TACKLING AIR POLLUTION IN SMART CITIES
Policies and Guidelines

Anisha Raman & Shambhavi Shukla*

According to the Census 2011, one-third of India can now be categorised as urban and the population of the cities is expected to rise from 285 million in 2001 to 590 million by 2030. Projections show that 68 Indian cities will have a population soaring over a million by 2030.

Cities have always been considered engines of industrial growth because they bring employment opportunities, better living standards, security and an escape from poverty. Data from around the globe shows that more than half of the world's population lives in urban centres, and, 70 per cent of that population will be living in cities by 2050. This rapid growth has spawned crises such as crumbling urban infrastructure and dangerously polluted environment.

Many cities are choking under pollution caused by anthropogenic sources - such as traffic, industry and energy - and even the seasonal anomalies now seem like a catastrophe. Unsustainable urban planning, scarcity of land, and incentivising motorisation has led to cities becoming mono-functional and increasingly dependent on private automobiles, resulting in unnecessary urban sprawl.

According to the World Health Organisation (WHO), seven million people die prematurely from health risks every year owing to air pollution. Years of unsustainable policies in sectors such as transport, energy, industry and waste management have resulted in poor air quality in the cities. It is in the recognition of this crisis that the dialogue on pollution and climate change has now been shifted from a global to a regional context.

Countries committed to climate change programmes--reducing greenhouse gas (GHG) emissions--have prioritised a local-action approach on pollution by adapting sustainable development policies on energy production and consumption, emission cuts, clean fuel and sustainable transport. These commitments are actualised through national policies, state intervention, and strategic long and short-term plans. It is understood that such national plans have a long gestation period, owing to political and economic impediments, resource allocation and rent-seeking capital interests.

Polycentric governance structures as well as city structures have to be adapted into city planning. Planning and action have to now move to the municipal level where concerted deliberation between autonomous government agencies are informed and checked through active citizen participation. In terms of action on pollution, this system requires citizens to be aware of the extent of their exposure to pollution. The awareness empowers them to act as pressure groups on the government agencies for timely and efficient delivery of public services.

Urban planning, integrated with a technological approach, is now offered as a solution to the decades-long flawed planning and economic practices. Efficient delivery of public service, behavioural changes and a sustainable reduction in consumption must therefore not only be useful in order to limit the current level of emissions, but also to compensate for the effects of haphazard urbanisation.

The New Emphasis on Smart Cities

What is a smart city?[2] The World Bank defines a smart city as one that is technology-intensive. This means highly-efficient public services owing to information gathered by thousands of interconnected devices, coupled with software applications.

The Indian government, on the other hand, has not defined smart cities yet. The smart city policy promotes cities that provide core infrastructure to its residents, ensuring a decent quality of life and sustainable environment through the matrix of 'smart solutions'. It situates itself on the principles of a sustainable and an inclusive development model in compact areas.

Smart Cities Mission in India

The mission is set to cover 100 cities in five years (FY 2015-16 to FY 2019-20). Its statement has economic growth at its core, through targeted local area development, promoting mixed land use to create compatible closely-networked urban habitats. It sets out to bring in its fold the urban policy design of public transit oriented urban mobility, smart parking, intelligent traffic management and integrated multi-modal transport, prioritising non-motorised transport, digitalisation of public services, and waste management - reduction of C&D (construction and demolition) waste.

The Smart Cities Mission Also Aims At:

- Creating walkable localities: Reducing congestion, air pollution and resource depletion, and promoting local economy

- Promoting a variety of transport options: Promote interactions and ensure security. The road network is created or refurbished not only for vehicles and public transport, but also for pedestrians and cyclists. Necessary administrative services are offered within walking or cycling distance. Transit-oriented development (TOD), public transport and last mile para-transit connectivity

- Applying smart solutions to infrastructure and services in area-based development in order to make them better - using fewer resources and providing cheaper services.

This mission presents a unique opportunity for India to adapt to advanced air-quality-monitoring technology. It can incorporate affordable technology by introducing low-cost air-quality sensors into the regulatory ambient air monitoring programme run by the Central Pollution Control Board (CPCB). This approach would complement the existing monitoring system by providing data on air quality - in hotspots and targeted localised areas - providing real-time information to government and citizens alike. The data would help the government in framing policies. This approach will also bring about a behavioural change in the citizens by providing information about a city - allowing them to make decisions that can improve the quality of their lives.

Current Concentration of Air Toxins

A majority of Indian cities have failed to maintain their particulate matter levels, as most of them do not comply with the CPCB set Air-Quality Standards. The numbers have reduced from 13 per cent in 2007 to two per cent in 2016. In the National Capital Region (NCR), air pollution levels stayed above the permissible standards for 75 per cent of the days during the last year alone.

