T20 Policy Brief

Task Force 3:
LiFE, Resilience, and Values for Wellbeing

IMPROVING AIR QUALITY MONITORING IN G20 COUNTRIES THROUGH LOW-COST SENSOR-SATELLITE SYNERGIES

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Abstract

Air pollution, a critical global environmental problem, severely threatens human health and well-being. To address this crisis, global stocktaking and transparency is crucial. Measurement, reporting, and verification of emissions are vital, necessitating tools like low-cost sensors and satellite systems. The G20 nations, representing a significant portion of the global population and economy, are pivotal to regulating and mitigating air pollution. This policy brief focuses on the challenges that emerging economies face, highlights the role of the G20 in dealing with these challenges, and proposes policy recommendations to enhance monitoring systems. These recommendations involve collaborative research and development, global data-sharing platforms, cooperation with international organisations, and integration with the Lifestyle for Environment (LiFE) mission. The emphasis is on formalising standardised protocols, subnational action plans, and capacity building. By implementing these recommendations, the G20 countries can effectively improve air quality monitoring and contribute to cleaner and healthier environments.

The Challenge

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Air pollution is a pressing global environmental concern due to its severe effects on human health and overall well-being. In 2015, exposure to ambient air pollution alone resulted in approximately nine million premature deaths and imposed a tremendous economic cost of around US$2.9 trillion on the world economy (Fuller et al., 2022; Health Effects Institute, 2019). Recent estimates indicate that nearly the entire global population, accounting for 99 percent, is exposed to air quality that exceeds the limits established by the World Health Organisation (WHO, 2022).

The G20 plays a crucial role in regulating pollution levels and bears significant responsibility for mitigating its adverse effects. Collectively, these nations represent approximately 85 percent of the global GDP, two-thirds of the worldwide population, and over 75 percent of international trade (G20, 2023). A recent study has indicated that consumption within G20 countries contributes to approximately 2 million premature deaths due to fine particulate matter ($PM_{2.5}$) pollution transmitted through global supply chains (Nansai et al., 2021). Furthermore, within the consumption-based footprint of the G20, only 11 percent of these deaths occur in non-G20 nations. This alarming situation necessitates implementing comprehensive measures governed by local and global air quality regulations. Effective regulations must be supported by robust datasets derived from evidence-based research.

Traditional monitoring instruments, such as the gravimetric method, β-ray absorption method, and tapered element oscillating microbalance, are limited in their deployment owing to their high operational costs, particularly in low- and middle-income countries like India (Ayers et al., 1999; Le et al., 2020; Noble et al., 2001). In complex urban environments, concentrations of $PM_{2.5}$ can vary within distances as small as a few tens of metres; therefore, such small-scale heterogeneity cannot be neglected (Brantley et al., 2019; deSouza et al., 2020).

