018, Taking Action on Air Pollution Control in Beijing-Tianjin-Hebei (BTH) Region: Progress, Challenges and Opportunities, International Journal of Environmental Research and Public Health. Cheng Huihui et al. 2018, "Breakthroughs: China's path to clean air 2013-2017", Clean Air Asia, China.

adjacent areas implemented a single alerting and emergency response strategy, significantly lowering pollution and working on a regional level for the first time in disaster response. These standards were extended to the 2+26 cities in 2017, as were the procedures for issuing, adjusting, and lifting alerts paving the way for a unified regional response to heavy air pollution and coordinated measures to reduce emissions in Beijing-Tianjin-Hebei and Surrounding Areas.

The Chinese government began implementing a comprehensive strategy for air quality management in February 2017. It asked four ministries (Ecology and Environment, the National Economic Development Committee, Finance, and Energy) to coordinate with two autonomous cities (Beijing and Tianjian) and 26 major cities (2+26) in four surrounding provinces (Hubei, Shanxi, Shangdong and Henan) to develop an air quality plan to manage air pollution. The Coordination includes the following three major provisions:

- Developing air quality standards and applying them to these 28 major cities;
- Publicly disclosing relative city rankings of air quality each month and evaluating government officials quarterly based on those relative rankings; and
- Auditing air quality in these 28 major cities using environmental inspectors. These inspectors have the right to shut down polluting enterprises and criticize or fire city authorities (see *Figure 12: Structure of China's environmental regulatory governance*).

Figure 7: Structure of China's environmental regulatory governance



Source: Chan Yang, 2020, "Policies, regulatory framework and enforcement for air quality management: The case of China – Environment working paper No. 157", Organisation for Economic Co-operation and Development, France.

A special system for regional collaboration in vehicle pollution management was also devised. This involves joint inspections of new vehicle conformance and penalties for violations occurring outside the car's registration city.

For air pollution prevention and control in BTH and surrounding areas, an information-sharing platform was developed, which shares real-time information regarding air quality and key pollution source emissions in seven provinces (including autonomous regions and municipalities). Including the ones discussed before, certain primary duties were assigned to the BTH region and neighbouring areas' joint preventive and control cooperation mechanism under the principle of "shared responsibility, information sharing, coordinated consultations, and joint prevention and control":

- The collaboration mechanism ensures that the cooperation team meets twice a year. The purpose of the meeting is to carry out critical duties and coordinate efforts to address key issues. Leaders from the central government also attended the meeting to help with organization and coordination.
- One key purpose of the mechanism is to develop regional policy measures and regulations aimed at the region's pollution characteristics that are more rigorous than national norms. Regional measures and criteria for the coal, automobile, and industrial sectors have been established. The most notable of these standards is the VOCs Content Limit Standards for Architectural Coatings and Adhesives, the first regional standard established jointly by Beijing, Tianjin and Hebei.
- The Coordination Group for the cooperation mechanism publishes a brief report on local governments' policies, measures, and experiences regularly. The BTH region and adjacent areas are gradually establishing unique information platforms for monitoring regional air quality, supervising polluters, and so on, using China's existing air quality monitoring and information network. This region's seven provinces (autonomous regions and direct-administered municipalities) completed real-time sharing of critical information such as air quality and main polluter emissions.
- Under the cooperation mechanism, EIA for planning is carried out, and EIA consultation on significant projects in the region.
- Another component of the collaboration mechanism is related to regional collaborative environmental investigations and law enforcement. Heavy-duty diesel vehicles, "scattered, unregulated, and high-pollution" industries, and straw burning are among the sources of severe air pollution in the region that are the focus of a special investigation.
- Joint law enforcement and special investigations aid in overcoming the challenges that cross-administrative region law enforcement faces. When it comes

to monitoring motor vehicle pollution, for example, cooperative law enforcement comprises environmental protection, transportation, and public security departments from several cities sharing environmental infraction information concerning automobiles. Local law enforcement officers can investigate and potentially prosecute unlawful and non-local automobiles in this manner.

A 30-member regional air pollution prevention and control expert committee also supports the collaboration mechanism. These professionals are experts in air pollution sources and reactions, remote sensing and atmospheric monitoring, pollution prevention and control technology, energy and environmental economics, etc. The expert committee is largely in charge of regional air pollution prevention and control activities such as assessing issues, assisting with planning and recommending effective technology.

