Improving the capacity of countries to report on air quality in cities

Users' guide to the repository of United Nations tools

World Health Organization

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Acronyms

AAQS	ambient air quality standards
AQG	air quality guidelines
AQI	air quality index
AQM	air quality management
AQMS	air quality management system
BAR-HAP	benefits of actions to reduce household air pollution
CAMS	Copernicus Atmosphere Monitoring Service
CCAC	Climate and Clean Air Coalition
CEA	cost-effectiveness assessment
CLRTAP	Convention on Long-Range Transboundary Air Pollution
DALYs	disability adjusted life years
DIMAQ	Data Integration Model for Air Quality
EMAPEC	Estimating the Morbidity from Air Pollution and its Economic Costs
GAPH -TAG	Global Air Pollution and Health - Technical Advisory Group
GAW	Global Atmosphere Watch Programme
GDP	gross domestic product
HEAT	health economic assessment tool
HIA	health impact assessment
LCS	low-cost sensor
OECD	Organization for Economic Co-operation and Development
PM	particulate matter
PMEH	Pollution Management and Environmental Health
NO2	nitrogen dioxide
O3	ozone
SO2	sulfur dioxide
NCDs	noncommunicable diseases
USEPA	United States Environmental Protection Agency
UNEP	United Nations Environment Programme
UNECE	United Nations Economic Commission for Europe
UNSD	United Nations Statistics Division
WMO	World Meteorological Organization
VSL	value of a statistical life
YLDs	years lived with disability

Executive summary

Exposure to air pollution is the second leading risk factor for premature death from non-communicable diseases worldwide, after tobacco exposure. In many countries it is one of the leading risks to health– ranking second only to malnutrition in sub-Saharan Africa, for instance[1].

In 2019, WHO estimated that 6.7 million premature deaths could be attributed to ambient and household air pollution from particulate matter (particles with a diameter less than 2.5 µm, $PM_{2.5}$. Of the 4.2 million deaths attributed specifically to ambient air pollution exposures, the greatest burden is in WHO's South-East Asia and Western Pacific regions with 89% of these deaths occurring in low- and middle- income countries[2].

In 2021, WHO updated its air quality guidelines with more stringent values for selected pollutants, particularly NO_2 and $PM_{2.5}$ – the most widely accepted indicators for health impacts. Altogether some 99% of people worldwide breathe unsafe air, with urban air pollution a particularly acute problem.

WHO data on air quality from some 6700 cities worldwide, updated in 2022, reveals that air pollution in 83% of high-income cities and 99% of low-income cities that are monitoring air quality exceeds WHO recommended levels. All in all, only about 10% of people living in cities assessed breathe air that meets WHO AQG levels. And thousands of cities and towns in low- and middle-income areas still lack equipment and capacity for monitoring air pollution levels at all – with the gap most pronounced in sub-Saharan Africa.

A common UN repository of tools for air quality assessment in a stepwise approach

This guidance and tools presented here represent an effort to address this yawning gap between reality and aspirations for better air quality – in a stepwise approach that advances progress on Sustainable Development Goal (SDG) 11 – “Make cities and human settlements inclusive, safe, resilient and sustainable.”

It provides a user's guide to a new, common UN repository of tools for assessing and addressing air pollution and health.

The online repository, developed by UN agencies engaged in air quality and health action, and maintained by WHO, offers a stepwise approach to support monitoring and reporting on SDG indicator 11.6.2, annual mean levels of fine particulate matter ($PM_{2.5}$) in urban areas– for which WHO also is the custodial agency. The repository can be accessed and used by anyone wishing to explore these issues.

The aim is to offer a way forward for cities and national ministries to develop frameworks for monitoring air quality in cities as one of the indicators of progress on SDG target 11.6: “By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.”

This one-stop shop includes tools for national governments, cities, and other subnational entities at all levels of development in air quality monitoring - including cities that currently have no programmes in place.

Air quality tools in a ‘one-stop shop’

The guidance and tools presented in the repository focus on eight domains, identified by the working group as critical to the holistic development of air quality assessment and reporting programmes (Fig. 1). These include:

1. **Air quality monitoring** scoping and stocktaking;
2. **Policies** for air quality monitoring, from baseline assessments of needs and gaps to setting of standards;
3. **Measurement** of air pollutant concentrations, from reference-grade monitors to low-cost sensors;
4. **Modeling** of air quality and exposures, including the development of emissions inventories, source attribution, and air quality forecasting;
5. **Health impact assessment –** HIA frameworks may capture quantitative measures such as deaths and illnesses attributable to air pollution from measured and modeled data as well as qualitative assessments;
6. **Economic impact assessment** of the air pollution-related illness and deaths, in terms of costs to health; lost productivity and other economic or social costs;
7. **Funding for air quality assessment**;
8. **Education, training and awareness-raising** needs and opportunities.

Fig. 1. A stepwise approach to Air Quality

Assessment – tools and guidance

Strengthening collaboration between UN agencies

This guidance is the product of a series of consultations between six UN agencies supporting air quality monitoring and reporting, meeting between August 2021-2022 as the interagency *Air Quality Working Group* hosted by the World Health Organization (WHO). The collaboration included: the United Nations Economic Commission for Europe (UNECE), the United Nations Environment Programme (UNEP), UN Habitat, the World Bank and the World Meteorological Organization (WMO). As such, the guidance offers a broad suite of air quality assessment, monitoring and reporting tools and methods. The initiative responds to UN Member States demands for support in building capacity for air quality management in a coherent and integrated manner.

The creation of this common repository represents the strengthened linkage between air quality programmes and frameworks managed by the agencies that participated in the Working Group. These include:

- UNECE Convention on Long-Range Transboundary Air Pollution;
- Air|UNEP – UN Environment Programme;
- WHO's Air Quality and Health Programme;
- WMO's Global Atmosphere Watch Programme;
- The World Bank's Pollution Management and Environmental Health Programme;
- UN-Habitat Global Urban Observatory.

The overall aim is to offer Member States a coherent repertoire of tools and resources relevant to this vital health, environment and development dimension of Agenda 2030 for Sustainable Development.

Development of this report was also supported by the multi-stakeholder, Global Air Pollution and Health – Technical Advisory Group (GAPH – TAG), which was established by WHO in 2021. This group includes about 80 experts worldwide from academia, research institutions, government and non-governmental organizations.

1 The state of air quality and health impacts in Africa. Seattle: Institute for Health Metrics and Evaluation, 2022: (https://www.healthdata.org/policy-report/state-air-quality-and-health-impacts-africa, accessed 4 May, 2023).

2 Ambient (outdoor) air pollution. Key facts. Geneva: World Health Organization, 2022: (https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health, accessed 4 May 2023).

SECTION 1

Background and context

Air pollution is the most important environmental determinant of health in many countries today – and most particularly in urban or peri-urban areas where pollution levels are often highest. WHO estimates that in 2019 about 6.7 million deaths were attributable annually to the effects of ambient and household air pollution. Details on the methods for modeling such estimates, which can be applied at national or subnational level, are described in the tools presented in this repository, linking to resources such as the WHO Global Health Observatory *(1)*.

WHO data on air pollution from some 6700 cities worldwide, updated in 2022, reveals that air pollution in 83% of high-income cities and 99% of low-income cities that are monitoring air quality exceeded WHO recommended levels. And thousands of cities and towns in low- and middle-income regions of the world still lack the capacity for monitoring air pollution levels at all – with the gap most pronounced in sub-Saharan Africa. Altogether, over 99% of people worldwide are exposed to health-harmful levels of fine particulate matter – with the most acute problems typically found in urban areas *(1)*.

Improved air quality assessment and reporting by Member States is thus critical to better air quality management that addresses a key risk to health and also advances progress on SDG Target 11.6: "By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management."

Advancing progress on SDG 11.6 and beyond

More specifically, this guidance aims to advance progress in Member State monitoring and reporting on the associated SDG indicator 11.6.2 – annual mean levels of $PM_{2.5}$ in urban areas– for which WHO also is the custodial agency.

The mandate to track and monitor SDG 11.6.2 is one of three air-pollution related indicators reflected in the SDGs, the other two being: SDG 3.9.1; mortality from air pollution, and SDG 7.1.2. access to clean household energy, a proxy indicator for exposure to household air pollution.

An important part of SDG 11.6.2 reporting at country level is thus the availability of publicly accessible ground-level air pollution data from national or local governments.

With this in mind, WHO convened key stakeholders from the leading UN and UN specialized agencies supporting air pollution assessment at global, national and subnational level, to discuss the challenges of air quality monitoring, and to explore how to support countries in improving their air quality management capacity - with particular reference to the SDG 11.6.2 indicator (see the Annex for a complete description of the Working Group objectives).

The result was the creation of an online repository of tools for air quality monitoring and management, hosted by WHO. This accompanying document is intended to guide policymakers, practitioners and researchers in the use of the tools that can help national and subnational entities advance policies and practices towards the SDG 11.6 target for improved urban air quality.

BOX 1

BOX 1. A snapshot of selected documents contained in the repository

Domain	Title	Institutions
Polices	Actions on air quality-A global summary of policies and programmes to reduce air pollution	UNEP
Measurements	WMO/GAW Aerosol measurement procedures, guidelines and recommendations	WMO
Modelling	WMO Sand & Dust Storm - Warning Advisory and Assessment System (SDS-WAS)	WMO
Health impact assessment	AirQ+: software tool for health risk assessment of air pollution	WHO
Economic impact assessment	Global health cost of ambient $PM_{2.5}$ air pollution	World Bank
Funding	Financing opportunities: programs for urban areas and sub-national entities	UN-Habitat
Education/Training	WHO Academy	WHO

WHO's new guidelines updated in 2021, sharply reduced recommended limits for key air pollutants such as $PM_{2.5}$, the pollutant most closely associated with mortality impacts. The new WHO guideline limit of 5 **µg/m³** for $PM_{2.5}$ is one-half of that established in 2005. For nitrogen dioxide (NO_2), the WHO guideline level of 10 **µg/m³** is one quarter that of the 2005 limit (Table 1).

TABLE 1

Table 1. WHO air quality guideline levels and interim targets, mean annual average

Pollutant	Interim target				AQG (2021)	AQG (2005)
	1	2	3	4		
$PM_{2.5}$, µg/m³	35	25	15	10	5	10
PM_{10}, µg/m³	70	50	30	20	15	20
NO_2 , µg/m³	40	30	20		10	40

Source: WHO air quality guidelines, 2021

The updated WHO AQG are based on the mounting evidence of the damage that air pollution inflicts on human health at far lower concentrations than previously recognized *(2)*. They are designed to help countries and cities achieve air quality that protects public health.

Moreover, reducing the levels of key air pollutants will also contribute to slowing climate change. They have thus been welcomed by the health community, medical societies, and patient organizations *(3)*.

Looking beyond 2030, the SDG 11.6.2. Working Group, together with WHO GAPH-TAG, are also discussing the development and incorporation of more defined targets for meeting the AQG into the post-2030 development agenda.

Among the members of the GAPH – TAG, discussions are ongoing about how best to achieve this. So far, discussions have centered around a high-level summary of potential targets that countries could use to assess their progress in reducing air pollution, but this work is not yet complete. For the target, a percent reduction per year was proposed. The percentage target would vary on a country-by-country basis, with reference to the country's baseline air quality in relation to the WHO AQG levels and interim targets. In terms of a baseline time period, a three-year average has been proposed to account for different national standards and interannual variability due to meteorology or exceptional circumstances.

Benchmark for setting national air quality standards

The WHO guidelines serve as benchmarks to guide countries in setting national air quality standards. However, as noted in a recent UNEP report, "there is no common legal framework for Ambient Air Quality Standards (AAQS) globally and effective enforcement of AAQS remains a significant legal challenge. Many countries lack legislation that sets AAQS or requires air quality monitoring and only a few countries address transboundary air pollution"*(4)*.

This is the status quo despite the fact that in the 2015 World Health Assembly resolution "Health and the environment: addressing the health impact of air pollution" (WHA/68), all 194 WHO Member States committed to addressing the health impacts of air pollution, mandating WHO's Department of Environment, Climate Change and Health to support countries in improving their own capacity to better monitor air quality and develop mitigation measures *(5)*.

Besides the WHO Resolution, other voluntary or limited legal frameworks also exist, with notable examples as: the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and UN Environment Assembly (UNEA) resolutions on air pollution *(6, 7)*.

SECTION 2

Tools and guidance documents to support SDG 11.6.2 reporting

The global SDG indicator framework was adopted by the United Nations General Assembly on 6 July 2015 and is contained in the Resolution adopted by the General Assembly on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313). WHO is custodial agency for the three air-pollution-related indicators, among them SDG 11.6.2, 'Air quality in urban areas' (Tier 1) *(8).* Progress on the SDG Target, with respect to the indicator, is currently reported every 2–3 years, in the form of modelled estimates of population-weighted $PM_{2.5}$, based on input data from ground measurements and satellite data *(9)*.

A critical aspect of the SDG 11.6.2 reporting criteria at country level is the provision of publicly available ground-level air pollution data from national or local governments. The collection and auditing of these data is an inherent part of a country's Air Quality Management System (AQMS). Thus, in developing and implementing an AQMS, countries are also enhancing their ability to meet the SDG 11.6.2 reporting criteria.

AQMS cover a wide range of elements; in the present repository we limit our tools and guidance to the domains that can be supported by the institutions represented in the SDG 11.6.2 Working Group. While not exhaustive, it represents an important starting point for Member States.

