PMEH

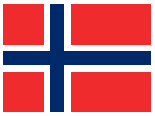
POLLUTION MANAGEMENT & ENVIRONMENTAL HEALTH

WORLD BANK GROUP

POLLUTION MANAGEMENT AND ENVIRONMENTAL HEALTH

2019 ANNUAL REPORT

The Pollution Management and Environmental Health (PMEH) multidonor partnership, established in 2014 and administered by the World Bank, supports countries in managing air quality and toxic sites and generates cutting-edge knowledge and guidance to reduce pollution for public health, poverty reduction, economic growth, and environmental and climate co-benefits.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2019 ANNUAL REPORT

Pollution Management and Environmental Health (PMEH),
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All dollar amounts are in US dollars ($) unless otherwise indicated.

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ACRONYMS

AOD	Aerosol Optical Depth
AQM	Air-Quality Management
ASGM	Artisanal Small-Scale Gold Mining
EPA Ghana	Ghana Environmental Protection Agency
GAINS	Greenhouse gas–Air pollution Interactions and Synergies
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	German Corporation for International Cooperation
Jing-Jin-Ji Region	National Capital Region of the People's Republic of China including Beijing-Tianjin-Hebei
LEAP-IBC	Long-range Energy Alternatives Planning system – Integrated Benefits Calculator
LMICs	Low- and Middle-Income Countries
NAPCC	(India) National Action Plan on Climate Change
NCAP	(India) National Clean Air Programme
OECD Countries	Member Countries of the Organisation for Economic Co-operation and Development
PMEH	Pollution Management and Environmental Health
$PM_{2.5}$	Particulate Matter Pollution Particles with a Diameter of 2.5 Micrometers or Less
PM_{10}	Particulate Matter Pollution Particles with a Diameter of 10 Micrometers or Less
SLCP	Short-Lived Climate Pollutants
TSIP	Toxic-Sites Identification Program
WHO	World Health Organization

OVERVIEW

Over the past half-century, industrialization and rapid urbanization in low- and middle-income countries (LMICs) has dramatically increased pollution. Higher levels of pollution, in turn, increase inequality and impede economic development. Pollution is the largest environmental cause of disease and premature death in the world. Land, air, and water pollution together are responsible for the deaths of more than 10 million people per year and 92 percent of the pollution-related deaths are in LMICs, with children among those at the greatest risk (Landrigan et al. 2018).

In recent years, policy leaders have increasingly recognized that tackling pollution is a priority issue to improve livelihoods and reduce premature deaths. However, tackling this global challenge requires a thorough understanding of current pollution levels in a given region, the sources that contribute to that pollution, and economically effective policies to reduce pollution. Achieving globally standardized methods to measure, monitor, and mitigate pollution is pivotal to transforming government policies and ultimately changing individual behavior.

The Pollution Management and Environmental Health (PMEH) multi-donor partnership was established in 2014 to support World Bank client countries in reducing pollution through technical assistance, analytical work, and knowledge management. Through this work, the PMEH program is protecting public health, reducing poverty, boosting shared prosperity, and promoting climate co-benefits. The program aims to achieve three main objectives:

1. ***Strengthened Air-Quality Management*** Support LMICs to strengthen air-quality management and mitigate climate change.
2. ***Strengthened Analytics*** Build the evidence base for improving pollution management and environmental health by increasing stakeholders' understanding of the linkages between pollution, public health, economic productivity, and pollution's associated costs in LMICs.

3. ***Communications and Knowledge Management*** Disseminate knowledge and promote awareness of pollution management and environmental health issues among policy leaders, business partners, city leaders, and the general public.

The objectives of the PMEH program are consistent with the following Sustainable Development Goals and targets:

- ***(SDG 3) 3.9*** Substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination.
- ***(SDG 6) 6.3*** Improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and increasing recycling and safe reuse globally.
- ***(SDG11) 11.6*** Reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.
- ***(SDG12) 12.4*** Achieve environmentally sound management of chemicals and all wastes throughout their lifecycle in accordance with agreed international frameworks and significantly reduce their release to air, water, and soil in order to minimize their adverse impacts on human health and the environment.
- ***(SDG 13) 13.2*** Integrate climate-change measures into national policies, strategies, and planning.