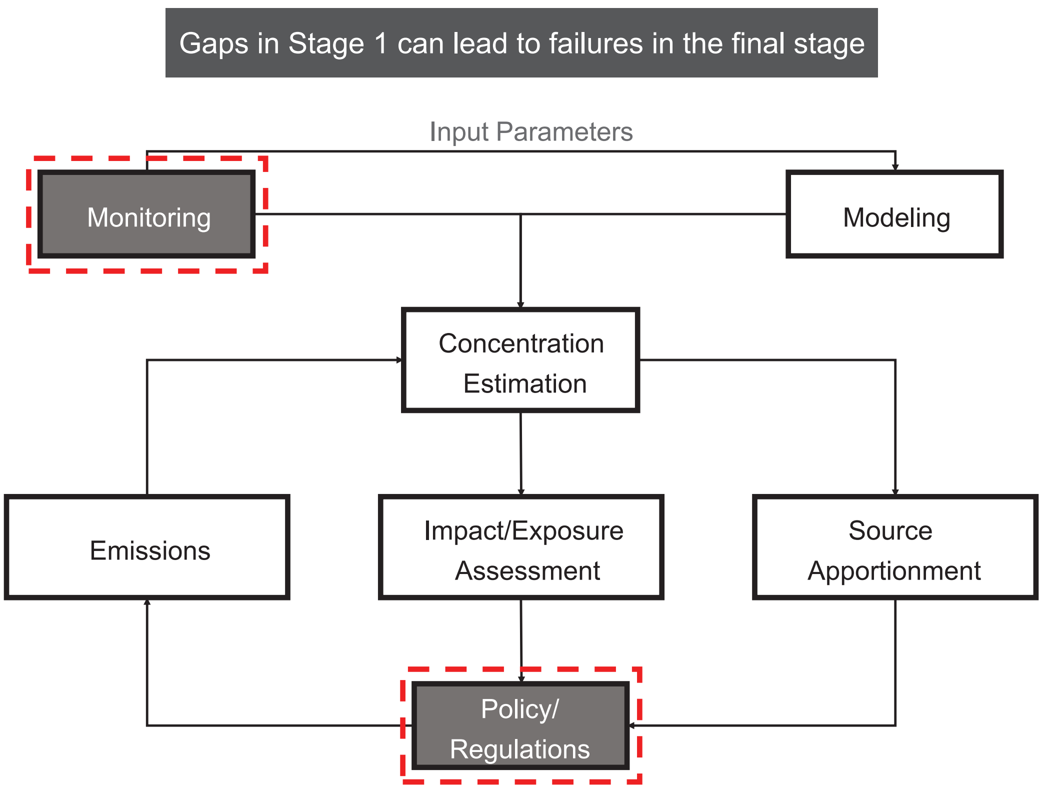
Several G20 nations have implemented targeted measures to deal with and mitigate air pollution. For example, the US has developed State Implementation Plans (EPA, 2023), India has established an Action Plan for Control of Air Pollution in non-attainment cities (Ministry of

Environment, Forest and Climate Change, 2019), the European Union (EU) member states have initiated National Air Quality Programmes (European Commission, 2021), and Japan has implemented low-emission zones in its cities (Nishitateno and Burke, 2022).

Monitoring is an integral part and the initial step of an air quality management system. The absence of adequate monitoring systems leads to failures in formulating appropriate regulations and mitigation policies (Larssen and Bohler, 2021). A general air quality management system flowchart follows (see Figure 1).

Developing and underdeveloped countries typically possess a sparse and heterogenous network of air

Figure 1: Flowchart of an air quality management system[a]