Aside from these seven goals, the collaboration mechanism promotes additional forms of cooperation among cities in the region. Six cities in the region, for example, organized two teams to battle air pollution beginning in 2015. Beijing and Tianjin joined together with two Hebei cities to provide finance, technology and other types of assistance for air pollution prevention and control. Between 2016 and 2017, Beijing committed RMB 600 million to help Baoding and Langfang abolish small coal-fired boilers and manage major coal-fired boilers. Tianjin gave Cangzhou and Tangshan RMB 400 million in finance and technical assistance to reduce local air pollution in 2016.

MEP released another action plan in mid-2017 to reach the former action plan's targets for the BTH region, the Action Plan to Comprehensive Control Autumn and Winter Air Pollution in Beijing-Tianjin-Hebei and Surrounding Regions 2017–2018, and a supervision group of 1,400 staff was set up to perform rigid accountability inspections in BTH, Shandong Province and Henan Province. In 2018, the Ministry of Environmental Protection (MEP) was reorganized into the Ministry of Ecology and Environment by the State Council to improve MEP's authority in developing more coordinated air pollution control strategies, to address ownership gaps and accountabilities amongst disparate agencies and, to streamline the policymaking processes. Along with this, the Jing-Jin-Ji Ambient Environmental Bureau was established to facilitate the central authorities' power in managing the cross-province air quality regulations.

South Asia

To address transboundary air pollution in South Asia, the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for

South Asia was adopted by Ministers of the Environment at the Seventh Meeting of the Governing Council of South Asia Cooperative Environment Programme (SACEP) in 1998 in Male, Republic of Maldives. The member countries of the Malé Declaration include Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri Lanka. It largely focussed on the need to initiate studies and programme on air pollution in each country of South Asia.

This led to the establishment of the network of organizations to implement the declaration and compilation of baseline information on air quality monitoring and management in each country. This is expected to provide information on the transboundary air pollution and identify the gaps in the existing monitoring system.

This was expected to put in place the expertise equipment and information, needed for the quantitative monitoring, analysis and policy recommendations for eventual prevention and/or control of air pollution. The overall objective has been to expand the existing network, strengthen monitoring facilities; and to generate evidences on the transboundary effects of air pollution and improve information exchange.

In this process the United Nations Environment Programme (UNEP) is responsible for coordination. The South Asia Cooperative Environment Programme (SACEP) is the sub-regional intergovernmental body, the Stockholm Environment Institute (SEI) provides technical support and SIDA (Swedish International Cooperation Development Agency) is responsible for financial support.

During the early meetings the signatories decided that each country will assess and analyse the origin and causes, nature, extent and effects of local and regional air pollution. They would also develop and/or adopt strategies to prevent and minimize air pollution; initiate cooperation on monitoring targeting sulphur and nitrogen and volatile organic compounds emissions, concentrations and deposition; and standardize methodologies to monitor phenomena like acid depositions and analyse their impacts. This would need to be supported by the training programmes and transfer of financial resources and technology, with support from bilateral and multilateral sources. Economic analysis would be the focus—this has to be multi-stakeholder process and should be backed by dissemination of information and awareness. The Agreement also asks for preventive steps while urbanizing and industrialising.

It has also been underscored that before steps are taken to give legal binding to regulate trans-boundary air pollution, there should be very detailed discussions of data and collecting more data. A lot of its success will also depend on the funding support and investments. "Transboundary Effects for South Asia" is the only inter-governmental agreement that implements regional efforts to address the trans-boundary air pollution in South Asia.

Based upon the indicators stated above, a quarterly report is compiled by CPCB in some of the major cities. For real time data collection, automatic monitoring stations have also been established. Under the Malé Declaration, 11 automatic monitoring stations are also planned at strategic locations to measure the trans-boundary movement of pollutants among the South Asia Association of Region.

The most recent inter-governmental meeting (IG15) was conducted in 2016. During the initial years the focus was on baseline studies to provide information on their air quality management system and to identify gaps in their current system to quantify the transboundary air pollution. Subsequently, capacity-building programmes were initiated. This was also combined with impact assessment studies and actions. During 2010-2013 there was discussion around long-term financing mechanism. In 2014–16, the attention was given to promoting policy measures in South Asia to control air pollution emissions, including short-lived climate pollutants.