Scope and limitations of this repository

It should also be noted that the tools contained in this repository primarily address needs and gaps in the monitoring and reporting of particulate matter ($PM_{2.5}$ and PM_{10}) – which are regarded as the best proxy indicator for health impacts from air pollution and a starting point for countries developing AQMS. This does not, however, diminish the importance of tracking other pollutants for which WHO has developed guideline limits, and which still have critical impacts on health and mortality, including NO_2, CO, ozone and volatile organic compounds (VOCs) *(10)*. For these, as well, available guidance is provided.

Despite SDG 11.6.2 being originally defined as an indicator for concentrations of particulate matter in urban settings, we include guidance and tools suitable for use in multiple geographies and jurisdictions (e.g., regional, national, subnational). This recognizes that urban air quality initiatives alone, however important, cannot adequately address air pollution. Indeed, in many locales, many urban air pollutants emerge from sources well outside of metropolitan boundaries, for example waste or crop burning *(11)*. In South Asian cities about two-third of the air pollutants to which residents are exposed originate from outside the city *(12)*. Similarly, air quality risks are also intertwined with behavioural risk factors, such as physical inactivity, and socioeconomic disparities that affect noncommunicable diseases. An ongoing WHO project is looking more closely at a framework for action at city level to address risk factors for noncommunicable diseases – including air pollution *(13)*.

2.1 Setting the stage – scoping and stocktaking

These tools are particularly useful for countries, and sub-national jurisdictions that do not yet have formal air quality and health policies and programmes. But they are also relevant to countries and jurisdictions wishing to rapidly assess policies, programmes and tools that are already in place, with an eye for improvements.

Screening tool

The AQM screening tool is a good tool for countries with non-existent or developing air quality infrastructure, involving a short, qualitative assessment to help countries evaluate the baseline of their AQMS. The tool consists of 10 questions. On completing the AQM screening tool, countries are encouraged to undertake the more comprehensive AQM survey in order to better understand gaps and opportunities with a view to improving their AQMS.

BOX 2

Box 2. The AQM screening tool

1. Does your city have at least one site monitoring urban background concentrations, which has been operating continuously for at least one year (and therefore provides data from which evaluation of possible chronic, long-term health effects is possible)? **Yes/No**
2. Is this monitoring controlled by your government or external organizations/affiliations? **Local / Foreign entity**
3. How many monitoring sites do you have within your country? **Number**
4. Do any of these monitoring sites have more than three years of data? **Yes/No**
5. Is air quality information openly available in public reports, on the internet or on information boards in the city centre? **Yes/No**
6. Is a quality control procedure applied to data before they are released publicly? **Yes/No**
7. Are there any national or subnational air quality standards? **Yes/No**
8. Do these national or subnational air quality standards have limit values for chronic or acute effects that are aligned with WHO Air Quality Guidelines? **Yes/No**
9. Are there enforced regulations to ensure compliance with air quality standards (if an area exceeds an air quality standard, are additional measures enforced to control emissions and ensure that this is not repeated)? **Yes/No**
10. Are warnings to the public issued during or before regional or national forecasted periods of poor air quality? **Yes/No**

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Survey tool

The AQM survey is another useful tool for building capacity and enhancing work on air quality; it helps countries to assess their air quality monitoring capacities, identifying areas in which they are making progress, and areas requiring more focus and resources. This survey, developed by UNEP and WHO *(14)* has been updated in line with lessons learned following use in different projects *(15,16)*. The AQM survey contains 30–40 questions in four sections:

I. Measurement capacity, which assesses the ambient air monitoring taking place and the funding needed to improve the accuracy, precision and representativeness of the data produced;

II. Data assessment and availability, which evaluates the statistical operations and data assessments performed on raw data as well as public accessibility of this data;

III. Emissions estimates, which assess the information that is available for emissions, how it has been determined, and how air pollution inventories are developed;

IV. Air quality management capability, which evaluates the tools used to control air pollution, such as the existence of air quality standards/guidelines and the presence of emission controls.

Presented in Box 3 is a snapshot of the AQM survey, which is available here to download.

BOX 3

BOX 3. A snapshot of the sections and questions contained in the complete AQM survey

Section 1: Measurement capacity

1. For which of the following pollutants does your city have at least one site monitoring central urban background concentrations, which has been operating for at least one year (and therefore provides data from which evaluation of possible chronic, long-term, health effects is possible)?*

Answers	*$PM_{2.5}$*	*PM_{10}*	*NO_2*	*O_3*	*If other pollutants, please specify:*	*1)*	*2)*	*3)*	*4)*	*5)*
YES	*x*	*x*	*x*	*x*		*CO*				
NO										
Max Score	*0,5*	*0,5*	*0,5*	*0,5*	*0,5*					
Your Score	*0,5*	*0,5*	*0,5*	*0,5*	*0,5*					

15. Are warnings to the public issued during or before forecasted periods of poor air quality?

Answers	*YES*	*NO*	*Max Score*	*Your Score*
As raw data	*x*		*2,5*	*2,5*

Section 4: Indicators of air quality management capability

21. Are there air quality standards?

Answers	*YES*	*NO*	*Max Score*	*Your Score*
	x		*2*	*2*
If yes, please specify the year for the relevant level:			*0,5*	*0*
National level from year:				
Sub-national level from year:				
City leve from year:				

The broader AQM survey has been adapted in the form of a targeted survey aimed at capturing information relevant to the impacts of air pollution exposures on non communicable disease burden (NCDs). It is currently being deployed by the WHO Department for Noncommunicable Diseases as part of an NCD City Indicators project *(17)*. The NCD air pollution indicator contains five components, which have been adapted from the four sections in the complete AQM survey and are bolded for ease of reference in Box 4. A sixth section is included to account for household air pollution – which is a key contributor to NCDs such heart disease and stroke as well as indirectly, to ambient air pollution exposures.

BOX 4

Box 4. Air pollution indicators in the WHO-NCD indicator project

1. **Indicators of measurement capacity: Availability of monitoring sites for air pollution data collection**

   1a) Does your city monitor air pollution in at least one populated urban background site? *Yes/No*

   1ai) If yes, for which pollutants: $PM_{2.5}$, PM_{10}, NO_2, O_3, *others*

   1b) Has it been operating for at least one year? *Yes/No*

   1c) Does your city have any other monitoring sites located near to industries or roadways? *Yes/No*

   1d) Is a quality control procedure applied to the data before it is finally released? *Yes/No*

   1e) Are the sites reviewed at least every five years to ensure they still meet the objectives of the network and hence are appropriate? *Yes/No*

   1f) Is there city-level data on air pollution ($PM_{2.5}$) weighted by population density? *Yes/No*

2. **Indicators of availability of air quality information and trends: Data assessment and availability**

   2a) Is air quality information openly available in public reports, on the internet or on information boards in the city centre? *Yes/No*

   2b) Is air quality information available as raw or aggregated data? *Yes/No*

   2c) In the last three years, has there been any mass media education or awareness campaign on air pollution? *Yes/No*

   2d) In the last five years, the city-level trend of air pollution for $PM_{2.5}$ is: *increasing/decreasing/stable*

   2e) Are warnings to the public issued during or before forecasted periods of poor air quality? *Yes/No*

3. **Indicators of emission estimates**

   3a) Has your city conducted emission inventories for air pollution sources in the past five years? *Yes/No*

   3ai) If yes, specify for which of the following emission sources estimates been calculated: i) *residential emissions; ii) power-generating facilities emissions; iii) Industrial emissions, traffic; iv) agriculture*

4. **Indicators of air quality standards**

   4a) Are there air quality standards in your country? Y*es/No*

   4ai) If yes, specify which level(s): n*ational/subnational/city*

   4b) Does your city have ambient air quality standards, such as limit values for acute effect (i.e., 24-hour time period)? *Yes/No*

   4bi) If yes, specify for which pollutants: $PM_{2.5}$, PM_{10}, NO_2, O_3, *others*

   4c) Does your city have ambient air quality standards, such as limit values for chronic effect (monthly or yearly averaging time)? *Yes/No*

   4ci) If yes, specify for which pollutants: $PM_{2.5}$, PM_{10}, NO_2, O_3, *others*

5. **Indicators of air quality management capability and enforcement of air pollution reduction policies**

   5a) Are there enforced regulations to ensure compliance with air quality standards (if an area exceeds an air quality standard, are additional measures enforced to control emissions and ensure that this is not repeated)? *Yes/No*

   5b) Are environmental impact assessments conducted before the construction of new major projects, such as roads or industrial facilities? *Yes/No*

   5c) Are additional emission controls imposed on industry or is vehicle use restricted during episodes of particularly poor air quality? *Yes/No*

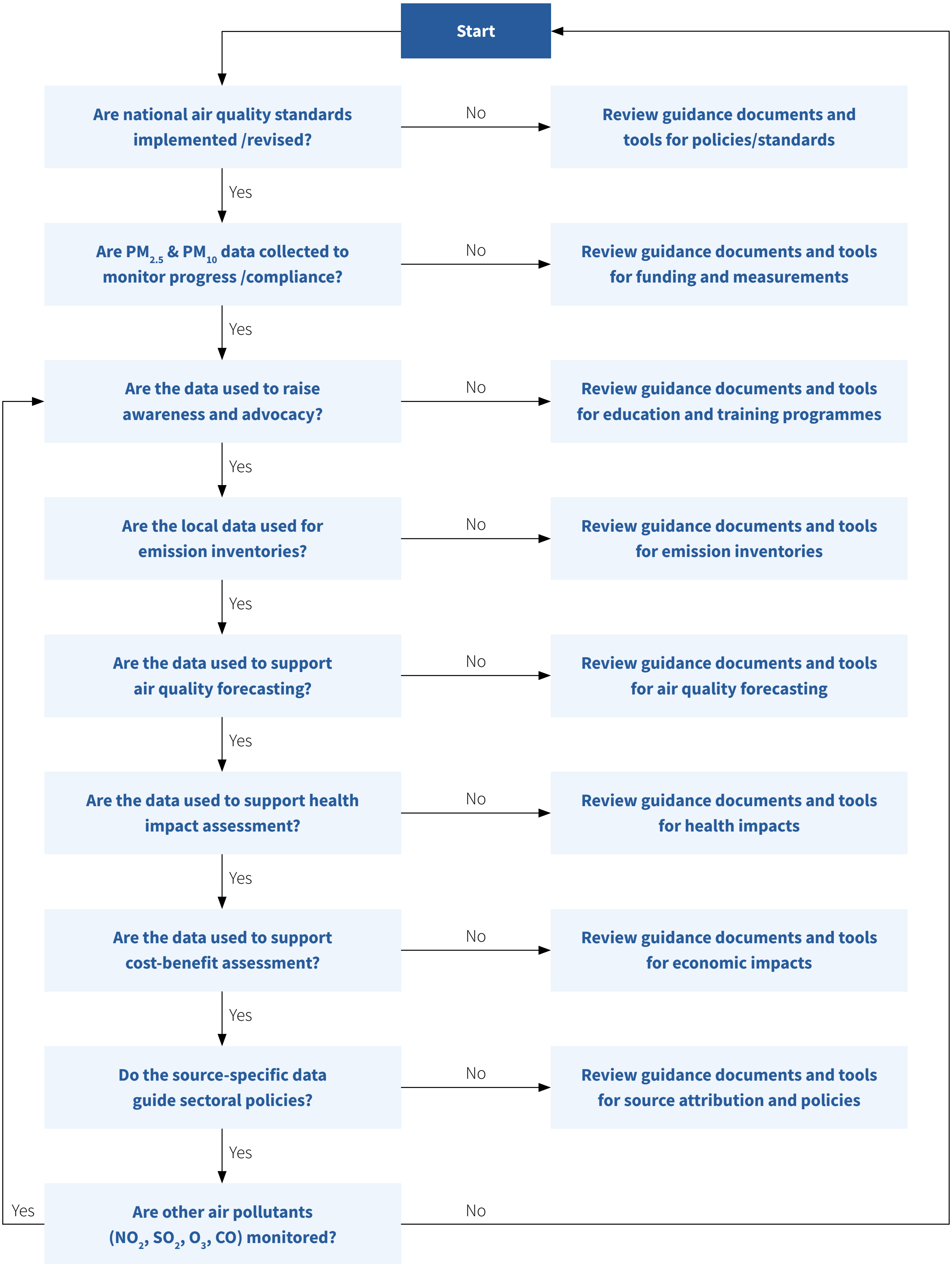
   5d) Are there quality norms imposed on solid fuels to be used by households? 1) for coal? 2) for wood/biomass? *Yes/No*

6. **Proportion of the population with primary reliance on clean fuels and technologies for cooking**

   Specify the population with primary reliance on clean fuels and technologies for cooking (%)

After assessing the baseline AQMS status, the decision tree (Fig. 1) can guide users on next steps. The decision tree identifies which aspects of AQM most need to be prioritized in a given town, city or country, and directs users to other appropriate tools in the online repository.