Source: Scaperdas, 2000; Guttikunda et al., 2008; Larssen and Bohler, 2021

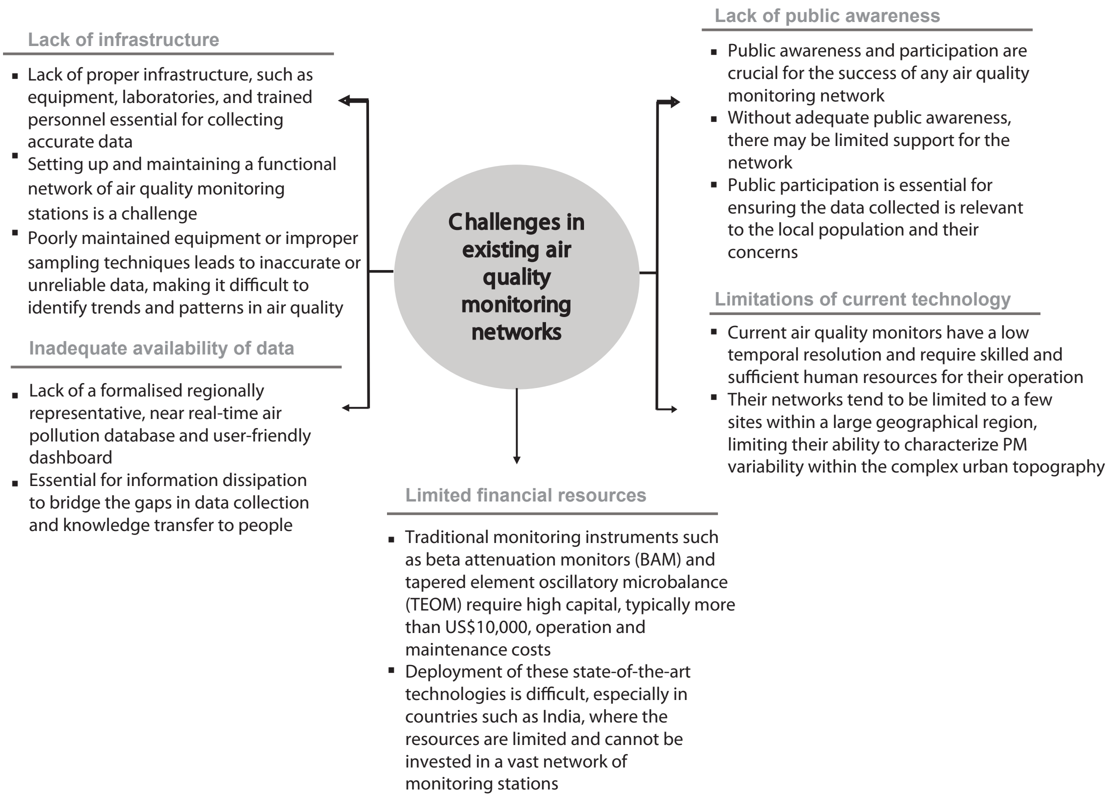
Source: Authors' compilation

a Specific protocols and standards may vary among countries and regions based on their specific environmental conditions, priorities, and regulatory frameworks.

quality monitors. For instance, the existing monitoring network in India comprises 438 continuous ambient air quality monitoring stations (Guttikunda et al., 2023). Assessments indicate that India requires 1600–4000 monitoring stations, which is five to 12 times the current number, requiring an estimated capital (annual operating) cost between US$21 million and US$540 million (US$106 million to US$270 million) (Brauer et al., 2019).

Recent air pollution incidents have heightened concerns among regulatory bodies, prompting them to expand the monitoring network (Lu et al., 2015; Marlier et al., 2016; Turner et al., 2016). However, bridging the gaps in monitoring and homogenising the air quality monitoring network presents various challenges. These challenges encompass inadequate infrastructure, including equipment, laboratories, trained personnel, limited financial resources, insufficient technological advancements, and a lack of data availability and awareness (see Figure 2).

Figure 2: Challenges in air quality monitoring system in emerging economies



Source: Authors' compilation

The G20's Role

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Air pollution continues to be a persistent and significant concern among the G20 countries. In recent years, the need to promote and adopt low-cost sensors (LCS) and satellite measurements for air quality monitoring has become increasingly evident (Brauer et al., 2019; Gupta et al., 2018; Guttikunda et al., 2023; Li et al., 2020). These advancements are necessary for enhancing the effectiveness of air quality monitoring systems.

For air quality improvement and information dissemination, the G20 countries have a substantial role to play. They possess the potential to foster collaboration, facilitate knowledge exchange and international cooperation, and establish a roadmap for regulatory reforms. By advantageously using their position and influence, G20 countries can contribute significantly to enhancing the global air quality network.

Spearheading research, innovation, and development for the scaled deployment of LCS

THe G20 countries have acknowledged the importance of employing advanced technologies, such as LCS and satellite measurements, to enhance air quality monitoring and data collection (EPA, 2021; European Commission, 2022; G20 Osaka Leaders Declaration, 2019). To effectively expand the implementation of these solutions, it is imperative to bolster the participation of research organisations, given their pivotal role in advancing knowledge and fostering innovation. Providing support to research and development (R&D) institutions becomes vital, as they possess the capacity and resources to enhance the reliability of low-cost sensing methods.

Presently, numerous institutions in G20 countries, including the National Institute of Environmental Studies in Japan, the National Aeronautics and Space Administration (NASA) in the US, and the National Environmental Engineering Research Institute in India, actively contribute to the development and evaluation of novel technologies designed for air quality monitoring. Exploring the collaborative avenues can enable the joint development and sharing of advanced technologies and methodologies for air quality monitoring, and advantageously using pooled resources and expertise.

Harnessing citizen science through global data sharing platforms

Community groups and citizen science initiatives have emerged as valuable contributors to air quality monitoring efforts, advantageously using the collective power of individuals and communities to participate in the collection and analysis of air quality data (Varaden et al., 2020). This active involvement of citizens in data collection can significantly benefit G20 countries by harnessing the vast potential of community-driven monitoring, resulting in a broader coverage of monitoring sites and an enhanced understanding of local air pollution patterns (Varaden et al., 2018).