The Environment Protection and Control Authority (EPCA) has been constituted by the Supreme Court as the coordinating agency between Ministry of Environment and Forest (MoEF), central and state pollution control boards, and other state government agencies on all matters pertaining to air pollution within the

jurisdiction of Delhi NCR. It issues directions to stakeholders to form a cohesive action plan on air pollution. In the MC Mehta case, NCR states were then mandated to implement a Graded Response Action Plan (GRAP) in their cities. The plan puts authorities under the scanner and holds out the promise of improvement in air quality. A graded response lays down stratified actions that are required to be taken as and when the concentration of pollutants—particulate matter (PM) in the case of Delhi NCR—reaches a certain level. GRAP includes a range of actions assigned to various agencies such as municipal bodies, land-owning organisations, pollution-control boards and law enforcement outfits. The action plan is initiated by the urban local bodies based on the health and air quality advisory issued by the Central Pollution Control Board. In order to achieve these intensified efforts, work at the municipal level becomes a necessity for cities battling air pollution.

Until now, government efforts to limit or control air pollution have been insufficient. The cities have not been assigned an important role in the monitoring process. This is due to the centralistic approach, which primarily focuses on national level. It has to be broken down to regional as well as municipal levels. The scope for an action plan at the local level has been ignored so far. The Smart Cities Mission extends the scope and latitude for action at the grassroots level. It also helps improve coordinated efforts between the governance structures.

Low Cost Monitors

Liveability in a city is determined by its ambient environment, in which air quality is the major constituent. Monitoring air quality and sustaining good air are important aspects of city management. Pollution poses serious health and environmental risks, with cities exceeding the limits for several air pollutants such as PM, ozone and nitrogen oxides. In India, out of the 5,000 cities and towns, a regulatory-monitoring network exists only in 268 cities out of which only 24 cities have the capacity to conduct real-time monitoring. The rest depends on inefficient manual monitoring.

Current air quality monitoring (AQM) stations take air samples from just a few places throughout a city and then create a city-wide Air-Quality Index (AQI). These limited number of AQM stations can't provide an actionable level of detail down to the city block. CPCB has identified a list of polluted cities in which the prescribed National Ambient Air Quality Standards (NAAQS) are violated. Some of the smart cities have also failed to meet the set standards. The Indian protocol for monitoring air mandates a minimum 104 measurements in a year at a particular site, failing which the city annual average is not calculated. The monitoring of air takes place at a considerable height to get a clear idea of the AQI.

Having a low-cost monitoring system is also important. It will help in assessing numerous pollution hotspots in the city. Emission measurements are gathered for gases (carbon monoxide, carbon dioxide, and nitrogen oxides) and then they are linked with the weather data from the same period. However, forecasting software provides the data needed to implement targeted responses. Air-quality monitoring grid is important to generate data on a regular basis. It helps to assess the risks and implement control measures. Developed countries (US, Japan and European nations) have evolved advanced monitoring systems whereas developing countries in Asia and Africa are still languishing with very basic monitoring.[3] Advance systems are more resource-intensive and need a sound technical capacity for quality control of data, operations and dissemination. This is often much beyond what a city can afford.

Indian cities require monitoring techniques which can be deployed quickly and are affordable. Low-cost sensor-based monitors can be distributed extensively across India's urban and rural landscape to generate local data. It helps in carrying out exposure mapping across micro environments. The cloud-based air quality-monitoring devices offer more flexibly located measurement nodes, with all the benefits of cloud-

data management and integration. Guidelines and methods are being worked upon to integrate real-time pollution gas and particle measurements into the smart city platform. It is crucial to monitor local and neighborhood activities that contribute to the city's air pollution. The action planning and implementation therefore have to necessarily come down to the local level to make an impact at the state level. Precision of the urban inventories depend on the use of the local- activity data as well as cross-border emission.

Smart cities represent an opportunity to increase the density of air-quality sensing. A cluster of sensors can be placed to form a network grid and installed downwind of an industrial facility or used for fence-line monitoring of places with high exposure to pollution. This brings air-quality measurements in line with an array of city-wide measurements that the approach is expected to offer to a smart city.[4] Sensor-based monitoring helps in a vast coverage and provides real-time alert which regulatory monitors fail to offer. These technologies analyse pollution and toxin levels on a street-by-street basis, providing real-time data by time and location.[5] Due to different standards, insufficient data quality, divergent calculation approaches and missing data, the comparability of urban emissions is impeded. Such systems should be operated in a coordinated manner with other cities and the gathered data should be published in a common database in order to ensure comparability.