Fig. 1. Air quality management decision tool



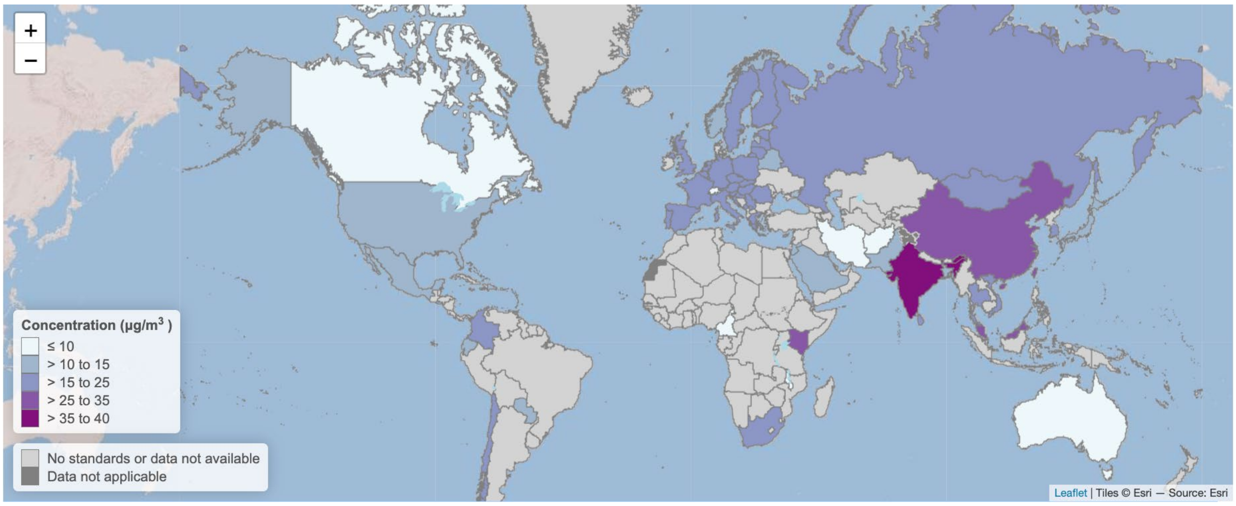
Source: Authors

2.2 Policies / standards / interventions

One of the first steps in setting up an AQMS is the development and implementation of regulatory standards or laws controlling air pollution. A global snapshot of air quality legislation was recently published by UNEP *(18)*. It found that of the UN's 195 Member and Observer States, some 66 countries, or about one third, still have no legal requirement for the monitoring of air quality *(18)*.

While about two-thirds of countries worldwide do have some kind of national air quality standards, these are typically not aligned with 2021 WHO AQG. Indeed, major inconsistences with WHO guidelines exist, both in terms of the stringency of the standards, as well as in terms of the intervals for which pollutants should be measured and assessed (e.g., hourly, daily, annually). Such inconsistencies also make regional and global comparisons of status and progress challenging *(12)*.

Fig. 2. National air quality standards for multiple pollutants for various averaging times



Pollutant

- ■ $PM_{2.5}$ (*)
- ☐ PM_{10} (*)
- ☐ NO_2 (**)
- ☐ O_3 (†)
- ☐ SO_2 (‡)
- ☐ CO (⎕)

Averaging period

- ■ 1 year
- ☐ 24 hours
- ☐ 8 hours (daily max)
- ☐ 8 hours
- ☐ 1 hour

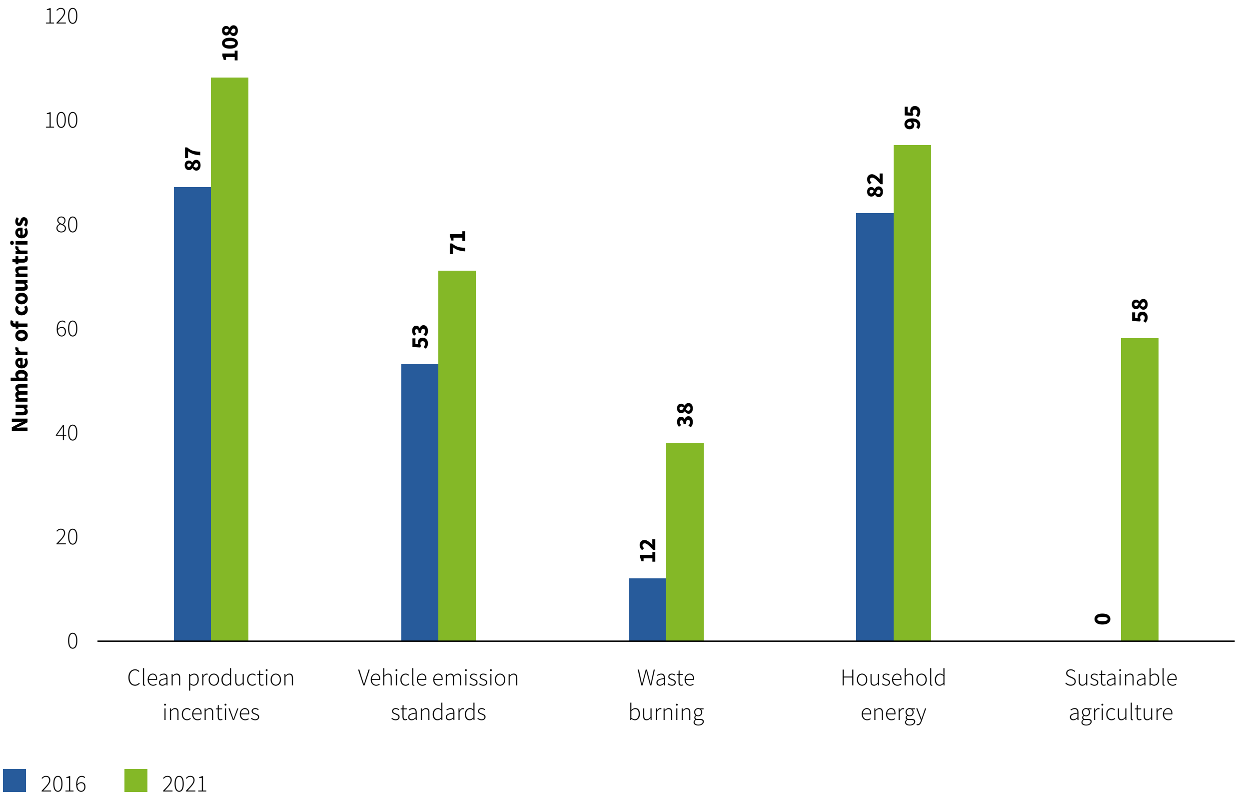
Various averaging times for multiple pollutants

* 1 year, 24 hours
** 1 year, 1 hour
† 8 hours, daily maximum
‡ 24 hours
⎕ 24 hours, 8 hours, 1 hour

Note: The global map displays standards for fine particulate matter for a one-year averaging time *(19)*.

Another dimension of policy to be considered is the pace of change; that is the development and implementation of new air pollution reduction policies or interventions over time. A recent global summary of policy trends by UNEP *(20)* reflects increasing action by more countries over the last five years in five domains, and particularly with respect to clean production incentives and waste burning in sectors such as industries, transportation, solid waste management and household air pollution (Fig. 3).

Fig. 3. Changes in the number of countries implementing sectoral interventions to reduce air pollution from 2016 to 2021



Source: Actions for air quality. Global summary of policies and programmes to reduce air pollution, 2021, UNEP (20).

Below are selected examples of other tools and guidance documents contained in the repository which can be used to consider new policies, their relevance, and modes of implementation. For a complete list, see the policies/standards/interventions section of the online repository.

Tools:

- *Law and climate change toolkit (UNEP)*
- *Country air quality policies database (UNEP)*
- *Non-motorized transport project assessment tool (NMT-PAT) (UNEP)*

Guidance

- *Environmental law-making and oversight for sustainable development: a guide for legislators (UNEP)*
- *Used vehicles inspection and monitoring framework and implementation compliance system (UNEP)*
- *UNEP handbook for drafting laws on energy efficiency and renewable energy (UNEP)*
- *Guidance document on economic instruments to reduce emissions of regional air pollutants (UNECE)*
- *Air pollution in Asia and the Pacific: science-based solutions (CCAC)*

2.3 Measurement methods

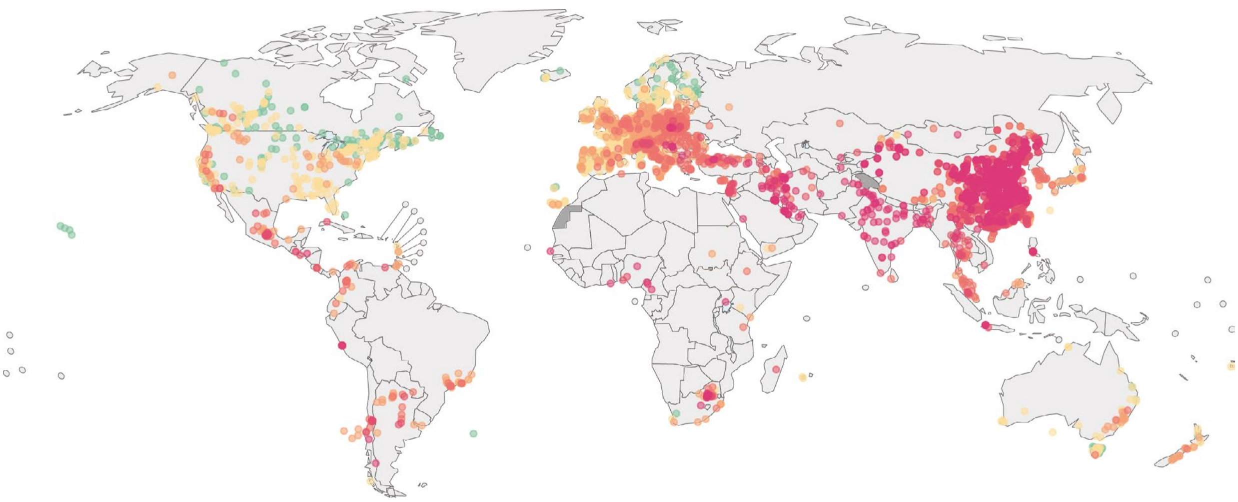
The importance of monitoring and measuring air pollution concentrations locally cannot be overstated. While some data can be inferred from satellites and other sources, ground station monitoring is a critical part of any AQMS, allowing countries to determine baseline air quality levels more precisely as well as assessing trends. Ground station monitoring is also essential for air quality modelling, which in turn, is critical to conducting health impact assessments of current pollution levels, trends over time, and the effectiveness of interventions.

Ambient air quality is monitored in 117 countries according to the 2022 WHO ambient air quality database *(21).* Within the 117 counties that monitor air quality, some 6700 settlements have been identified by WHO as tracking local concentrations of PM_{10} and/or $PM_{2.5}$. In roughly 4000 settlements, NO_2 is also monitored.

Although PM and NO_2 are measured in thousands of locations throughout the world, monitoring capacity varies dramatically from region to region and country to country. Some parts of Latin America and South Asia, as well as many countries in sub-Saharan Africa, have only sparse monitoring data, or no monitoring data whatsoever *(21).*

Fig. 4 reflects the dispersal of settlements with local data on ground-level $PM_{2.5}$ concentrations.

Fig. 4. Locations of settlements with data on $PM_{2.5}$ concentrations, 2010–2019



$PM_{2.5}$ (µg/m³)

≤5 *5≤10* *10≤15* *15≤25* *25≤35* *>35*

Recognizing the costliness of conventional, reference-grade ground station monitors, guidance for the use of low-cost sensors (LCS) to assess ground-level pollution is also included in the repository.

Among the tools are a recent WMO report assessing reliability and use of low-cost sensors in determining air pollution concentrations in diverse settings *(22)*. The report concludes that LCS, on their own, are not yet suitable replacements for reference-grade monitors but can complement the conventional tools and devices. In particular, LCS may be suitable for assessing variations in air pollution concentrations over short periods of time, or variations at the same point in time in different locations. But they are not yet suitable for determining average annual concentrations or analyzing trends over time (Fig. 5). There remains, in particular, a need for more stringent protocols for calibrating and validating LCS against reference-grade monitors. Standard protocols for calibrating and validating LCS published by the European Union *(23)* and the USA are also contained in the repository *(24)*.

Fig. 5. Span of current capabilities and applications across different types of atmospheric composition measurement networks

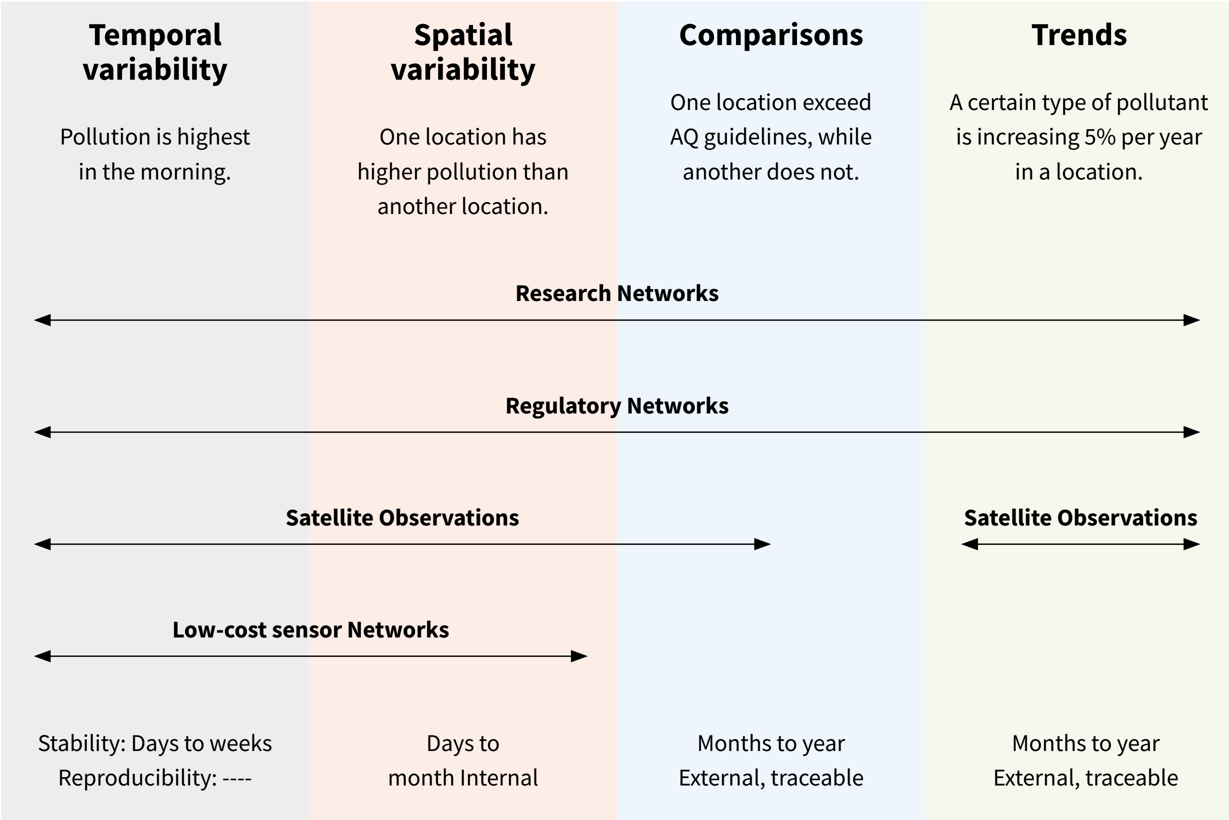


Diagram adapted from WMO report: *An update on low-cost sensors for the measurement of atmospheric composition (22)*

Below are examples of tools and guidance in the extraction of measurement data from ground-level monitors, as well as hourly and annual observations that can be used for short- and long- term health-based assessments. For a complete list of available tools and guidance, see the "Measurements" section of the online repository.