Establishing a dedicated global data-sharing platform within the G20 structure is crucial to strengthening the participatory approach further. This platform should be modelled after existing initiatives, such as the European Citizen Science Association, or the Global Learning and Observations to Benefit the Environment programmes (Kullenberg et al., 2018). Creating such a platform facilitates collaboration, data sharing, and knowledge exchange among citizens, researchers, and policymakers. It will empower citizens with accessible air quality data and analytical tools, bridging the gap between citizens and scientific communities (Eitzel et al., 2017). This approach cultivates a culture of environmental stewardship, encouraging individuals to take responsibility for their surrounding and engage in actions that promote cleaner and healthier environments (Burgess et al., 2021; Hecker et al., 2021).

Driving cooperation among regional and international institutions

International organisations play a vital role in enhancing air quality monitoring networks by offering technical expertise, sharing best practices, and facilitating cooperation between countries. Their involvement ensures a standardised, practical approach to worldwide monitoring and mitigating air pollution. Moreover, regional organisations play a significant role in building a comprehensive emissions database at a granular level. By leveraging their regional expertise and resources, these organisations contribute to developing a robust and reliable database that can be utilised for informed decision-making and policy formulation.

Through their technical assistance and collaboration, international and regional organisations enhance the capabilities of countries in monitoring air quality, ensuring the implementation of standardised methodologies and the adoption of best practices.

Collaborative opportunities for G20 countries and the LiFE mission

The Lifestyle for Environment (LiFE) mission by the government of India places significant importance on the well-being of the citizens. Since air is one of the fundamental elements of life, monitoring and maintaining healthy or 'breathable' air is imperative. Through robust monitoring, citizens and policymakers gain a better understanding of the sources and effects of air pollution, enabling them to implement targeted measures for emission reduction. The G20 countries have the opportunity to support the LiFE mission by sharing their technical expertise and providing resources that can aid in the expansion of India's air quality monitoring networks.

Many G20 countries have already taken notable initiatives to enhance air quality monitoring. These initiatives involve collaborative efforts in R&D, exchange of information, and international cooperation (Table 1). The primary focus of these initiatives is to develop advanced technologies, establish data-sharing platforms, and implement effective strategies for air quality management.

G20 Member	Initiative
US	o The United States Environmental Protection Agency launched the AirNow Citizen Science Programme in 2020, which provides citizens with tools to collect and share air quality data.
EU	o In 2019, the EU launched the Clean Air Forum, an online platform for citizens to exchange information on air quality and engage in discussions on air pollution matters. o In 2021, the European Commission and the Chinese Ministry of Ecology and Environment agreed to cooperate on air quality monitoring through satellite observations and the exchange of best practices.
India	o India has deployed a network of low-cost sensors across several cities, which is publicly available through the National Air Quality Index portal for over 100 cities in the country.

Source: Authors' compilation

Recommendations to the G20

3

The primary objective is to enhance the air quality in regions within the G20 facing significant air pollution challenges. Implementing a resilient, adaptable, and continuously monitored network at a granular scale is essential to accomplish this objective. Access to real-time dashboards, such as Urban Emissions in India, AirNow in the US, and the Air Quality Health Index by the government of Canada, plays a crucial role in achieving this goal. It enables the effective execution of strategies to reduce air pollution by curbing emissions from various sources while facilitating prompt monitoring of their impacts.

Air pollution is a dynamic phenomenon wherein different sources influence air quality at distinct intervals. The availability of real-time monitoring through the network provides valuable insight into these temporal variations. In their study, Brauer et al. (2019) introduced the concept of source-based airsheds in India, defined as regions characterized by shared meteorological and geographical conditions, and common emission sources that affect air quality. Low-cost sensing technologies can complement the advanced air quality monitoring stations. It allows for evaluation of the most effective strategies tailored to address specific pollution sources and their temporal patterns. Consequently, decision-makers and environmental stakeholders gain a reliable means to assess and refine pollution-reduction measures.