What Smart City Offers: Power and Communication?

A smart city reduces the cost of implementing high-density air-quality sensor networks through power and communication infrastructure. The focus of smart city integrators is the network, the hardware and the software required to run it. Most smart city air-quality projects have emphasised heavily on integrating sensors with the network and coupling. Combining the data with other data sets, such as meteorological data, adds value to the raw air-quality data.

These technologies will inevitably lead to an intense public interest as people will be able to monitor the surrounding air and understand the level of actual exposure. This is a powerful tool to connect people with the problem, demystify smog and demand action. *The Array of Things*—a Chicago-based project—is collated data on emissions generated in the city and put in a public domain as a common source. China has engaged with software giant IBM to assist the government in identifying sources of pollution within the city. The scope for such technological integration is wide; it goes beyond just monitoring air quality. It can aid a city or state to prepare a cleaner vehicle roadmap. Technology is available to assess the impact of low-emission vehicles on reducing air pollution. For a country that is embarking on the low carbon mobility roadmap-transition to cleaner Bharat Stage-VI fuels, introduction of electric vehicles - this would be a crucial tool to administer and evaluate mobility-policy intervention.

For this technological overhaul to have any effect, it is crucial to see a similar shift in governance structure at the grassroots level. The current top-down governance structure has failed due to a lack of coordination between agencies and rent-seeking strategy of the automobile and industrial sector. This is despite the constitution of task forces to deliver a cohesive implementation strategy. The most current state action plan - the GRAP - requires a polycentric structure. It requires a concerted effort from all urban local bodies, under the supervision of the EPCA, to act together on identified sources of pollution in Delhi NCR. This strategy would only be a success through an exchange of information, data transparency between all stakeholders, and accountability through active participation in the process.

The government processes are still shrouded in red-tapism and administrative delay, while the lower department is under the pressure of processing the tasks. Efficiency in collation and dissemination of

information is tied to action in such a plan. For the air pollution mitigation plan to be effective, the polycentric structure has to be supplemented by decentralised and concurrent databases in urban areas. The data collection process has to be extended to the district and neighbourhood level. The MoEF is in the process of setting up guidelines for sensor-based monitoring. Globally the technology is still at a nascent stage. The current issues of quality control in low-cost monitors and data integrity are being worked upon. The industry has invested heavily in the research and development of sensor-based monitoring. The system can be brought in place to complement the regulatory monitoring once the guidelines are set.

Approach in Other Countries

Various countries have attempted to integrate sensor-based monitoring into existing infrastructure, based on citizen partnership, to initiate community-level action in key areas. Chicago is implementing a city-wide sensor network that will allow officials to make decisions based on real-time data. In Pittsburgh, high-tech cameras allow citizens and officials to quantify and monitor pollution events. Such patterns will allow the city to predict potential incidents and take preventative action. In addition to better monitoring of environmental issues, the city plans to make the data available on a public domain, for use by individuals and developers. Other cities have integrated sensors into multi-purpose solutions. More than 65 cities worldwide including Boston, Los Angeles and Miami have park benches equipped with solar panels that channel electricity via USB ports to charge devices. These benches not only serve as a social space and sustainable source of energy, but also house sensors that record air quality, temperature, traffic and radiation.

A distinct advantage of infrastructure-embedded air sensors is their longevity. Integrating sensors into lasting features of the urban landscape allows cities to collect data over time and map trends without additional interventions. Moreover, these systems can provide instantaneous air-quality data, a useful tool to nudge citizens to action during times of poor air quality. [6]

Citizens' Participation

The Air Quality Index, developed in 1968, remains a valuable and widely-used standard for signalling potentially hazardous levels of pollution to local officials and residents. But the development of more advanced sensors, analytics, and communication tools is allowing these cities to make citizens more aware and address the health outcomes of poor air quality. By distributing the data-collection network, cities can develop smarter and timelier responses to pollution and help ensure cleaner air for all residents.[7] This model is based on participatory governance wherein citizens play an active role. The digitalisation of process would inform the citizens of the effectiveness and promptness of the government action on the city level air quality.