Tools:

- *GAWSIS: Station information system (WMO)*
- *WHO Ambient air quality database (WHO)*
- *World environment situation room (UNEP)*

Guidance:

- *WMO/GAW Aerosol measurement procedures, guidelines and recommendations (WMO)*
- *EMEP Manual for sampling and chemical analysis (UNECE)*
- *Monitoring ambient air quality for health impact assessment (WHO)*

2.4 Modelling methods

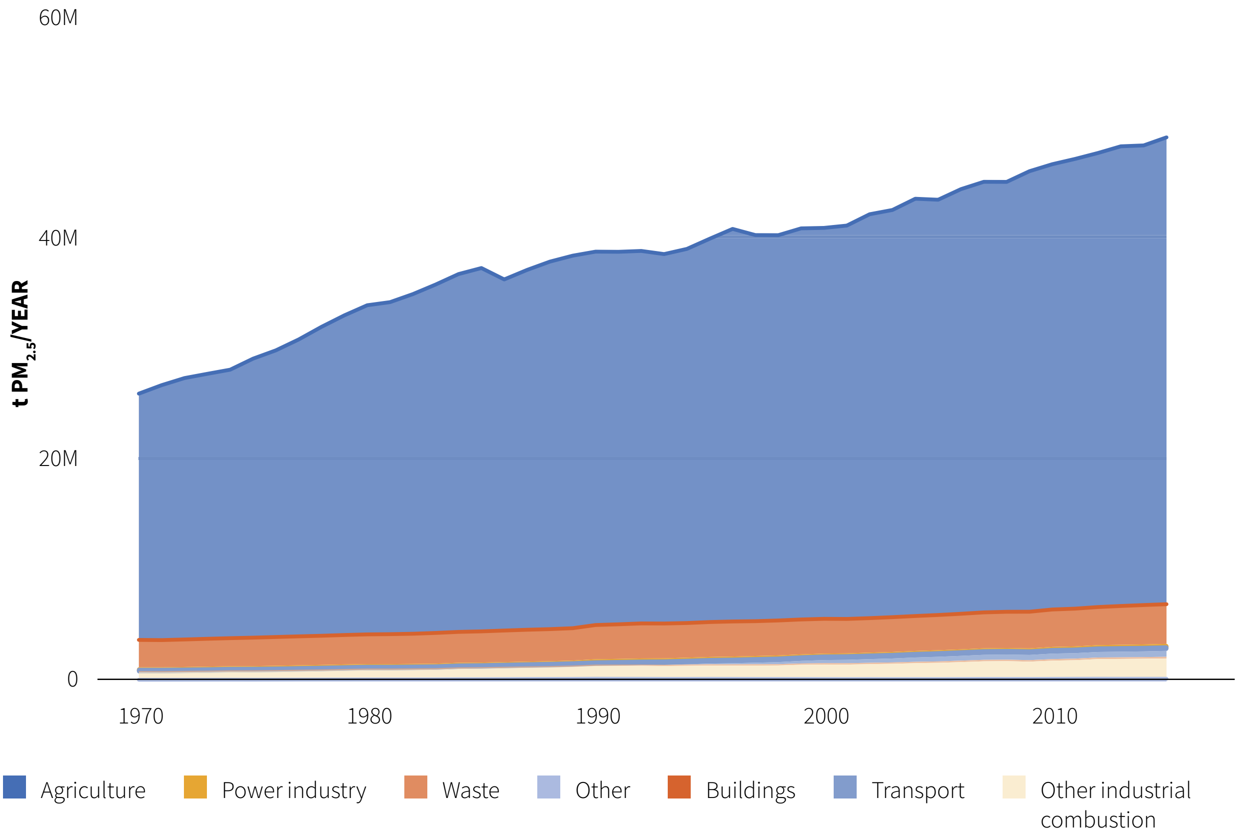
There are multiple modelling domains within the air quality sphere. In this section we focus on models that enable countries to identify the sources of pollution and to predict air quality in the near-term future.

Emission inventories

These models allow countries to estimate quantities of pollutants that have been or will be discharged into the atmosphere by specific sectors – enabling the prioritization and design of policies to abate the most serious sources. Emission inventories can be used to account for greenhouse gases as well as air pollutants. Emissions inventories are most typically developed for sector-specific sources of air pollution, such as transport, energy production, building, agriculture and waste. The mass of pollution emissions emitted (or removed) is derived from emission factors', typically available in a generic format online, for various sectors, and local ''activity'' data *(25)*. For example, in the transport sector, the mass of particulate matter emitted by different vehicle and fuel types for a kilometer of travel in urban and rural driving conditions would constitute the ''emission factor'' and the total hourly, daily, weekly or annual kilometers of travel for the vehicle/fleet would comprise the ''activity data".

The contributions of different sectors to ambient air pollution varies enormously by country, its level of development, cultural norms, climate and other factors, as well as by the type of pollutant being measured. However, worldwide building energy consumption constituted the greatest contribution to emissions of fine particulate matter in 2015 *(26)* (Fig. 6).

Fig. 6. Tons of $PM_{2.5}$ emitted per year by each sector



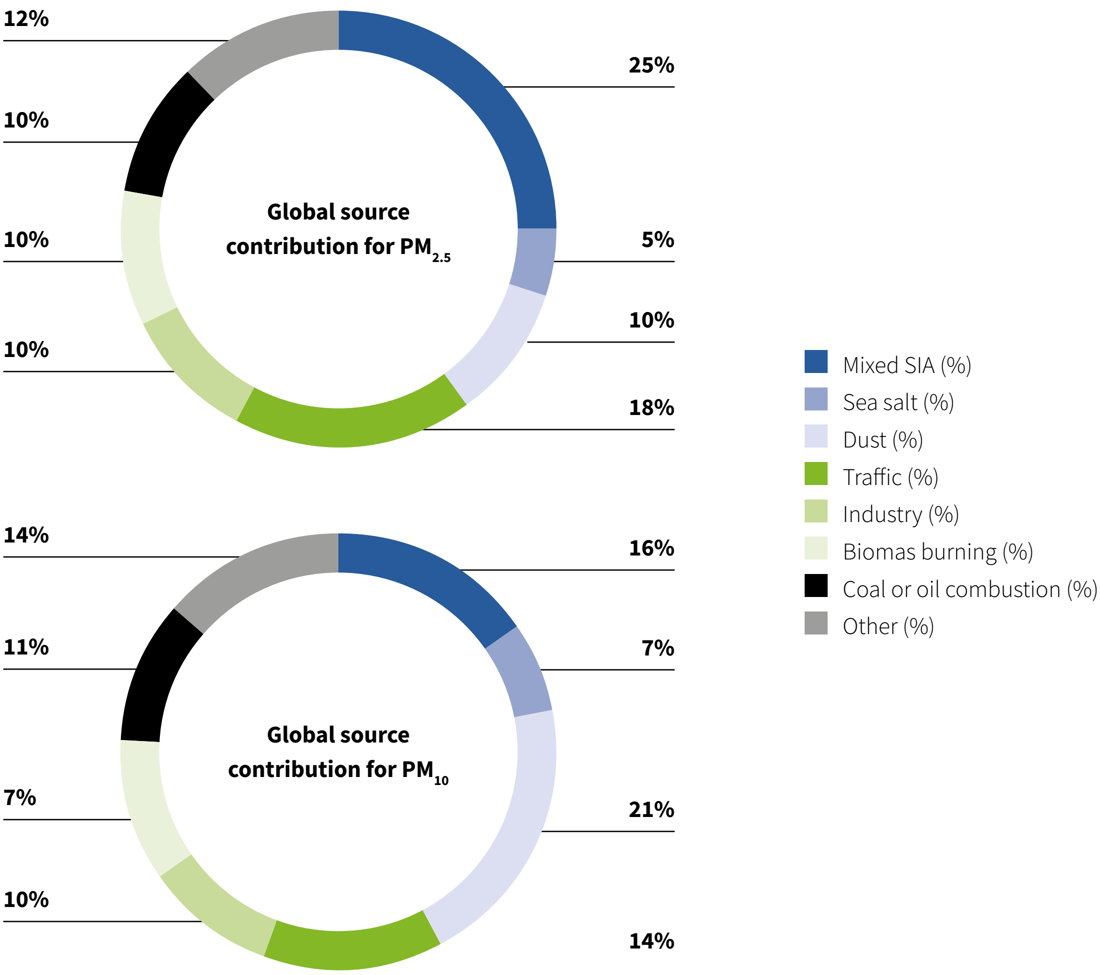
Date sourced from JRC: Emissions Database for Global Atmospheric Research *(26)*

Source attribution/apportionment

While emission inventories may allow countries to extrapolate estimations of the major contributors to their air pollution "footprint" without the need for ground measurements, the uncertainty of these estimates can also be significant, depending on how representative the generic emission factors are of local sources, and how well those sources can be aggregated and measured. For instance, in countries with used car fleets, actual emissions factors per kilometer of travel for any given type of vehicle will vary greatly with the vehicle age as well as in relation to the quality of fuel available (e.g., high sulfur content). For countries with poor vehicle registration and travel data, accurate estimations of data can, in turn, be extremely challenging.

Another way to assess the comparative importance of various sectors to air pollution, is to use source attribution or source apportionment methods – assessing the chemical components of air pollutants captured and tracing them back to sources from different sectors. Chemical analyses of pollutants can support conclusions about the main sources of air pollution observed at the time. That is because the chemical composition of pollution from power generation sources is typically different than pollution from transport, household emissions, and so on. However, source attribution requires at least some ground measurement data. A global review of source apportionment studies found that the following eight source types most frequently identified by such analysis include: dust, traffic emissions, industrial emissions, biomass burning, coal/oil combustion for power generation, as well as sea salt and other secondary inorganic aerosols (SIA) *(27).* Globally, transport ranks as the second largest source of $PM_{2.5}$, when pollution is analyzed through such methods. The largest source, however, is in fact a broad group of “secondary inorganic aerosols”, including SO_2 and NO emissions produced by fossil fuel emissions, which then undergo various atmospheric interactions. Dust, including both natural soil and desert dust as well as dust from human sources like road works, construction, and land degradation, was the largest contributor to PM_{10}. Once again, however, local sources of air pollution will vary widely, in line with geographic and urban development features, as well as climate and other variables.

Fig. 7. Global percent contributions for $PM_{2.5}$ (top) and PM_{10} (bottom)



Data sourced from Hopke et al 2022. Global review of recent source apportionments for airborne particulate matter *(45)*

When conducted repeatedly over time, source apportionment studies can enable policy-makers to evaluate which policies or interventions adopted for different sectors have impacted measured pollution levels – and to what extent. In addition, source-specific concentrations of particulate matter, for example, can enable the identification of sources that are particularly harmful to health and subsequently facilitate the source-specific assessment of disease burden. The WHO Global Air Pollution and Health – Technical Advisory Group is also supporting the development and testing of new tools for source-specific assessment of disease burden *(28)*.

BOX 5

Box 5. WHO's tool for modelling ambient air pollution - DIMAQ

The 2022 WHO ambient air quality database provides a snapshot of annual mean concentrations of particulate matter PM_{10} $PM_{2.5}$, as well as of NO_2. Annual mean values are based on local daily measurements, when available. When daily data is unavailable, intermittent monitoring data that can be reliably aggregated into an annual mean can also be used for estimating health impacts attributable to air pollution. The main sources of data are official data sent to WHO upon request; data publicly available from official national and subnational reports; and/or national and subnational websites containing measurements of PM_{10} or $PM_{2.5}$. Ground-level measurements compiled by international research and academic institutions are used when official data is unavailable.