Post 2016, the Malé Declaration process slowed down largely because of lack of committed funding either from the member countries as well as from the multilateral agencies. However, it is reported that India has initiated new funding cycle and efforts are on to develop work plans for the next phase of action to begin in 2022. The range of activities are expected to include air quality monitoring and modelling, assessment of policy formulation, research support, and guideline development among others. Several scientific, technical and policy groups are to be created to support this process.

6. The way forward

This review has established that the scope of the National Clean Air Programme (NCAP) needs to be expanded to go beyond the city to a larger region for an airshed approach and include a strategy and framework for regional air quality management in India. The most recent effort is the preparation of the state action plan that has created an opportunity for more harmonized action across districts of the state. This will allow coverage of all urban and rural pollution sources and also minimize pollution impacts in urban and rural areas.

More steps are needed to develop regional monitoring strategy, legal framework, operative mechanism for integrated action and alignment of responsibilities of different authorities and compliance system within the region and the federal system. This strategy is needed to meet the clean air standards. As the science has established clearly that it is not possible for any local administrative unit to meet the clean air benchmark without minimizing the regional influence, strategies for airshed-level control become necessary to meet the clean air targets.

Adopt regional scale air quality monitoring strategy and assessment of regional contribution to pollution: Air quality monitoring networks need to identify the spatial scale that is appropriate for capturing the areas and/or regions for profiling of the pollution pattern and movement. There has to be a clear delineation of monitoring at the micro scale, neighbourhood scale, urban scale and regional scale to characterize regional air-quality trends, geographic patterns and regional background and transport of pollution.

This is needed to address interstate pollution impact on downwind locations and account for it in mitigation strategy to meet the air quality standards. State-level action plans can be designed to reduce the effect on downwind states and tighten the action for additional reduction in the upwind states. In India, under the Malé Declaration, CPCB has identified 11 monitoring sites to assess regional pollution trends in the sub-content. Likewise, similar action is needed within the country. Technically, there is a requirement of identifying urban background sites in the CPCB air quality monitoring protocol. But this has not been implemented. This protocol will have to be further developed.

Provide for delineation of air quality control regions: The scope of the Air Act, 1981 needs to be expanded to establish regions as air quality control regions and define the jurisdictional boundaries to meet the air quality standards. Establish a set of responsibilities and relationships amongst national, state, and local agencies to mitigate air pollution. The state clean air action plan need to identify the regulations, programmes and roadmap to attain the standards within the delineated region. The scope of non-attainment areas needs to expand in scope to include sub-regions like the Indo-Gangetic Plain. As in the US, the upwind areas that significantly contribute to the nonattainment areas in the downwind states also need to be designated as "nonattainment" areas even if they have locally lowered pollution and achieved the NAAQS standards. Establishing upwind and downwind strategies will be critical for this framework to work efficiently.

Legal framework for regional air quality management: Regional air quality management will require a legal framework to be defined within the ambit of the Air Act, 1981 and Environment Protection Act 1986 and necessary amendment is needed to support this process. Technically, identification of critically polluted areas is possible within the existing provision of the Air Act, 1981 for the purpose of air quality management. CPCB is vested with the power to declare Critically Polluted Areas and Severely Polluted Areas. However, this approach is now confined to only management of industrial clusters as per the Comprehensive Environmental Pollution Index (CEPI) Act. It is necessary to expand the scope of its application to include multiple jurisdictions in airshed like the Indo-Gangetic Plain to declare as air pollution control area and develop management plans for coordinated and collaborative action. This legal backup is important to establish the responsibilities of states and/or cities and vertical and horizontal accountability to meet the regional level targets related to overall air quality as well as the sectoral targets. This also needs to fix downwind and upwind responsibilities and accountability within the region.