Adoption and scaling of an integrated network of LCS and satellite products to increase the homogeneity of air quality monitoring

G20 nations must prioritise establishing the necessary infrastructure to effectively integrate networks of LCS and satellite measurements with existing air quality monitoring stations. While these technologies may face challenges, such as local meteorological conditions and uncertainties in aerosol properties, they can still provide valuable complementary information on air pollution on a larger scale. Satellite-based systems provide a proxy of aerosol concentration in a broad spatial grid. However, these systems have limitations regarding spatiotemporal resolution, vertical resolution, measurement accuracy, validation, and calibration.

To overcome these limitations, integrating data from LCS becomes crucial. A synergistic approach that combines LCS and satellite monitoring technologies can enhance the spatial distribution of air quality measurements while maintaining the critical characteristics of pollution mapping.

The G20 countries can play a vital role by collaborating and sharing expertise, resources, and best practices to scale up this integrated network and develop a common monitoring framework. Such collaboration will enable the exchange of air quality data and facilitate the development of targeted policies and interventions based on this information. The benefits of these efforts include improved public health outcomes, reduced environmental degradation, and increased economic productivity.

Formalising standardised protocols, adopting sub-national and regional action plans, and capacity building

Standardised protocols are essential for data comparison and sharing, benefiting research, policymaking, and international cooperation in air quality monitoring. Harmonising the existing definitions of air pollution is necessary to provide a standardised definition encompassing various pollutants, source apportionment findings, and exposure studies. This comprehensive definition will allow the quantification of the impacts on human health and the environment.

G20 countries can adopt sub-national and regional action plans. These plans should strengthen collaboration between environmental agencies, public health departments, and transport departments. Key avenues for facilitating these efforts include meetings of environment ministers, the working group on sustainable energy and climate change, the G20 task force on health, the sustainable cities alliance, and research and knowledge exchange platforms. Action plans should identify the sources of air pollution in specific areas and develop targeted strategies to mitigate them. Successful initiatives like the Mayor's Transport Strategy 2018 can serve as models, emphasising an integrated approach that reduces emissions from road transport, promotes active travel, and improves public transport. Collaborative efforts among local authorities, transport organisations, and government bodies are crucial in implementing such measures.

Quality control and assurance are critical in ensuring reliable and comparable data across regions. Building the necessary skills, knowledge, and institutional capacity is essential for implementing robust air quality monitoring programmes. To facilitate capacity building, investments should be made in training programmes and technical assistance. Training should cover standard operating procedures, quality assurance and controls, and data analysis techniques. Implementing calibration standards, proficiency testing, and inter-laboratory comparisons can further enhance quality control. Technical guidelines and protocols should be established to ensure data collection, analysis, and reporting consistency. These measures will support informed decision-making on air quality improvement initiatives and the evaluation of their effectiveness.

Supporting and promoting R&D to spur technological advancement of air quality monitors through a Global Clean Air Technology Fund

Technological advancements can enable accurate and reliable air quality monitoring to inform policy decisions and improve public health outcomes. To support and promote R&D in air quality monitoring, the establishment of a Global Clean Air Technology Fund (GCATF) by G20 countries can be considered. It can be a dedicated fund that supports developing and deploying advanced air quality monitoring technologies. It can be financed through various sources, such as government contributions, private sector donations, and international development assistance. The GCATF can also provide technical assistance to countries that lack the capacity to implement advanced air quality monitoring technologies. The fund can benefit G20 countries by spurring technological advancement in air quality monitoring, which is essential for improving public health and the environment.

Facilitating the globalisation and expansion of India's 'Swachh Vayu Sarvekshan'

Swachh Vayu Sarvekshan is a comprehensive air quality monitoring and management programme developed by India to deal with air pollution. The programme involves deploying advanced air quality monitoring systems, creating a centralised database to track real-time air quality trends, and public awareness campaigns to promote sustainable air pollution reduction practices. It has successfully addressed air pollution in India and can serve as a model for other countries facing similar challenges (CREA, 2023; PIB, 2022). Facilitating the globalisation and expansion of Swachh Vayu Sarvekshan can effectively improve air quality in the G20 countries. This can involve training programmes, technical assistance, and sharing best practices and lessons learned. They can benefit from the knowledge and expertise developed by the GoI to strengthen their monitoring networks, create a centralised air quality database, and implement public awareness campaigns to promote sustainable practices.

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