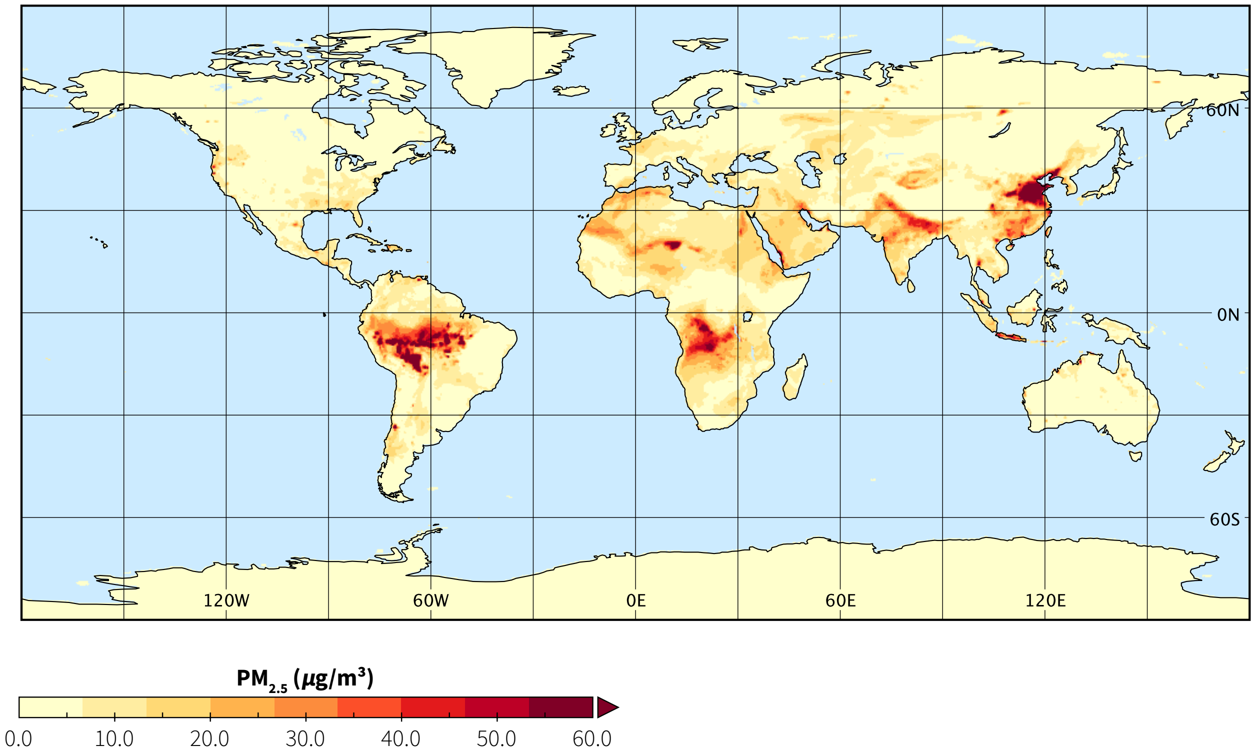
The measurements derived from the WHO air quality database are subsequently used to calibrate satellite data and chemical transport models along with demographic and topographical data within the Data Integration Model for Air Quality (DIMAQ) framework *(9)*. These global, high-resolution model estimates (0.1° grid-cell/11 km) are reported as the SDG 11.6.2 values by WHO *(29)* and it is also used for the calculation of the SDG indicator 3.9.1, mortality from air pollution.

Air quality forecasting

Many countries have developed real-time air quality forecasting to protect their citizens from unhealthy air. Air quality forecasts can be used to predict poor air quality days for public health advisories and for the planning or implementation of special air monitoring actions. These forecasts can provide warnings for sensitive groups as well as information on how to reduce individual exposure. Given the increasing frequency and intensity of sand and dust storms, it has become more relevant to develop warning systems for these specific air pollution events.

The development of an air quality forecast requires input from several forecasting models, e.g., meteorological, emission and desert dust forecasts *(30)*. Air quality forecasts can be developed at the global, regional, national, and urban level. One example of a global AQ forecast is the Copernicus Atmosphere Monitoring Service, which provides five-day forecasts of atmospheric pollutants every day (Fig. 8) *(31)*.

Fig. 8. Copernicus Atmosphere Monitoring Service particulate matter forecast [ug/m3]



Data sourced from CAMS: *Particulate matter forecast (31)*

The following are examples of tools and guidance that can be used to develop and implement models for emission inventories, source apportionment and air quality forecasts. For the complete list, see the online repository.

Tools:

- *Database on source apportionment studies for particulate matter (WHO)*
- *WMO Sand & dust storm - warning advisory & assessment system (SDS-WAS) (WMO)*
- *Sand and dust storms compendium: information and guidance on assessing and addressing risks (UNCCD)*
- *Delta tool for source apportionment (DeltaSA) (EC/JRC)*
- *Positive matrix factorization model for environmental data analyses (US EPA)*

Guidance:

- *EMEP/EEA air pollutant emission inventory guidebook 2019 (UNECE)*
- *Guidelines for reporting emissions and projections data under the Convention on Long-range Transboundary Air Pollution (UNECE)*
- *Source apportionment to support air quality management practices (EC/JRC)*
- *European guide on air pollution source apportionment for particulate matter with source-oriented models and their combined use with receptor models (EC/JRC)*
- *Training materials and best practices for chemical weather / air quality forecasting (WMO)*

2.5 Health impact assessments

Exposure to air pollution causes 6.7 million deaths globally and is the second highest risk factor for noncommunicable diseases after tobacco use. Mortality due to exposure to air pollution has been associated with several diseases, e.g., heart disease, stroke, lung cancer, chronic obstructive pulmonary disease, and lower respiratory infections.

Given the significant effects that air pollution can have on health, it is important to assess and predict the potential impact that various policies and interventions can have on population health. HIA is an approach used to assess the potential health effects of a policy, programme, or project on a population, particularly on vulnerable or disadvantaged groups (Fig. 9). One of the main outputs from HIAs are recommendations that aim to maximize a programme' s positive health effects and minimize its negative health effects. The approach facilitates engagement with members of the public and decision-makers. It also helps decision-makers to make choices about alternatives and improvements to prevent disease or injury and to actively promote health.

Fig. 9. Flow chart illustrating the steps involved in health impact assessments

Phases	Steps	Questions	Actions
Policy and programme development phase for prospective assessments	Screening	• Who should carry out screening? • How to carry out the screening?	• Contact stakeholders and decision-makers • Identify resources
Stakeholders participation	Scoping	• What is the geographical boundary of the HIA? • What is the timeframe for the HIA to deliver? • What skills are there in the HIA team?	• Define roles • Use local data, expert opinion
	Appraisal → Reporting	• Does the policy have the potential to affect environmental or social determinants that impact health outcomes? If so, which specific health determinants will be assessed? • Would health inequities be impacted? • Is the project impacts to health likely to be significant in terms of the number of individuals impacted, the magnitude, and/or immediacy of impacts? • Are methods, expertise and evidence available to assess health impacts of the policy?	• Document review • Secondary data review • Surveys, interviews, and focus groups • Field observations • Statistical analysis/GIS mapping • Interpret analysis of data collection • Identify evidence-based mitigations and recommendations
Policy implementation phase	Monitoring	• What needs to be monitored after the proposal is implemented to check the estimates of the HIA? • Are there any particular aspects that require careful consideration in case of early intervention? • Did the policy decision change in a way that was consistent with the recommendations of the HIA?	• Communicate HIA findings • Identify goals for the monitoring process

Source: WHO Health impact assessment *(32)*

BOX 6

Box 6. WHO's tool for modelling HIAs - AirQ+

To quantify the health impacts and burden from exposure to air pollution, including estimates of the reduction in life expectancy, countries can use the AirQ+ tool. AirQ+ can calculate health impacts from short-term changes in air pollution (using relative risk (RR) estimates from time-series studies) as well as the effects of long-term exposures (using RR estimates from cohort studies). The tool contains preloaded RRs for selected health outcomes; conversion factors between $PM_{2.5}$ and PM_{10} and national solid fuel use. However, users can input local data for air quality, population demographics and mortality rates of health outcomes, if available. The tool can also facilitate scenario analysis, to estimate changes in country mortality if air pollution levels change in the future *(33)*.

The following tools and guidance documents can also be used to develop and implement HIAs.

Tools:

- *WHO's AirQ+: software tool for health risk assessment of air pollution (WHO)*
- *Environmental benefits mapping and analysis programme – community edition (BenMAP-CE) (USEPA)*
- *HEAT Health Economic Assessment Tool for walking and cycling*
- *CLIMAQ-H Climate Mitigation, Air Quality and Health tool*

Additional tools under development and test by WHO, include:

- *Greener: the green urban spaces and health tool (WHO)*
- *iSThAT: integrated sustainable transport and health assess- ment tool (WHO)*

Guidance documents:

- *Health impact assessment toolkit for cities (WHO)*
- *Personal interventions and risk communication on air pollution (WHO)*
- *Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration-response functions for cost-benefit analysis of particulate matter, ozone and nitrogen dioxide (WHO)*

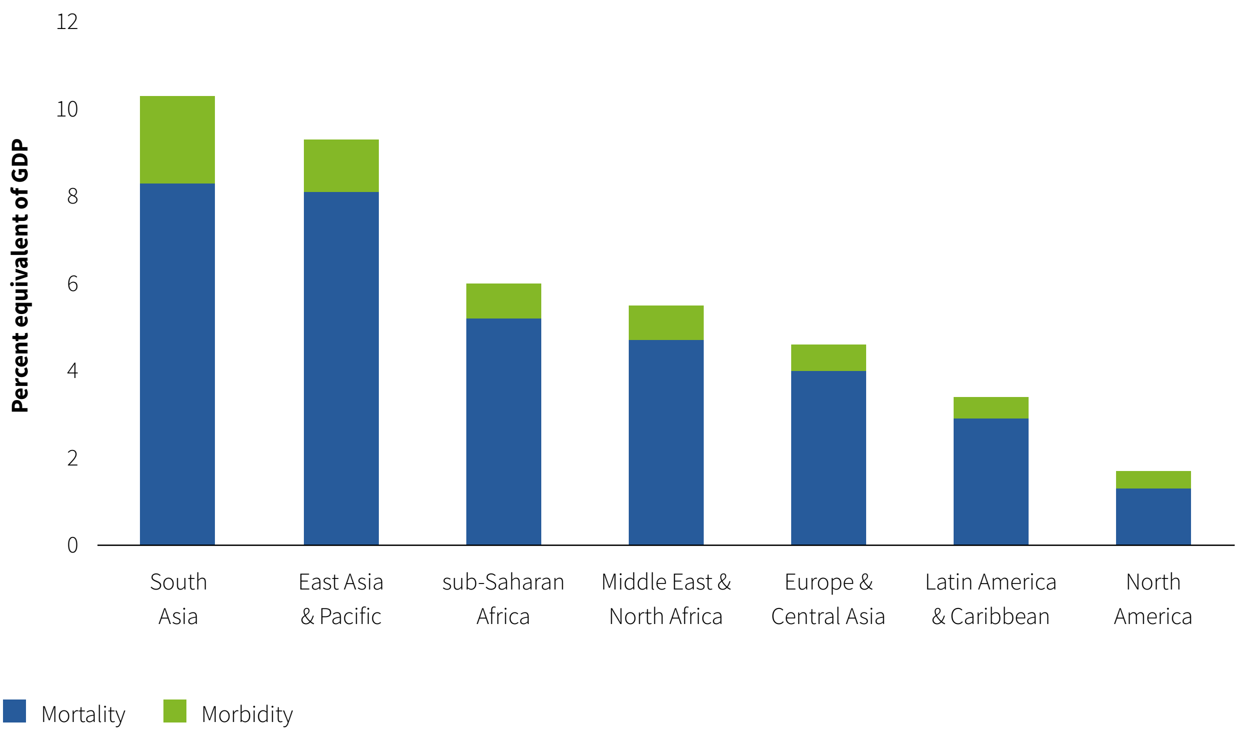
For additional tools and guidance documents related to health impacts assessments, see the online repository.

2.6 Economic impact assessments

Recognizing the health impact of air pollution is important. Translating those impacts into assessments of the economic costs that countries and cities pay for premature mortality and morbidity due to air pollution exposure is another powerful tool for driving policy change. The cost of health damage from air pollution is usually quantified separately for premature deaths and disease/disability (morbidity). The cost of premature deaths can be derived from the value of statistical life (VSL) which indicates how much individuals are willing to pay for a reduction in the risk or likelihood of premature death. However, since VSL is highly influenced by income level and other socioeconomic factors, it tends to be different for each country. In low-income countries, for example, calculations of VSL are typically adjusted relative to the high-income country value *(34)*.