Establish responsibility in state and/or regional plans to account for contribution to air quality in downwind regions: The legal framework needs to regulate inter-region and/or state transport of pollution. For instance, the interstate transport provisions of the US Clean Air Act is called the Good Neighbor policy that address interstate transport of pollutants to the downwind states. The clean air plans of states, regions and cities in India should include measures for the pollution sources within their jurisdiction to prevent significant contribution to nonattainment areas. The plans must be continually updated for this based on assessment. If states fail in this, CPCB and the Central Ministry of Environment needs to step in with its own regional plan for harmonized action and to regulate pollution from sources in upwind states and mandate time bound implementation. This needs to be done pollutant-wise. This can pave the way for capping of pollution concentration and emissions budget at a regional scale to support compliance with the national ambient air quality standards. States need to be mandated to take additional steps to satisfy good neighbor provisions or prove why additional measures are not necessary as is done in the US. Ensure that downwind states meet the standards while minimizing contribution from the upwind states. High-emitting states need to comply with the requirements.

Create regulatory and institutional framework for regional air quality management: Currently, air pollution control is aligned with existing municipal, city and state boundaries and their respective administrative jurisdictions. Once there is geographical delineation of air pollution control areas, it may include multiple state governments like in Delhi-NCR, and joint effort of local, state and national bodies will be needed. This requires an intra-state approach as well as inter-state approach to control pollution in a larger landscape and needs to be reflected in attainment plans. The Central government needs to ensure that the multi-sector regulations are met in both upwind and downwind locations.

Need oversight for multi-jurisdiction action in the targeted regions: This will require a formal collaborative and integrated process for regional harmonization of action plans with adequate financial support, resource mobilization strategies and capacity building. The only precedence of multi-jurisdiction air pollution action is evident in Delhi-NCR, which has its roots in the ongoing public interest litigation in the Supreme Court that treated Delhi-NCR as an integrated unit for the purpose of issuing directions on pollution control. Only recently, an executive system in the form of the Air Commission has been created as a sub-regional institution for overseeing the pollution control action in this region. It is empowered to take decisions and also enforce penal action in the region that is governed by different state governments. But this is not well aligned with the vertical and horizontal integration of line departments in each sector and alignment of the budget line that is needed in each state for an effective operational framework.

More institutional integration is needed. For instance, China has created administrative units like the Jing-Jin-Ji Regional Coordination Group for Air Pollution Prevention and Control in Beijing-Tianjin-Hebei region and surrounding areas. This is backed by the China's State Council. The Ministry of Environment Protection and the State Council has framed the 'Jing-jin-ji and surrounding area Air Pollution Action Plan and enforcement regulation', including air quality standards to be applied at a region scale. Regional measures and criteria for the coal, automobile and industrial sectors have been defined for regional collaboration and joint law enforcement. The Jing-Jin-Ji Ambient Environmental Bureau also facilitates the Central authorities' power in managing the cross-province air quality regulations. Such a framework need to be developed for both vertical and horizontal integration.

Operationalize shared responsibility: Regional airshed air quality management based on the principles of shared responsibility, knowledge base and accountability is an important mechanism to regulate the air quality in a region. While outlining the framework, extra efforts are needed to establish accountability. For a given non-attainment downwind state or city, the corresponding high contributing upwind state or city should also be regarded as responsible or non-attainment irrespective of their NAAQS status. There can be challenges as it is difficult to define percentage or concentration contributed by the upwind regions to the downwind region's non-attainment. The regulatory framework can complement the existing city-centric measures and expand the efforts to a regional level. A comprehensive stakeholder engagement is significant for the success of any regulatory framework.

Reinvent Malè Declaration to re-energize regional cooperation in South Asia: A regional approach will increasingly require addressing pollution ingress from the larger subcontinent. Already estimates have emerged to show the relative contribution from outside India to local pollution. There is already a framework for regional cooperation on air pollution mitigation in South Asia. This Malé Declaration needs to be strengthened further with committed funding and action plan with adequate technical and scientific support. The Member States can define common monitoring goal and method and information sharing system, development of science for pollution source assessment and transboundary effects, and adopt interim targets for clean air to seek upward harmonization in policy action. This will require committed funding from the Member States and also multilateral agencies as well as work plan with a roadmap.