Avenues for IT Application: Mobility Crisis

Travel-demand management, an umbrella term denoting actions undertaken to streamline the demand for travel, has grown significantly in India. The severity of pollution and congestion caused by traffic are determined by how people choose to travel. India took 55 years to attain 10 million cars by 2005. It added 20 million - twice the number - in the next 10 years. Both cars and two-wheelers have a similar growth rate. According to the 2021 Master Plan for Delhi, the per capita trip rate, meaning private commute (excluding walk trips) for Delhi has grown from 0.72 in 1981 to 0.87 in 2008. This means that the total number of daily travel trips has increased from 45 lakh in 1981 to 118 lakh in 2001 and 144 lakh trips in 2008. This is

projected to increase to 280 lakh daily travel trips by 2020. With an average trip distance of 10.2 km and growing travel intensity, only augmenting road capacity for vehicles will not help. Cities need to reinvent their public transport system to expand road capacity. Inadequate supply of public transport and poor integration of these systems have resulted in buses and metro systems running at crushing capacities during peak hours, making public transport increasingly unattractive.

Why are Buses Sustainable?

Buses can be flexibly organised to cover maximum areas of population concentration in a city. They also allow direct connectivity with minimal interchange, thus saving both time and money. Bus services are affordable, cost-effective and space-efficient for a majority of the population. However, there is a lack of deliberation in choosing which technology to adapt when planning for transport facilities in states. Studies by academicians from the Indian Institute of Technology (IIT), Delhi, show that a bus rapid transit (BRT) system has a better carrying capacity than a metro rail system. BRT is comparatively flexible and cost-effective too, but still, metro receives the technology advancements.

How Can Existing Bus Services Be Made Efficient?

The issue of inadequate bus fleet size is further compounded by low vehicle utilisation and a high rate of breakdowns. These problems are endemic to bus services across the country. Technological interventions in the form of Intelligent Transportation System (ITS) have been introduced in a few cities with positive results. ITS is the integration of modern technology in various aspects of the transportation system to make it more efficient and user-friendly - mainly by collection of fare using electronic ticket-vending machines, tracking bus-service time, and eliminating bunching of buses.

Creating data that can be used for software-assisted real-time adjustments in fleet and crew scheduling will also be beneficial. For instance, buses under the cluster scheme have on-board GPS units that help Delhi Integrated Multi-Modal Transit System (DIMTS) to monitor their movement. DTC buses do not currently have such units as an earlier attempt to instal such units had failed.

Smart Solutions: A Polycentric Approach

The Indian system of governance is pretty complex. Its traditional allocation of land-use legal authority to multiple local bodies leads to urban sprawls which cause migration of people to far flung areas away from the city centre. Residents of such remote locations then become completely dependent on automobiles for travel. This kind of poorly-planned development has a terrible impact on the ecosystem as well as on the residents. Therefore, legal efforts to reshape urban form becomes difficult.

This impediment is also reflected in the Smart Cities Mission. The mission statement states that special purpose vehicles (SPVs) created under the mission must be empowered by the state government, and have autonomy in implementing the project. However, there has been no legislative amendment in municipal laws to this effect despite numerous smart-city projects being underway. However, legal reforms alone would not lead to urban transformation and control urban sprawl. The division of regulatory authority among local, state and central governments, with a federal government of limited power, creates difficulty in implementing efforts to combat the sprawl's harm. The lack of balanced governance creates predictable political and economic hurdles for citizens. It also acts as an impediment for public health and environmental advocates seeking to reshape urban form. Not only must laws and regulations change, but new forms of governance also need to be created.

For instance, sprawl and its underlying dynamics tend to be regional or broader in cause and effect. Central and state agencies mandate highway construction but have a limited programmatic charge, dealing little with associated harms and ripple effects of projects. State agencies often are a source of patronage projects, mostly legacy projects for the ruling party that are undertaken with little evidence of public benefit.

Government officials seldom have incentives to oppose such capital-intensive projects. Historically, land-use planning and governance have been a local governmental duty, under broad state-law authorisations. Even if a local government concluded that a metropolitan area's dysfunctions were due to the presence of multiple dispersed bodies, it would have limited capacity for legal remedy. Inter-governmental competition for business and new development thus continues, creating more population dispersion, air pollution and traffic.

Provisions of the Air Act, 1988

The Air Act 1988 has mandated the National Ambient Air Quality Standards (NAAQS) to protect public health "with an adequate margin of safety" for pervasive pollutants such as ground-level ozone, particulates, and carbon monoxide. This law creates incentives for urban designs that are less automobile-dependent, by obligating state and local governments to derive state implementation plans to attain the NAAQS.

Based on the level of compliance with these standards, the CPCB categorises cities as non-attainment cities. The non-attainment cities are mandated under the Air Act and various Supreme Court judgements to develop strategic action plans to achieve targeted emission reduction. Urban planning reflecting these principles aims to reduce single-passenger automobile use, traffic congestion, and multiple short trips a day—reducing automobiles' substantial contribution to ozone pollution.