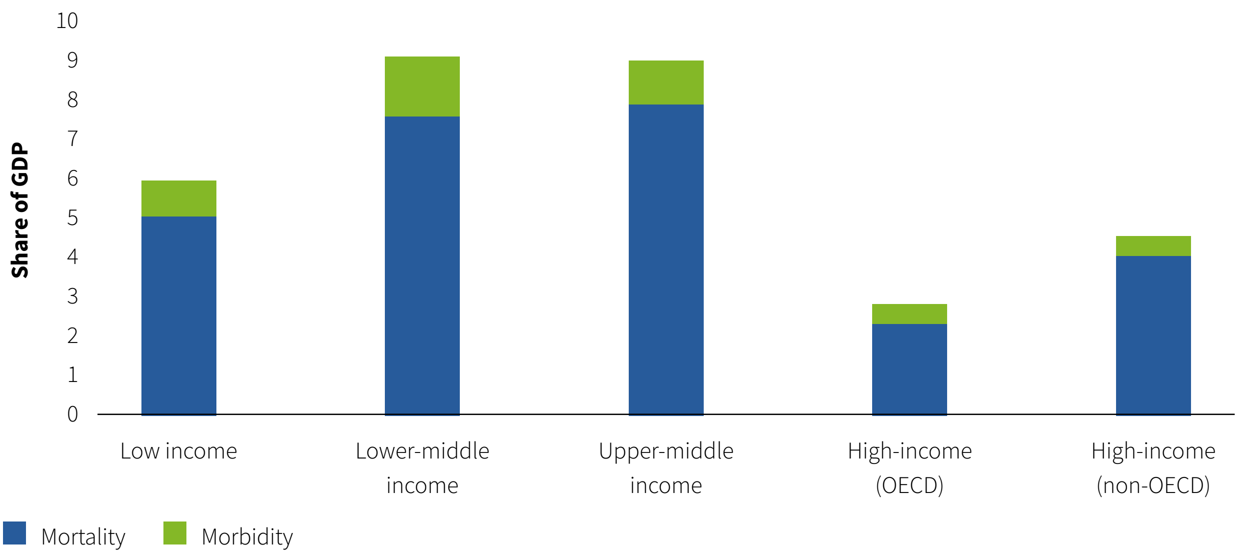
The economic costs of morbidity can be estimated by considering morbidity patterns from the different diseases that air pollution causes, to the number of years lived with disability (YLDs), and from that, days lived with the disease. The cost of a day of disease can then be estimated in relation to the average daily wage rate in a given country. Using these methods, a recent World Bank report found that the global health cost of premature mortality and morbidity attributed to $PM_{2.5}$ air pollution in 2019 was US$ 8.1 trillion *(35)*. The greatest burden of health costs was experienced in South Asia (Fig. 10) and in lower-middle- and upper-middle-income countries (Fig. 11), with a 10.3% and 9% loss of gross domestic product (GDP), respectively, being attributable to air pollution-related health impacts. However, as the percentage of GDP lost as a result of air pollution-related death and disease is relative to the GDP of the region, this relative cost could be comparable to or different to the absolute economic costs to health from air pollution.

Fig. 10. Cost of health damage from $PM_{2.5}$ exposure in 2019 by region, as a percent equivalent of GDP



Data sourced from World Bank report: The global health cost of $PM_{2.5}$ air pollution: a case for action beyond 2021 *(35)*

Fig. 11. Cost of health damage from $PM_{2.5}$ exposure in 2019 by income group as a share of GDP



Data sourced from World Bank report: The global health cost of $PM_{2.5}$ air pollution: a case for action beyond 2021 *(35)*.

Along with estimating the existing macro-economic impacts of air pollution-related death and disease, health economists also have developed methods for estimating the "cost-effectiveness" (CEA) of cleaner and more sustainable interventions. CEA assesses the mortality and morbidity (disease and disability) that can potentially be reduced by a specific intervention and economic investment in a particular sector[3]. Models of such assessment include WHO's health economic assessment tool (HEAT) for walking and cycling, which assesses how expansion of non-motorized transport networks can reduce death and illness from NCDs that are related to both air pollution and physical inactivity. Another example is the benefits of actions to reduce household air pollution (BAR-HAP) tool - which allows a policy-maker to estimate savings in lives and illness from cleaner cooking systems.

BOX 7

Box 7. WHO's working group on Estimating the Morbidity from Air Pollution and its Economic Costs (EMAPEC)

Currently, a WHO-led working group, EMAPEC, is further exploring methods to quantify in economic terms, the adverse health effects of air pollution, that are regionally relevant.

EMAPEC aims to develop methods to quantify the economic costs of morbidity that can be used in different regions. This work involves the review and selection of concentration-response functions for morbidities that have a significant economic impact, as well as the identification of relevant background morbidity statistics.

EMAPEC will pilot these new methods on a few countries with different context and data availability to assess the impact of lack of data on morbidity costs *(36)*.

3 For instance, a CEA-based assessment could estimate that the deaths and disability adjusted life years (DALYs), that might be reduced by Finance Ministry decisions to reduce taxes or eliminate customs duties on items such as clean stoves – so as to reduce air pollution. The advantage of a CEA is that it quantifies savings in human terms (avoided deaths and disease) relative to a given economic cost or investment – thereby sidestepping the problems associated with valuing human life in monetary terms across higher and lower-income countries. Instead, the cost of an intervention per DALYs averted in a given country can be compared against the yardstick of that country's own GDP per capita – to economically assess the investment and its return on an even playing field.

The following are examples of tools and guidance that can be used to conduct economic impact assessments. See the on-line repository for the complete listing.

Tools:

- *Low emissions analysis platform (SEI)*
- *Environmental benefits mapping and analysis programme – community edition (BenMAP-CE) (USEPA)*
- *Health economic assessment tool (HEAT) for walking and cycling (WHO)*
- *Benefits of actions to reduce household air pollution (BAR- HAP) (WHO)*

Guidance:

- *The global health cost of $PM_{2.5}$ air pollution: a case for action beyond 2021 (World Bank)*
- *The cost of air pollution: strengthening the economic case for action (World Bank)*
- *Cost-benefit analysis of NMT infrastructure projects (UNEP)*
- *WHO Guide to identifying the economic consequences of dis- ease and injury (WHO)*

2.7 Funding air quality monitoring and management

At the foundation of every AQMS is the ability to build and strengthen capacity, which can take the form of equipment acquisition or technical training of operators. Inherent to building capacity is the availability of funding to acquire human and/or infrastructure resources. For example, according to one recent US EPA report, the cost for reference-grade air quality monitors to measure particulate matter [monitors meeting either Federal Reference Methods or Federal Equivalent Methods standards], can range from US$ 15 000– US$ 40 000 *(37)*.

LCS are another type of air quality monitor that have attracted more interest recently. A recent WMO report on LCS detailed the costs associated with these systems, whose purchase can range from US$ 1000 to US$ 2000. However, the additional operating cost for maintenance, software management, quality control and quality assurance of the data over five years can rise as high as US$ 14 000 – and must also therefore be closely considered in procurement decisions *(22)*.

BOX 8

Box 8. An official development funder - World Bank

One example of international assistance has been the World Bank's Pollution Management and Environmental Health (PMEH) programme, a multi-donor partnership established in 2014 to provide support to countries to establish AQMS, and support analysis of the data collected so as to advance mitigation strategies, in line with health, climate and sustainable development priorities *(38)*.

Over the past decade, the PMEH programme has worked across countries and cities, with a mandate to establish a "full-scale" air quality management plan for each city, including components such as monitoring, emission inventory, health impact assessment, source apportionment, stakeholder engagement, policy design and implementation.

The World Bank's project, Enhancement of Environmental Quality Services in Peru *(39)*, supported the Government of Peru by generating and sharing information for environmental quality control at the national level including the procurement of air and water monitoring stations. An initial analysis during the project's preparation phase estimated a cost of US$ 6.6 million for the procurement and functioning of 16 air quality monitoring stations. In another project in Ghana, the cost of equipment, monitors, samplers, supplies and expendables related to ambient compliance monitoring and $PM_{2.5}$ field sampling were estimated to be US$ 498 000 *(40)*.

Despite the progress made, a recent report by the Clean Air Fund, the *State of Global Air Quality Funding 2021 (41)*, found that official development assistance and other official flows for air quality projects amounted to just US$ 1.4 billion in 2019, or less than 1% of total aid. Meanwhile private philanthropies disbursed US$ 44.7 million, or less than 0.1% of total grant allocations.

Along with the World Bank, the Asian Development Bank are the most active official development funders. National government agencies such as the German Development Agency and US Agency for International Development also fund projects. Other institutions that can provide support in other forms include the UNEP-hosted Climate and Clean Air Coalition (CCAC), which funds projects that advance policies and actions to reduce short-lived climate pollutants, such as ozone and black carbon – where sharp, rapid emissions reductions could yield particularly big benefits for health and climate *(43)*.

The following are examples of tools that can be used to explore funding opportunities. See the online repository for the complete listing.

Tools:

- *Finding a funding opportunity (USAID)*
- *Emerging cities and sustainable programme (IADB))*

Guidance:

- *Financing opportunities: programs for urban areas and sub-national entities (UN-Habitat)*

2.8 Education/training programmes on air pollution and health

Fundamental to the progress of AQMS is the education and training of people who are living with air pollution, and most directly impacted by it. This involves raising awareness about the impacts of air pollution on human health as well as empowering citizens to advocate for concrete actions by policy-makers and community members to reduce air pollution. Firstly, developing technical capacity for professionals to understand and act on air quality monitoring is critical. This includes not only the professional skills associated with AQMS, but also professional training for workers in other sectors, including those that generate air pollution, such as industry, transport, and energy, as well as environment and health agencies that manage its adverse impacts.

With regards to the health sector, WHO is currently developing training modules in air pollution and health. The modules aim to empower health workers to help their patients understand how air pollution exposures may be a risk factor for NCDs, to which they may be vulnerable, and then identify actions they can take to reduce their air pollution exposures *(43)*.

UNECE has recently launched an air quality training programme aimed at government, non-government and private sector professionals and academics, that aims to educate them about the CLRTAP protocols, as an international framework for cooperation on cleaner air, along with other measures for preventing air pollution *(44)*.

Education and awareness raising in the broader community

Open and transparent communication about not only the health impacts of air pollution, but also practical solutions, is critical to successfully engaging and energizing community and nongovernmental organizations. Awareness-raising campaigns and calls to action need to be planned and prioritized in a stepwise approach with clear targets building to an achievable goal – in a specific time frame. Examples include calls to halt waste burning around schools or businesses in designated neighborhoods; building pathways for more walking and cycling; or banning particularly polluting transport modes by a particular date. "Citizen scientists" including bike clubs or joggers can assist in monitoring air quality data. Even if such data is not derived from reference-grade monitors, it can be an important educational and awareness raising tool. The BreatheLife campaign, led by WHO with UNEP/CCAC offers dozens of examples of cities, regions and countries that have joined the campaign to take action on air pollution, in the context of awareness-raising.

An indicative list of training programmes and tools is cited below, with others noted in the online repository.

Training for specialists

- *WHO Academy (WHO)*
- *One UN Climate change learning partnership, UN CC: e-Learn (UNECE)*
- *World Bank Open Learning Campus (World Bank)*
- *E-Learning | UNEP Law and Environment Assistance Platform (UNEP)*
- *WMO Education and Training Programme (WMO)*

Awareness-raising and training for the broader community

- *BreatheLife campaign (WHO/UNEP/CCAC)*

SECTION 3

Case study: national air quality management system in Senegal

Dakar, the capital of Senegal, is a city of about 4 million people extending over 550 square kilometers, and home to more than 40% of the nation's urban dwellers. Dakar also is the base for 70% of the country's industries – all in an area occupying only 0.3% of Senegal's geographic space. Along with rapid population growth, the city has been forced to cope with spiraling pollution risks. Among those are diesel emissions from a fleet of 300,000 diesel vehicles, mostly used cars and trucks imported from abroad. Pollution from the burning of household waste as well as waste burning in open dumps is also a growing problem.

Even so, Dakar, and Senegal more widely, has been one of the leaders in Africa in air pollution legislation and monitoring. Air pollution has been regulated in Senegal since 2003 by the national Environmental Code (Standard NS-05-062), which was established to restrict industrial pollution emissions as well as controlling ambient air pollution concentrations more generally. The standard was revised in 2018. The revisions included a significant reduction in thresholds of ambient air pollution with respect to PM_{10} (annual mean of 40 μg/m^3)and $PM_{2.5}$ (annual mean of 25 μg/m^3 which is comparable to WHO interim target (IT2)) were introduced.

Leadership in air quality monitoring

Dakar was also one of the few cities in sub-Saharan Africa to regularly monitor air quality– about a decade after the publication of the 1999 World Bank report which estimated that the economic costs of air pollution in Dakar to exceed US$ 100 million *(46)*.

In 2009, the Senegalese government established an Air Quality Management Centre under the Environment Ministry. The five initial monitoring stations and a central laboratory were then established in 2009, financed by the Nordic Development Fund in collaboration with Senegal's Ministry of Transportation. Complementing this, the World Bank's Transport and Urban Mobility Support Project funded the establishment of one more station in 2017. The most recent station was established in 2021 in tandem with the establishment of a Bus Rapid Transit (BRT) project.

The Centre now oversees a network of seven stationary air quality monitoring stations in the Dakar metropolitan region: four alongside roads; one in the city's industrial zone; one peri-urban station; and one background station remote from traffic, industry and the city center.

A mobile monitoring station, housed in a truck, complements the network. (Fig. 12a). The stations are equipped with automatic ambient air analysers (gas and particles) to measure pollutants such as: NO_2, SO_2, O_3, CO, BTX (benzene, toluene, xylene), PM_{10} and $PM_{2.5}$.