References

1. Chan Yang, 2020, "Policies, regulatory framework and enforcement for air quality management: The case of China – Environment working paper No. 157", Organisation for Economic Co-operation and Development, France.
2. HEI and IHME 2020, State of Global Air 2020, https://www.stateofglobalair.org/data/#/air/plot
3. Ibid.
4. Lancet study, 2017, The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study 2017
5. IQ Air 2020, World's most polluted cities 2020 (PM2.5). Available at https://www.iqair.com/world-most-polluted-cities . Accessed on July 30, 2021
6. Garima Sharma, *"Airshed Delineation and Management"*, CPCB. Available at https://cerca.iitd.ac.in/app/assets/opinion-papers/Airshed%20Delineation%20&%20Management.pdf. Accessed on July 22, 2021
7. A report on Impact of lockdown on Ambient Air Quality, 2020, Central Pollution Control Board, https://cpcb.nic.in/upload/Report-Impact-lockdown-AAQ.pdf, 23 September
8. Zirnhelt N. et al. 2014, *"Airshed Management"*, In: Taylor E., McMillan A. (eds) Air Quality Management. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-7557-2_17.
9. Ibid.
10. Ibid.
11. Karin Shepardson, 2020, World Bank Engagement on Air Quality Management, Asia Development Bank Workshop on Scaling Support-Discussion with MDBs. Available at http://events.development.asia/system/files/materials/2020/11/202011-world-bank-engagement-air-quality-management.pdf
12. Ibid.
13. Ritesh Goutam 2014, *"Challenges in Early Warning of the Persistent and Widespread Winter Fog over the Indo-Gangetic Plains: A Satellite Perspective"*, Reducing Disaster: Early Warning Systems For Climate Change (pp.51–61). http://dx.doi.org/10.1007/978-94-017-8598-3_3
14. Xinming Du et al 2020, *"Cross-state air pollution transport calls for more centralization in India's environmental federalism"*, Atmospheric Pollution Research. Available at https://www.sciencedirect.com/science/article/abs/pii/S1309104220302038
15. Umesh Kulshrestha, Bablu Kumar, "Airmass Trajectories and Long Range Transport of Pollutants: Review of Wet Deposition Scenario in South Asia", Advances in Meteorology, vol. 2014, Article ID 596041, 14 pages, 2014. https://doi.org/10.1155/2014/596041
16. Krishna B, Balakrishnan K, Siddiqui A R, Begum B A, Bachani D, Brauer M et al. Tackling the health burden of air pollution in South Asia BMJ 2017; 359 :j5209 doi:10.1136/bmj.j5209
17. Shabbir, Maryam; Junaid, Asma; Zahid, Junaid. 2019. Smog: A transboundary issue and its implications in India and Pakistan. Sustainable Development Policy Institute. http://hdl.handle.net/11540/9584.
18. Ibid.
19. Isha Khanna, Sumit Sharma, 2020, Could the National Capital Region serve as a control region for effective air quality management in Delhi?, Policy Brief, Collaborative Clean Air Policy Centre, May
20. Ibid.
21. Mukesh Sharma et al., 2015 Comprehensive Study on Air Pollution and Green House Gases (GHGs) in Delhi (Final Report: Air Pollution component) Submitted to Department of Environment Government of National Capital Territory of Delhi and Delhi Pollution Control

