English

LOGIN/SIGN UP TO SAVE

Implementation Guides July 2022

How resource-constrained cities can assess local air pollution

Air Quality | Climate Action Planning | Spotlight On: Climate and Clean Air

Author(s): **C40 Cities Climate Leadership Group, C40 Knowledge Hub**

Assessing air pollution concentrations and exposure is a fundamental step toward managing urban air quality. It enables cities to understand the severity of air pollution, set targets to curb emissions, implement policies to meet them, monitor progress, and ultimately improve public health. Emerging sensor technologies offer a way to estimate air pollution for cities that don't yet have data on local pollution levels, and that lack access to sophisticated monitoring equipment. Building on *How to set standards and monitor outdoor air quality*, this article explains how cities can use those technologies to accelerate air quality actions and outcomes, even with constrained resources.

Assess the current status of air quality monitoring and likely high-exposure areas

Identify any existing air quality monitors and sensors in the city, and seek access to data from any monitors not owned by the city government. Regulatory air quality monitoring uses reference-grade monitors which are usually owned and operated by national authorities, such as meteorological agencies. Most larger cities will have at least one such monitor; sometimes, one monitor provides a single measurement for the whole city. OpenAQ collects data that is shared openly and may help in identifying monitors and sensors, though it will not capture any privately-kept sources.

Work with relevant government departments and community groups to map likely air pollution sources such as major roads, industrial facilities or sites of open burning. Also map critical at-risk

populations such as densely populated residential areas and locations with vulnerable populations like schools, hospitals and informal settlements. As well as city departments, consider including representatives from neighbouring municipalities or regional governments to better enable the identification of major sources outside the city's borders. Starting at the earliest stages, involve departments that align with those involved in any climate action planning, as data on the sources and levels of air pollution will also support planning and monitoring of many climate measures.

This will help to determine the most appropriate monitoring instruments to deploy that would complement, rather than duplicate, existing infrastructure, and inform initial decisions about where to place them.

> The *Clean air, healthy planet* framework and associated Pathways-AQ modelling tool can help your city to integrate climate and clean air strategies. These resources can help to assess sources and types of air pollution, produce air quality and health data to inform climate scenarios, and enable the prioritisation of climate strategies that benefit air quality as well as climate goals. For example, these tools have found that open burning of waste is the largest contributor to annual average $PM_{2.5}$ concentrations in Accra, around half of Johannesburg's air pollution comes from outside city boundaries, and the transport sector is responsible for the greatest portion of $PM_{2.5}$ in Lima.[1]

Start with a pilot, and work with experts

Ideally, work with agencies at other levels of government and/or experts to plan deployment effectively. For example, Mumbai entered into a partnership with the Maharashtra Pollution Control Board and the Indian Institute of Technology Kanpur to run a lower-cost sensor pilot from November 2020 to May 2021, testing the local performance of lower-cost sensors placed next to regulatory-grade monitors. Quezon City partnered with Clean Air Asia to develop an air quality baseline study which identified existing sensors, key air pollution sources and areas with at-risk populations.

An initial pilot assessment of air pollution can boost public support for clean air actions and for increased investment in strategic air quality monitoring, such as a higher-density sensor network and/or the addition of higher-quality monitors.

Deploy a network of calibrated lower-cost sensors to measure air quality

Understanding air pollution at the local neighbourhood scale, or identifying hotspots, requires data with higher spatial resolution than a single reference-grade monitor can provide.

Deploying a network of reference monitors is not feasible for most cities – they are expensive (US $15k – 100k) and require highly-trained technical staff to operate and maintain.[2] Instead, there are now many lower-cost sensors on the market that resource-constrained cities can deploy. These average between US $200 – $5,000 and require less training to site and operate. Many can provide real-time data, and they are more portable, making them valuable for tracking rapidly-moving air pollution events such as wildfires as well as baseline urban air quality. Lower-cost sensors have a shorter lifespan than reference monitors and are likely to need replacing roughly annually, depending on siting conditions.

Lower-cost sensors to characterise air pollution levels include filter-based instruments which collect fine particulate matter ($PM_{2.5}$), passive samplers for gasses, where air passes through a sensor without a pump or a need for electricity, and lower-cost active samplers which pull air through the system. The following resources explain more about the different types of sensors:

- The United States Environmental Protection Agency's *Air Sensor Toolbox*, an online hub to support citizens, community groups, researchers and developers to participate in air quality monitoring.
- South Coast Air Quality Management District's *Air Quality Sensor Performance Evaluation Center*, which evaluates low-cost air quality sensors.