Continuing challenges

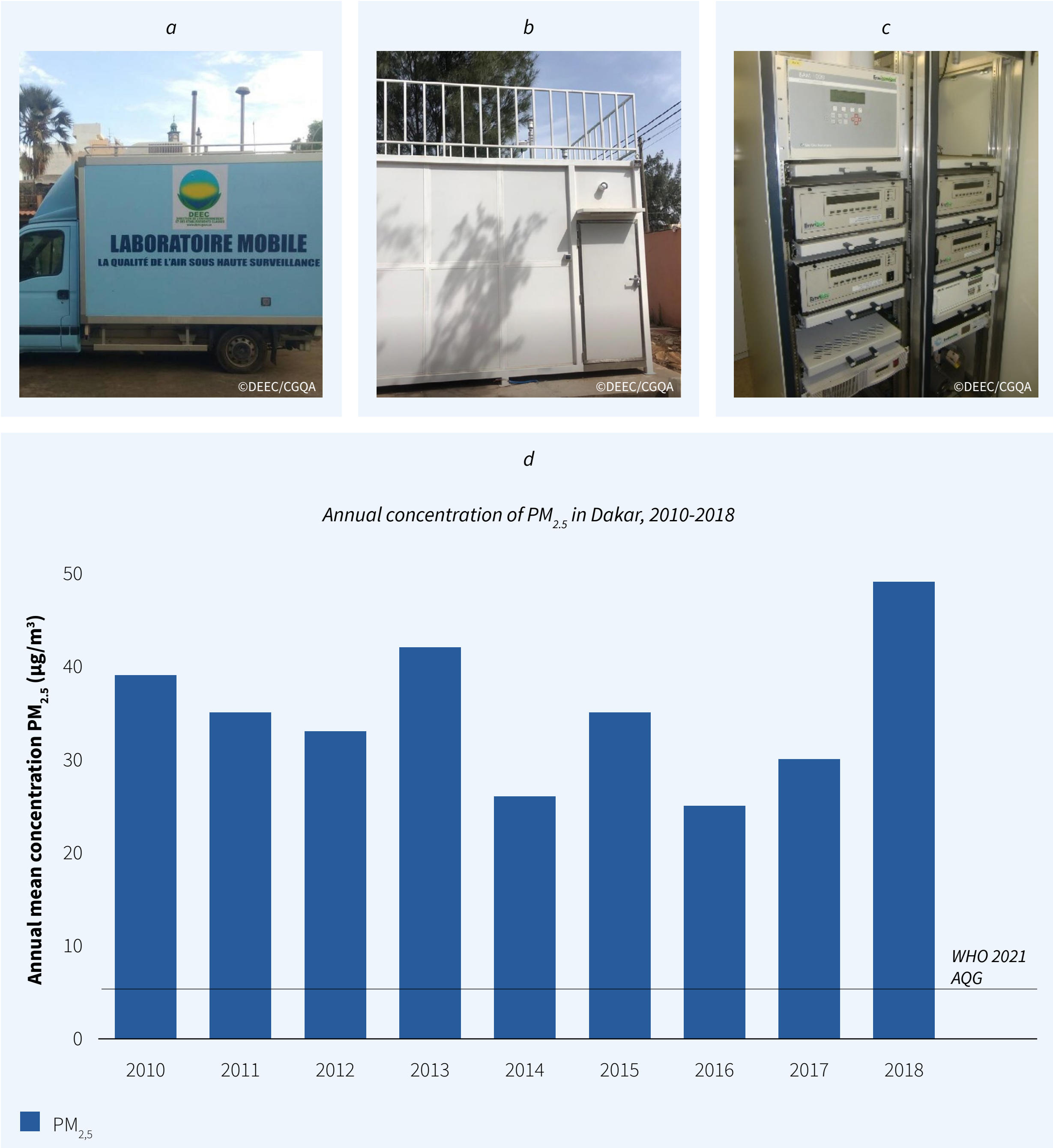
The establishment of the air quality monitoring system was a first step in addressing air pollution.

However, as recent data (Fig. 12d) indicates, pollution concentrations of $PM_{2.5}$ in fact rose very sharply between 2016-2018 – exceeding WHO guideline levels tenfold, and national limits by two-fold.

Furthermore, after more than 10 years of operation, the first five monitoring stations that were established are now malfunctioning and this has led to periods of data blackout or data losses over the last two years. To strengthen the air quality monitoring system, the Government's new Natural Resources Management Project, includes plans for rehabilitation of the air quality monitoring network and its expansion to other regions of the country.

Recent improvements to the AQMS have included the installation of ambient LCS to complement the fixed station network. Some 20 LCS units have recently been deployed in collaboration with UNEP as part of Dakar's pilot BRT project. The monitored pollutants are PM_{10}, $PM_{2.5}$, PM_1, CO, NO_2, O_3 and SO_2; temperature and relative humidity are also tracked. UNEP is currently procuring additional LCS for $PM_{2.5}$ to further support efforts to fill the measurement gap in Dakar. A more reliable and robust system should, in turn, pave the way for the development of better emission inventories and modelling which can improve air quality forecasting and scenario analysis of abatement strategies.

Fig. 12. **a) Mobile laboratory truck (top, left), b) Outside Pikine station (top, centre), c) Ambient air analysers (top, right) and d) Annual average concentrations of $PM_{2.5}$ in Dakar from 2010 to 2018 (bottom)**



Raising awareness

To improve public awareness about air quality, the use of electronic billboards to showcase pollution levels, along with periodic communications campaigns, are carried out. In addition, available air quality data is fed into an Air Quality Index (AQI), published and available online daily to inform the general public and decision-makers[4].

In the event of pollution peaks, which tend to occur in the dry season between mid-November and late June, health alerts and recommendations are developed and published in collaboration with health professionals. Air quality data is also summarized in national reports which can inform the effectiveness for abatement strategies and support epidemiological studies relating to respiratory and cardiovascular diseases.

The Senegalese experience illustrates how the implementation of an air quality monitoring system requires significant financial and human resources – not only in terms of capital investments but for ongoing maintenance and system improvements. Additionally, monitoring and reporting, while critical, are only the first steps. They need to be followed by abatement strategies that reduce air pollution exposures and health impacts. Tracking and reporting on health impacts from air pollution, both annually and during peak periods, can also be a significant contribution to awareness-raising and policy action. The overall aim should be increased consideration of the air quality dimensions of policies and projects relating to transport, industry, construction, etc. New large-scale infrastructure projects, should, in turn, not only respect air quality but should also contribute to the financing of improved monitoring capacity and its maintenance. Collaboration between ministries, local government and the private sector is thus critical to making AQMS meaningful and sustainable.

This case study was developed by Aminata Mbow Diokhané (Chief of Air Quality Management, Ministry of Environment, Senegal).

4. The AQI is also disseminated daily by email to recipients such as the health districts of the Dakar region.

SECTION 4

Conclusion

In many countries, air pollution is the most important environmental determinant of health; and it is responsible for about 6.7 million premature deaths every year.

The 2021 update of WHO AQG which were more stringent, showed that 99% of people worldwide were exposed to harmful levels of fine particulate matter. In 2021 WHO convened UN agencies in a working group to discuss the reporting criteria for SDG indicator 11.6.2 – air quality in cities – and support capacity building of Member States' air quality management capabilities. Critical to the SDG 11.6.2 reporting criteria is the availability of publicly accessible ground-level air pollution data from national or local government. Monitoring air pollution data not only enhances countries' ability to meet the SDG 11.6.2 reporting but it is also an inherent part of an AQMS.

This report leverages programmes and frameworks that already exist and provides direction to countries through air quality tools and guidance documents. Recognizing the interconnected domains within the AQMS, the report highlights the link between this management system and each of the eight domains: 1) setting the stage- scoping and stocktaking, 2) policies/standards/interventions, 3) measurement methods, 4) modelling methods, 5) health impact assessments, 6) economic impact assessments, 7) funding opportunities and 8) education/training programmes.

4.1 The way forward

At the foundation of an AQMS is the development and implementation of laws and standards to regulate and monitor air pollution, yet only two-thirds of the world have enacted air quality laws. Monitoring and achieving these standards require countries to consider the crosscutting nature of AQMS and develop plans and actions to address the individual yet interconnected components of the AQMS.

The importance of monitoring local air pollution cannot be overstated. But monitoring alone is only the first step in the ladder of AQMS actions allowing for a more meaningful level of intervention. Robust local data allows countries to monitor air quality baselines and trends, which is essential for air quality modelling and conducting health and economic assessments of air pollution, the burden of disease, and the impacts of potential interventions. Simultaneously such data allows for the development of real time air quality indices and near-term forecasts allowing for rapid public health response during air pollution peaks and emergencies. Each model plays a unique role in bolstering the AQMS with emission inventories or source apportionment models showing where air pollution originates, and air quality forecasting models informing what air pollution will look like in the future.

Core to building capacity for AQMS, is the availability of funding to support capital investments, as well as capacity building and ongoing maintenance. But due to the large scale of investments required, low-and-middle income countries frequently need to rely upon partnerships with multilateral agencies or bilateral donors for support.

While developing technical capacity for air quality monitoring is vital for AQMS, it is equally important to strengthen the knowledge and professional capacity of environmental and health workforces on actions one can take to reduce their air pollution exposures. Awareness raising also needs to increase the air quality literacy of the general public, and support mass movements for change.

For the advancement of the clean air agenda, it will be important to move from the qualitative target of SDG 11.6 ("By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.") to more quantitative targets for reducing air pollution.

Looking beyond 2030, the SDG 11.6.2 Working Group, together with UN agencies are discussing how they can support the attainment of the WHO AQG, including incorporation of more defined targets for meeting the guidelines in a post-2030 development agenda.

Going forward we must recognize that leveraging existing frameworks such as the SDGs and enhancing coordination among existing institutional players is the most efficient way to support countries in their battle against air pollution and its effects on health and ecosystems. Hopefully the guidance produced by this Working Group can bring us one step closer to safe and healthy air for all.

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Annex: summary of presentations and discussions

This annex provides the precise terms of reference for the interagency Working Group on SDG 11.6.2, as well as minutes of the meetings.

Working group on SDG 11.6.2: Terms of Reference

Background

In many countries, air pollution is the most important environmental determinant of health. The World Health Organization (WHO) estimates that about 7 million premature deaths are attributed annually to the effects of ambient and household air pollution and that over 90% of people worldwide are exposed to harmful levels of fine particulate matter. Evidence on the risks related to air pollution is a fundamental part of the assistance provided by WHO to enable its Member States to address environmental determinants of health.

As part of the World Health Assembly (WHA/68) resolution on "Health and the environment: addressing the health impact of air pollution" adopted in 2015[1], WHO, through its Department of Environment, Climate Change and Health, aims to address the urgent public health need to respond to the effects associated with air pollution. In addition, WHO has responsibility for stewarding three air pollution-related indicators for monitoring progress towards the Sustainable Development Goals (SDGs): in health (Goal 3) – mortality from air pollution, with SDG 3.9.1 –, in cities (Goal 11) – air quality levels in cities and communities, with SDG 11.6.2 – and in energy (Goal 7) – access to clean household energy, with SDG 7.1.2, a proxy indicator for household air pollution.

WHO has recently established the Global Air Pollution and Health Technical Advisory Group (GAPH-TAG)[2] to provide, among others, expert guidance on the data and methods used for SDG reporting on exposure and burden of disease from air pollution as well as on interventions and responses that the health sector can provide to protect health and reduce emissions.

In the last two years, in addition to the growing interest of Member States around SDGs indicators, there has also been an increasing demand to access available health evidence in an appropriate format, especially in low and middle-income countries. While WHO has leveraged the health argument within the energy sector[3] through its decades long work on household air pollution, related household energy databases and leadership in the SDG 7 (Energy) arena, the health sector has yet to take on an active role in discussions on ambient air pollution – beyond raising awareness. Elevating WHO's voice around the health aspects in SDG 11 (cities and communities) is a natural next step, especially in view of the release of the new WHO Air Quality Guidelines.

A wealth of processes, frameworks and programmes related to air pollution are already in place within the UN system, such as the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP)[4], the WMO Global Atmosphere Watch Programme[5], UNEP resolutions on air pollution[6] and the World Bank Pollution Management and Environmental Health Program[7].

Recognizing that interinstitutional work and cooperation across different UN agencies are crucial to effectively monitoring and reporting SDG 11.6.2 and addressing air pollution trajectories in the post 2030 era, WHO is convening key stakeholders from UN agencies involved in air pollution to discuss specific issues related to the indicator, its use and reporting by countries.

Purpose

The SDG framework is a key platform to build consensus among countries and leverage the results of discussions to take action. There is to date no such established group for SDG 11.6.2, neither at the UN inter-agency nor expert level.

The main objective of the Working Group SDG 11.6.2 (WG11.6.2) is to provide expert guidance on specific issues related to SDG 11.6.2 (i.e., Annual Mean Levels of Fine Particulate Matter ($PM_{2.5}$) in Urban Areas), its use and reporting by Member States.

While the SDG framework and related indicators is already in place and agreed upon by countries, the WG11.6.2 will explore the setting of baselines, targets and trajectories that are realistic and achievable. In doing so, the group will also address evolving challenges and emerging needs related to the reporting criteria to monitor country progress and future prospects.

This working group will also support the provision and use of tools and guidance documents needed by Member States to monitor their trajectories and meet targets for the SDG framework. In addition, WG11.6.2 will provide high level strategic thinking on what this indicator would look like in the post 2030 SDG era.

Roles and responsibilities

Within the activities on air pollution, and in particular the activities coordinated through the GAPH-TAG, WHO wants to maximize cross-team collaborations on the SDGs. Given this, it is important to specify the expected roles and responsibilities of each team within this framework.

UN agencies led activities with the support of GAPH-TAG:

- Consolidate UN guidance documents into a repository to complement the SDG 11.6.2 tool. The repository should serve as a one-stop shop that combines existing reports/ documents from multiple UN agencies such as existing air pollution databases from WHO, recommended monitoring methodologies for approved ($PM_{2.5}$) and potential future pollutants (e.g. nitrogen dioxide) from WMO, funding opportunities from World Bank, policy/intervention reports from UNEP and expertise in science-policy framework from the CLRTAP.
- Discuss how a post 2030 air pollution indicator would look like after incorporating lessons learnt from SDG 11.6.2 with beneficial components being integrated into the next indicator while unfavourable features being purposely omitted.