Committee, Delhi
22. Sagnik Dey et al., 2020, A Satellite-Based High-Resolution (1-km) Ambient PM2.5 Database for India over Two Decades (2000–2019): Applications for Air Quality Management, August, MDPI, file:///Users/anumita/Downloads/remotesensing-12-03872-v2%20(2).pdf
23. UEinfo 2019, Air pollution knowledge assessment (APnA) city programme covering 50 cities in India. https://urbanemissions.info/india-apna/
24. Ibid.
25. Anumita Roychowdhury and Avikal Somvanshi, 2021, Winter is coming: Understanding pre-winter air pollution baseline in Delhi-NCR, October, Mimeo.
26. Ibid.
27. Air pollution in North India: Moving beyond Delhi-NCR to unlock bigger pollution picture, https://www.cseindia.org/North-India-winter-Air-quality-paper.pdf
First smog episode of the season: Decoding this year's Delhi smog
https://www.cseindia.org/First-smog-note-graphs.pdf
28. Centre for Science and Environment, 2021, Capital Gains Clean Air Action in Delhi-NCR: What Next?, Delhi
29. Ibid.
30. Anon 2021, *"MoU signed towards execution of planned actions in time bound manner in 132 cities under National Clean Air Programme (NCAP)"*, Ministry of Environment, Forest and Climate Change. Available at https://www.pib.gov.in/PressReleasePage.aspx?PRID=1707867
31. IQ Air 2020, World's most polluted cities 2020 (PM2.5). Available at https://www.iqair.com/world-most-polluted-cities. Accessed on July 30, 2021
32. 42 U.S.C. ch. 85 (§§ 7401–7671q), US Clean Air Act
33. 42 U.S.C. ch. 85 (§§ 7401–7671q), Section 102(c), 81 Stat. 485, US Clean Air Act
34. Section 107(a)(2), *reprinted in 1967 U.S. CODE CONG. AND ADMIN. NEWS 522*
35. Clean Air Act § 109, 42 U.S.C. § 7409, ELR STAT. 42209
36. Clean Air Act § 110, 42 U.S.C. § 7410, ELR STAT. 42210
37. Anon., *The Environmental Law Reporter*, available at https://www.elr.info/sites/default/files/articles/16.10041. Accessed in July, 2020
38. 16 ELR 20013 *(6th Cir. Nov. 15, 1985)*
39. 16 ELR 20016 *(7th Cir. Nov. 4, 1985)*
40. CAA §110(a)(2); 42 U.S.C. §7410(a)(2)
41. CAA §110(k)(5); 42 U.S.C. §7410(k)(5)
42. Regarding EPA's authority to issue FIPs, see CAA Section 110(c)(1); 42 U.S.C. Section 7410(c)(1). Regarding the sanctions EPA may impose, see CAA Section 110(m); 42 U.S.C. Section 7410(m)
43. Kate C. Shouse 2018, *"The Clean Air Act's Good Neighbor Provision: Overview of Interstate Air Pollution Control"*, Congressional Research Service
44. 76 Federal Register 69052, November 7, 2011
Kate C. Shouse 2018, *"The Clean Air Act's Good Neighbor Provision: Overview of Interstate Air Pollution Control"*, Congressional Research Service
45. 75 Federal Register 35520, June 22, 2010
46. *GenOn REMA, LLC v. EPA*, 722 F.3d 513, 521-22 (3d Cir. 2013)
47. CAA §184; 42 U.S.C. §7511(c)
48. Ibid.
49. 86 FR 23054, US Federal Register. Available at https://www.federalregister.gov/documents/2021/04/30/2021-05705/revised-cross-state-air-pollution-rule-update-for-the-2008-ozone-naaqs
50. *Wisconsin v. EPA*, No. 16-406 (D.C. Cir.).
51. US EPA, "*Monitoring Network Design*". Available at https://www3.epa.gov/ttnamti1/files/ambient/pm25/qa/vol2sec06.pdf