Performance may change over the year due to weather conditions

For example, a pilot in Mumbai found that lower-cost sensors performed better from November to March than from April to June, due to higher humidity in the latter period. It may therefore be beneficial to calibrate sensors more than once in a year-long deployment.

Where possible, combine data from lower-cost sensors with that from reference grade monitors. The data from lower-cost sensors can vary from sensor to sensor, in different weather conditions and in different pollution environments, making calibration and colocation critical. Colocation is when a reference monitor and lower-cost sensor are operated at the same time and place under real world conditions for an evaluation period, allowing the sensors' sensitivities to be corrected for (i.e. calibrated) by adjusting sensor data.

If there is currently no reference-grade monitor in your city, or you cannot access the data it produces, consider purchasing one or explore opportunities to collocate with a monitor outside the city, ideally in a neighbouring city with similar environmental conditions. If that is not possible, deploy lower-cost sensors without collocation to gain an initial understanding of air quality levels and collocate later, at the first opportunity.

Plan the number, type and placement of monitors, and the frequency of calibration

required

To develop a deployment plan, consider:[3]

- **Monitoring goals.** If your goal is to understand average pollution levels across the entire city, sensors should be evenly spread, ensuring a representative sample in different settings (such as industrial, residential and commercial areas). If your city has set policy goals that target specific areas or vulnerable groups, place sensors near those groups or locations. To assess exposure levels for vulnerable populations, target areas such as informal settlements, childcare and healthcare facilities, for example. This can be informed by the earlier mapping of areas with vulnerable populations not covered by existing monitors. Purposes that require greater data accuracy (such as enforcing policy or regulatory limits) will require more frequent calibration than, for example, projects that aim to identify hotspot areas, which only require sensors to distinguish between high and low concentrations.

> If your primary purpose is to influence another agency/level of government to change or enact a policy, check that low-cost sensors will be accepted as an evidence base before deploying them. If not, consider other studies or approaches to drive impact.

- **Available infrastructure and data management system(s).** Operational challenges with power and internet connectivity can limit the data generated by the deployment of lower-cost sensors. If your city works mostly with handwritten documentation or Microsoft Excel, or has limited internet connectivity, choose sensors with a built in SD card. Cities with more advanced data management systems can use sensors with an associated cloud-based platform, which allow you to view the readings in real time. Cities with frequent power outages can prioritise the use of passive monitoring, where air passes through a sensor without a pump or a need for electricity, rather than using active sampling which pulls air through the system.

- **Financing.** When deciding the number and types of sensors needed, take into account customs and fees, and allocate budget for replacement parts and equipment needed for deployment (like cables and cable ties) as well as the sensors themselves. Build out a full project budget from the earliest stages, anticipating staffing and data analysis costs.

- **Staff capacity.** More sensors and more regular calibration will require more staff capacity to install and check on the monitors. Involve staff from multiple relevant departments and local civil society groups to nominate sites for placement within the identified areas, and explore opportunities to involve them in installation and monitoring to bolster capacity. Also invest in training to interpret the

data – while lower-cost sensors require less training to operate, training will be needed to interpret the data for local planning.

Consider using satellite-derived remote sensing to improve data

Remote sensing data from satellites does not replace that from ground-based monitors, but it can complement sparse networks of ground-based monitors to improve understanding of air pollution and population exposures. Read more about this data in *How to set standards and monitor outdoor air quality*.

More detailed advice on the use of low-cost sensors can be found in:

- Vital Strategies' *Integrated use of low-cost sensors to strengthen air quality management in Indian cities*, which provides advice for city governments on the use of these instruments, focusing on India but relevant more broadly.
- C40's *Sensing Change: How cities are using new sensing technologies to achieve air quality goals* which presents lessons from 11 leading cities – Addis Ababa, Dar es Salaam, Denver, Lima, Lisbon, London, Los Angeles, Mumbai, Paris, Portland, and Quezon City – on using new low-cost sensor technologies.
- *Breathe London Blueprint: Supporting cities' air pollution monitoring goals* and *Making the invisible visible: A guide for mapping hyperlocal air pollution to drive clean air action*. These two resources by the Environmental Defense Fund (EDF) focus on the use of low-cost sensors to create an advanced monitoring system that produces a real-time, hyperlocal dataset. However, the advice they provide on using low-cost sensors could be useful for cities interested in air quality monitoring more generally.

English

Article Feedback

Please help us improve the relevance and utility of our content by answering the questions below:

Submit

Show References and Credits