GAPH-TAG led activities with the support of UN agencies:

- Support on the integration of the new WHO AQG as a post-2030 target considering the baseline year, targets and trajectories for SDG 11.6.2 that will be examined by the GAPH-TAG. These targets will enable countries to evaluate the cost to benefit ratio of meeting these targets as well as inform the GPW13 Triple Billion Healthier Population estimates. See Appendix I for an example of the implementation of this objective.
- Refine air quality management tools (e.g., checklist, survey) to monitor country progress in collecting local air pollution data that could be incorporated into to the SDG 11.6.2 reporting. The checklist/ survey should provide best practices for monitoring fine particulate matter ($PM_{2.5}$) in "cities", "towns & semi-dense areas" and "rural areas". The survey should also include recommendations for collecting local air pollution data for countries with different technical capabilities (i.e., high vs low resolution monitoring), financial resources (i.e., funding opportunities for low vs high income countries) and diverse emission sources (i.e., anthropogenic vs natural).

Meeting 1: Finalizing the terms of reference

August 25, 2021 (virtual)

Agenda:

1. Opening and introduction to the objectives and members of the working group – Pierpaolo Mudu
2. Introduction to WHO activities on air pollution and health – Sophie Gumy
3. Updates from UN Agencies on activities related to air pollution – Soraya Smaoun (UNEP), Oksana Tarasova (WMO), Ernesto Sanchez-Triana and Yewande Aramide Awe (World Bank)
4. Presentation and discussion on the terms of reference for the working group – Kerolyn Shairsingh
5. Next steps for the working group – Kerolyn Shairsingh
6. Concluding remarks – Pierpaolo Mudu

Background

The global SDG indicator framework was adopted by the General Assembly on 6 July 2015 and is contained in the Resolution adopted by the General Assembly on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313). WHO is custodial agency for the three air-pollution-related indicators, among them SDG 11.6.2, 'Air quality in urban areas' (Tier 1). The indicator is currently reported on every 2–3 years, in the form of modelled estimates of population-weighted particulate matter ($PM_{2.5}$), based on input data from ground measurements and satellite data.

The meeting opened with a brief description of the purpose of the working group, followed by introductions from each participant. A high-level overview of WHO's role in the SDG 11.6.2 reporting mechanism was presented followed by brief updates on activities in each UN agency. Briefly, official SDG 11.6.2 reporting is conducted by the UN Statistics Division with technical support and mandatory country consultations coordinated by WHO. While the SDG 11.6.2 reporting criteria are being established there is a need to support Member States in developing their capacity to meet these criteria. To fill this gap, a working group for SDG 11.6.2 was established.

The specific objectives of this working group include:

- Supporting the development of baseline, targets and trajectories that can be used by Member States to monitor their progress in addressing air pollution and supporting the evaluation of costs and benefits of policies/ interventions.
- Developing checklists/surveys to promote the collection of local air pollution data that can be incorporated into SDG 11.6.2 reporting through systematic evaluation of key indicators required for air quality management systems.
- Creating a repository of guidance reports and/or documents related to policies/interventions, methodological options and funding opportunities to support capacity/capability for local monitoring of air pollution.

Discussion

Feedback provided after the presentation of the terms of reference revolved around the following:

- Clarification of the scope of the geographical scale being covered in the checklist and guidance reports (e.g. urban, rural, airshed level).
- Defining the specific pollutants that can be examined in the post-2030 era, in addition to $PM_{2.5}$, as this will influence the methodological reports included in the repository.
- Clarification of which emission sources (e.g. desert dust, transportation, agriculture) and related interventions will be considered in the repository of guidance reports.
- Emphasizing the role of the working group in promoting/ advocating the monitoring and collection of local data to validate satellite measurements which form the basis of SDG 11.6.2 estimates.
- Clearly defining how the checklist and guidance documents will be promoted to countries in order to enable capacity-building.
- Consideration of inviting members from UNCCD to be observers at future meetings.

Decisions / future directions

- Revise the terms of reference to include the degree of urbanization classification at either the first or second level.
- While only $PM_{2.5}$ will be examined within the scope of the SDG framework, NO_2 can be explored when considering air pollution indicators post-2030.
- UNEP, WMO and the World Bank have reports/ documents/ guidance on policies, standards, measurement guidelines and funding opportunities in the pipeline that will need to be considered.
- An email will shortly be sent to identify the date of the next meeting.

Meeting 2: Repository of UN guidance reports

December 6, 2021 (virtual)

Agenda:

1. Opening, welcome and update on recent activities – Sophie Gumy
2. Review of terms of reference – Kerolyn Shairsingh
3. Presentation and discussion on the Urban Health Initiative Air Quality Management (AQM) Survey – Pierpaolo Mudu
4. Discussion on the refinement of an AQM tool to integrate UN technical products to support country offices' technical requests – Kerolyn Shairsingh

Background

The global SDG indicator framework was adopted by the General Assembly on 6 July 2015 and is contained in the Resolution adopted by the General Assembly on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313). WHO is custodial agency for the three-air pollution-related indicators, among them SDG 11.6.2, 'Air quality in urban areas' (Tier 1). The indicator is currently reported on every 2–3 years, in the form of modelled estimates of population-weighted particulate matter ($PM_{2.5}$), on the basis of input data from ground measurements, chemical transport models and satellite data.

The meeting opened with a brief update on recent activities in WHO, followed by a description of the objectives for this working group as detailed in the terms of reference. A high-level overview of Urban Health Initiative's Air Quality Management (AQM) Survey was presented followed by open discussions on what guidance documents should be included in the repository and how the survey could be refined into a tool helping countries develop their capacity to monitor air pollution progress. Briefly, the AQM survey consists of four sections (measurement capacity, data assessment and availability, emission estimates and air quality management capability) which aim to assess policy, implementation and monitoring actions undertaken by countries. While the SDG 11.6.2 reporting criteria are being established there is a need to support Member States in developing their capacity to meet the criteria. We aim to fill this gap through the development of the repository of guidance documents and surveys/checklists.

Discussion

Feedback provided after the presentation of the Air Quality Management Survey revolved around the following:

- Clarification of the scope of pollutants to be included in the AQM tool and repository. While SDG11.6.2 focuses on particulate matter, guidance documents for the monitoring of specific aerosol chemical species could be included in the repository as a next step for countries that have the capacity/capability to enhance their air quality monitoring. It was also noted that WMO aerosol measurement guidelines are not classified by fine particulate but rather by physical and chemical properties (e.g. mass, size distribution).
- For the AQM tool, it would be good to tailor the technical guidance to a monitoring objective by integrating a decision tree into the tool to direct users to relevant guidance documents. Furthermore, many data have been collected but not accessed and they could be useful for some purposes but not others (e.g. health impact assessments (HIA) vs policies/interventions). For example, satellite data may not be good for HIA but useful for monitoring transboundary pollution transport. It may also be beneficial to include a checklist for clinicians by expanding that in Developing a clinical approach to air pollution and cardiovascular health by Michael B. Hadley, Jill Baumgartner and Rajesh Vedanthan. Another section of the survey could ask countries what technical support they need.
- It was pointed out that each country had its own monitoring and quality assurance methods and that it would be beneficial to develop a standardized method with a focus on monitoring for HIA. Countries would also benefit from monitoring guidance documents on how to access/use satellite data and low-cost sensors.
- Consideration needs to be given on how to deploy the tool and undertake capacity-building for the repository/ tools. It was suggested that once the tool has been developed it could be tested/piloted internally in UN agencies (e.g. WMO GAW, NCD risk unit). We could also have workshops within our departments. Capacity-building can also be implemented through the air pollution and health training modules that we are developing for health workers. We will examine the feasibility of adding the repository and tool to the metadata for SDG11.6.2 reporting but this will need approval from the UN Statistics Division.
- Upcoming initiatives that have similar objectives were discussed and should be kept in mind: PAHO is currently mapping technical tools and actors involved in monitoring SDG 11.6.2 and SDG 3.9.1, and UNEP is conducting an air quality guidance assessment which will be transformed into a digital platform, possibly in several languages.

Decisions / future directions

- The scope of the SDG framework is restricted to $PM_{2.5}$; however, guidance documents for specific aerosol chemical species can be included in the repository.
- A SharePoint folder will be shared with the WG to facilitate revision of the survey and uploading of guidance documents to the repository.
- An email will be sent out in early January to identify the date of the next meeting.

Meeting 3. Air quality management tools and potential baseline, targets and trajectories

April 1, 2022 (virtual)

Agenda:

1. Opening, welcome and update on recent activities – Sophie Gumy
2. Presentation of tools, surveys or checklist related to air pollution – UN Agencies
3. Discussion on UN tools and guidance documents to be included in repositories – Kerolyn Shairsingh
4. Summary of GAPH-TAG discussions on SDG 11.6.2 baseline years and targets – Jason West

Background

The global SDG indicator framework was adopted by the General Assembly on 6 July 2015 and is contained in the Resolution adopted by the General Assembly on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313). WHO is custodial agency for the three-air pollution-related indicators, among them SDG 11.6.2, ‘Air quality in urban areas’ (Tier 1). The indicator is currently reported every 2–3 years in the form of modelled estimates of population-weighted particulate matter ($PM_{2.5}$), on the basis of input data from ground measurements, chemical transport models and satellite data.

wality tools (Air Quality Management Screening tool, survey and decision tree) and guidance documents in the repositories. A high-level summary of the GAPH – TAG discussion on SDG

11.6.2 baseline years and targets were presented. Briefly, for the baseline year, a three-year average was proposed in lieu of a single year to account for different national standards and in- terannual variability due to meteorology. For the target, a per- cent reduction per year was proposed, the percentage varying in accordance with the country baseline air quality in relation to the AQG and interim targets. Additional discussions will be held in the GAPH-TAG Exposure Assessment Expert Working Group to specify target percentages and baseline years.

Discussion
Feedback provided after presentation of the current air quality tools guidance documents in the repositories revolved around the following:

- For the AQM Screening Tool, it was suggested that the nomenclature for the monitoring station should be adaptable for low- and middle-income countries. It may be beneficial to develop a decision tree tool for classifying stations. This standardized approach may be able to leverage existing guidance documents within the WMO GAFIS framework.
- It was pointed out that countries may be able to access data from reference monitors managed by external agencies, governments or universities, and that these data should be acknowledged in the Screening Tool. It may be beneficial to include a question that differentiates data availability by national vs international air quality managers.
- It was also suggested that the Screening Tool include a question covering the importance of having long-term measurements, i.e., beyond one year. It may be beneficial to incorporate the question from the AQM Survey examining the availability of data for at least five years.
- Consideration should be given as to how a country's progress be assessed relative to its baseline year if a three-year average is used. It may be necessary to use a rolling average for future assessments.

Upcoming initiatives with similar objectives were mentioned and should be kept in mind: UNECE, in collaboration with the UK and Sweden, has established a Task Force for International Cooperation on Air Pollution; UNEP, in collaboration with CAF, is undertaking a qualitative research initiative aimed at understanding gaps in AQM systems.

Decisions / future directions
- The current AQM tools will be revised with the incorporation of new tools.
- The repositories for the guidance documents will be updated on the basis of UN presentations.

- These repositories will be reshared with members for input in late April.
- A draft of the final report will be shared in mid-June for members' feedback.

Meeting 4. Finalizing the SDG11.6.2 report

August 3. 2022 (virtual)

Agenda
1. Opening, welcome and update on recent activities – Sophie Gumy
2. Presentation of the summary report for SDG 11.6.2 – Kerolyn Shairsingh
3. Discussion on report content and repository of tools and guidance documents – Kerolyn Shairsingh
4. Concluding remarks and next steps for the report launch – Sophie Gumy

Background
The global SDG indicator framework was adopted by the General Assembly on 6 July 2017 and is contained in the Resolution adopted by the General Assembly on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313). WHO is custodial agency for the three air-pollution-related indicators, among them SDG 11.6.2, 'Air quality in urban areas' (Tier 1). The indicator is currently reported every 2–3 years, in the form of modelled estimates of population-weighted particulate matter ($PM_{2.5}$), on the basis of input data from ground measurements, chemical transport models and satellite data.

The meeting opened with a brief update on air pollution activities in progress at WHO: the continuation of country consultations and the UNSD release of SDG estimates (fine particulate matter levels in cities – 11.6.2, and mortality attributed to air pollution – 3.9.1). The final report was then presented to the group with a high-level summary for each of the seven domains covered, and members were invited to comment on the content and the tools and guidance documents that have been added to the repository. This was followed by a brief overview of the case study developed for Senegal's national air quality management system.

Discussion
Feedback provided after the presentation of the final report revolved around the following:

- For the measurement domain, additional information and documents will be provided by WMO to guide the development and implementation of air quality monitoring stations.
- For the funding opportunities domain, it was pointed out that the costing of the equipment seemed low. Additional documentation for reference grade equipment will be provided by the World Bank, which also encompasses the

full life-cycle cost associated with installing and maintaining reference grade equipment. Several other funding agencies were also identified by members, e.g. the Asian Development Bank, the Inter-American Development Bank and USAID. UNEP and the World Bank have indicated that they will add more resources to the funding opportunities section.

- For educational/training programmes, several members indicated additional resources that offer online training in air quality management, e.g. the World Resource Institute, USEPA, the Health Effect Institute, the Clean Cooking Alliance and the Environmental Defence Fund. Additional content and documentation will be added to the report by the institutions present.

Decisions / future directions

- The revised final report will be shared with members for input before going to the editor in early August
- Members agreed that there should be future periodic meetings of the UN agencies.

Air Quality and Health Unit
World Health Organization
20 Avenue Appia
1211 Geneva 27
Switzerland

https://www.who.int/teams/environment-climate-change-and-health/air-quality-and-health

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