52. 40 CFR Part 58, Appendix D1
53. California Air Resources Board, 2021Annual Network Plan Covering Monitoring Operations in 25 California Air Districts July 2021. https://ww2.arb.ca.gov/sites/default/files/2021-07/2021%20Annual%20Network%20Plan_1.pdf
54. Ibid.
55. United States Environmental Protection Agency, 2017, Memorandum, Office of the Air Quality Planning and Standards
56. Federal Register/Vol. 84 No 234 Thursday December 5, 2019/Rules and Regulations
57. United States Environmental Protection Agency, 2017, Memorandum, Office of the Air Quality Planning and Standards
58. Céline Kauffmann et al. 2020, *"Study of International Regulatory Co-operation (IRC) Arrangements for Air Quality"*, OECD, France.
59. UNECE, The revised strategies for EMEP. Available at https://unece.org/emep-strategies
60. Byrne, A. 2015, *"The 1979 convention on long-range transboundary air pollution: Assessing its effectiveness as a multilateral environmental regime after 35 years"*, Transnational Environmental Law, Vol. 4/1, pp. 37-67
61. UNECE, *Overview of CLRTAP activities in Book on Environmental Treaties*. Available at https://unece.org/fileadmin/DAM/env/documents/2011/eb/ebbureau/Informal_document_N_4_271011.pdf
62. Céline Kauffmann et al. 2020, *"Study of International Regulatory Co-operation (IRC) Arrangements for Air Quality"*, OECD, France
63. UNECE, *Overview of CLRTAP activities in Book on Environmental Treaties*. Available at https://unece.org/fileadmin/DAM/env/documents/2011/eb/ebbureau/Informal_document_N_4_271011.pdf
64. University of Southern California Sol Price School of Public Policy 2017, *"Air Quality Management in the Jingjinji region"*, The World Bank China.
65. UN Environment 2019. *"A Review of 20 Years' Air Pollution Control in Beijing"*. United Nations Environment Programme, Nairobi, Kenya
66. Cheng Huihui et.al. 2018, *"Breakthroughs: China's path to clean air 2013-2017"*, Clean Air Asia, China
67. Wang, Li et al. 2018, "*Taking Action on Air Pollution Control in Beijing-Tianjin-Hebei (BTH) Region: Progress, Challenges and Opportunities"*, *International Journal of Environmental Research and Public Health*. doi:10.3390/ijerph15020306
68. Article 10 of the 13th Air Pollution Action Plan.
69. UN Environment 2019. *"A Review of 20 Years' Air Pollution Control in Beijing"*. United Nations Environment Programme, Nairobi, Kenya.
70. Xuehui Zhang et.al 2019, "*Is a Regional Coordination Approach to Air Pollution Management Helpful? Evidence from China"*, Sustainability 2020. doi:10.3390/su12010134
71. Cheng Huihui et.al. 2018, *"Breakthroughs: China's path to clean air 2013-2017"*, Clean Air Asia, China.
72. Chan Yang, 2020, "Policies, regulatory framework and enforcement for air quality management: The case of China – Environment working paper No. 157", Organisation for Economic Co-operation and Development, France.
73. Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia STAKEHOLDER'S MEETING Hotel 'The Park', 15, Sansad Marg, New Delhi – 110 001 (INDIA) September 24, 2002 Jointly organised by CPCB – Delhi, SACEP and UNEP/RRC-AP
    http://www.sacep.org/pdf/Male-Declaration-Publications/2002.09-Male-Declaration-Stakeholders-Forum-India.pdf
74. Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary

Effects for South Asia STAKEHOLDER'S MEETING Hotel 'The Park', 15, Sansad Marg, New Delhi – 110 001 (INDIA) September 24, 2002 Jointly organised by CPCB – Delhi, SACEP and UNEP/RRC-AP
http://www.sacep.org/pdf/Male-Declaration-Publications/2002.09-Male-Declaration-Stakeholders-Forum-India.pdf

75. Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia STAKEHOLDER'S MEETING Hotel 'The Park', 15, Sansad Marg, New Delhi – 110 001 (INDIA) September 24, 2002 Jointly organised by CPCB – Delhi, SACEP and UNEP/RRC-AP
http://www.sacep.org/pdf/Male-Declaration-Publications/2002.09-Male-Declaration-Stakeholders-Forum-India.pdf
76. Ibid.
77. Ibid.
78. Co-operations (SAARC) Countries. http://moef.gov.in/wp-content/uploads/report/0203/chap-05.htm. Prevention and control of pollution
79. Chan Yang, 2020, "Policies, regulatory framework and enforcement for air quality management: The case of China – Environment working paper No. 157", Organisation for Economic Co-operation and Development, France.

The clear blue skies during the hard lockdown phases of the pandemic were possible not only because local air pollution was minimized in cities with near shutdown of the economy, but also because the influence of pollution from the larger regions could be lessened. Nearly all the regions of India had cleaned up together during this humanitarian crisis.

But this crisis-led experience has a big lesson for air quality management in India. Air has no boundaries. Therefore, clean air action plans that draw hard boundaries around cities for the clean-up job and fail to address the major pollution sources in the larger orbit fight a losing battle, as pollution from the larger airshed continues to invade and undermine local efforts.

This science on the regional influence of pollution has begun to take shape in India. The National Clean Air Programme of the Government of India has taken on board the principle of regional air quality management. But there is no regulatory framework to enable multi-jurisdiction management for aligned action and to establish the upwind and downwind responsibilities of state governments to improve regional air quality. The deadly winter smog that wraps the entire Indo-Gangetic Plain every year is a lasting reminder of this regulatory gap. Globally, national governments have begun to develop such a framework for management of transboundary pollution within the country and between countries. India also needs its template for regional action.

CSE

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phones: 91-11-40616000 Fax: 91-11-29955879
E-mail: subhasish.parida@cseindia.org Website: www.cseindia.org