Local measures to encourage such behavioural changes, if able to create quantifiable air-quality improvements, could avoid the imposition of costlier pollution-control methods. It is in this context that smart city delivers the transformative process and becomes a solution to the crisis that most urban cities find themselves in. Town planning could hold the key to improving both outdoor and indoor air quality. Reduced congestion, implementing smart-parking solutions, developing optimised vehicle-route planning and establishing clean-air zones would also help improve air quality. However, their effects need to be carefully measured and monitored in order to make real progress.

The Way Forward

A polycentric approach to urban development herein becomes the way forward. This approach focuses on linking agglomeration of autonomous agencies and de-centralisation of authority, by strengthening small and medium-sized towns and networking them with larger cities. It combines the advantages of agglomeration and decentralisation. Such a hybrid-settlement strategy that emphasises polycentric approach is relevant for smart cities. With polycentric-spatial structure, better use can be made of a resource, intensifying land use, reducing the transportation of resources required for basic sustenance and moving people across cities.

Decentralised provision of energy and digital networking can support the advantage of polycentric-spatial structures. Polycentric decision-making promotes the participation opportunities of local civil society and collaborative governance. Cities should furthermore be embedded in polycentric-responsibility architecture. Giving cities and their civil societies more creative freedom within their nation-states to shape their development pathways will help. Also, enabling them to network leads to the development of a governance-and-responsibility architecture that's tiered locally.

References:

Anon., EU Environment and Climate change policies factsheet, European Union. Found at: http://cor.europa.eu/en/welcome/Documents/Update%204%20June%2015/MOOC_Environment%20and%20climate%20change.pdf

City: One, 2018, Air Quality Strategy- Berlin. Found at https://www.cityone.cz/en/air-quality-strategy-berlin/t6759

Anon., 2015, Making Cities smart and sustainable, PWC. Found at: https://www.pwc.in/assets/pdfs/publications/2015/making-cities-smart-and-sustainable.pdf
Kraas F. Et al, 2016, Humanity on the move: Unlocking the transformative power of cities, WBGU-German Advisory Council on Global Change Found at: http://www.wbgu.de/fileadmin/user_upload/wbgu.de/templates/dateien/veroeffentlichungen/hauptgutachten/hg2016/hg2016_en.pdf

Laura Adler, Data Smart City Solutions, 2015, Monitoring Air Quality and the Impacts of Pollution. Found at: https://datasmart.ash.harvard.edu/news/article/monitoring-air-quality-and-the-impacts-of-pollution-679

Anon., June 2015, Mission Statement & Guidelines, Smart City, Ministry of Urban Development: Found at:http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf

Yana Jin, Henrik Andersson, Shiqiu Zhang, Air Pollution Control Policies in China: A Retrospective and Prospects. Int J Environ Res Public Health, 2016 Dec; 13(12). Found at:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5201360

VivekVaidyanathan, Robin A. King and Martin deJong, Understanding Urban Transportation in India as polycentric system. Found at:http://www.tandfonline.com/doi/full/10.1016/j.polsoc.2013.05.005

German Advisory Council on Global Change 92016): Humanity on the move: Unlocking the transformative power of cities. Berlni:WBGU
http://www.wbgu.de/fileadmin/user_upload/wbgu.de/templates/dateien/veroef fentlichungen/hauptgutachten/hg2016/hg2016_en.pdf

McKinsey Global Institute (2010), India's urban awakening: Building inclusive cities sustaining economic growth. New York: Mckinsey and Company

Anumita Roychowdhury et al, Reinventing Air Quality Monitoring, Center for Science and Environment.206, New Delhi.

Anisha Raman and Shambhavi Shukla are Research Associates, Clean Air and Sustainable Mobility Programme at the Centre for Science and Environment

---

Endnotes :

1 https://www.siemens.com/innovation/en/home/pictures-of-the-future/infrastructure-and-finance/smart-cities-air-pollution-forecasting-models.html
2 https://www.aeroqual.com/smart-cities-air-quality
3 http://cdn.cseindia.org/attachments/0.85392300_1505190810_reinventing-air-quality-monitoring-potential-of-low-cost-dec27.pdf
4 https://www.aqmesh.com/integrated-air-quality-smartcity/
5 https://iq.intel.com/beyond-air-pollution-smart-cities-offer-breath-fresh-air/
6 https://datasmart.ash.harvard.edu/news/article/how-cities-are-using-the-internet-of-things-to-map-air-quality-1025
7 https://datasmart.ash.harvard.edu/news/article/monitoring-air-quality-and-the-impacts-of-pollution-679