PROGRAM HIGHLIGHTS

STRENGTHENED AIR-QUALITY MANAGEMENT

The PMEH program is supporting the planning of air-quality management (AQM) in cities and urban centers in seven countries: China, Egypt, Ghana, India, Nigeria, South Africa, and Vietnam. Following are highlights of key accomplishments to date from this work:

COUNTRY HIGHLIGHTS

- **CHINA** A combination of PMEH analytical work and World Bank Program-for-Results financing[1] supports the AQM program in Hebei. Through this combined effort, the government's AQM program has resulted in reductions of fine and ultrafine particulate matter pollution by more than 40 percent in the Jing-Jin-Ji region over the past five years. To improve the analytical capacity of the Chinese government, extensive technical training was completed for 780 researchers and government staff. Building on the successful efforts in the Jing-Jin-Ji region, support for cost-effective AQM interventions is being extended within 26 prefectures and two cities.

- **EGYPT** Three reports[2] on air pollution and motor-vehicle density, the health impacts of air pollution, and the cost of environmental degradation have been instrumental in accelerating AQM planning for the Egyptian government. Hard data and dialogue underpinned by PMEH analytical work provided the evidence base for the Ministry of Investment and International Cooperation to take important steps to strengthen AQM planning. PMEH analytical work demonstrated that millions of dollars in annual benefits could be realized through reduced air pollution and emphasized the importance of comprehensive planning. As a result of this PMEH analytical work, the Ministry of Investment and International Cooperation requested World Bank support to prepare an investment operation to scale up AQM planning for the Greater Cairo area.

- **GHANA** In Accra, PMEH assistance transitioned from a supporting role in coordination with other international partners to a leading role in steering a consortium of local and international organizations and experts assisting the Ghana Environmental Protection Agency to complete an update of the Greater Accra AQM plan.

- **INDIA** With PMEH support, India launched the National Clean Air Programme in 2019. This program aims to reduce air pollution by 20 to 30 percent across the country by 2024. In 2019, PMEH started working in the states of Bihar (Patna) and West Bengal (Kolkata City) to support the preparation of state-level AQM plans and strengthen the capacity of relevant institutions for planning and implementation. Technical workshops were organized that brought together environmental regulators, industry leaders, and academia from partner states. PMEH also convened high-level dialogues and established a roundtable process with policy thought leaders on the institutional reforms needed to scale and sustain India's air-quality improvements.

- **NIGERIA** PMEH supported publication of the report *The Cost of Air Pollution in Lagos State*. That cost was estimated to be $2.1 billion (Croitoru, Chang, and Kelly 2019). In addition, preliminary air-quality monitoring has commenced in Lagos and monitoring sites have been selected that will be used for establishing an air-quality baseline in the city and source-apportionment studies. Emissions inventory development, which will soon be initiated, will also support AQM planning for Lagos.

- **SOUTH AFRICA** Extensive meetings and workshops in Johannesburg led to agreements with the government on the scope of cost-effectiveness and source-apportionment studies that will include the procurement of equipment and a health-data review to be commissioned in 2020.

- **VIETNAM** The Vietnam AQM GAINS model has been developed and fully integrates climate co-benefits. With PMEH support, government counterparts at national and local levels are in the process of verifying and validating emissions-inventory data. Air-quality monitoring to support source-apportionment analysis started in August 2019 and will allow for a full year of monitoring of air pollutants in the larger Hanoi area. Monitoring will capture seasonal air-quality trends and provide the basis for source-apportionment

modelling. This evidence-based approach will help identify the most cost-effective policy options to help the city reach air-quality targets.

STRENGTHENED ANALYTICS

AIR-QUALITY MANAGEMENT

AQM analytical efforts focus on improving air-quality monitoring and estimating the health effects of ambient or outdoor air pollution in LMICs. A groundbreaking analysis on the cost of ambient air pollution estimated that globally, the health consequences of air-pollution exposure cost as much as $5.7 trillion in 2016. Findings from this analytical work have also provided guidance for addressing data gaps in air-quality monitoring[3] and demonstrated significant limitations associated with the use of satellite-based air-quality measurements in low- and middle-income countries.[4] A report that assessed the methodology of the Global Burden of Disease study revealed that air-pollution estimates for many LMICs are unreliable due to weak or absent ground-level air-quality monitors in these countries (Ostro et al. 2018).[5] Two reports were completed that examined the health effects of natural dust and of different chemical constituents of particulate-matter ($PM_{2.5}$) air pollution as well as of $PM_{2.5}$ from different sources. Findings also demonstrate that trace constituents of $PM_{2.5}$ and mass $PM_{2.5}$ from fossil-fuel combustion sources, notably coal-burning and diesel-fueled vehicles, are among the greatest contributors to toxicity of $PM_{2.5}$ air pollution. These outcomes have major implications for future mitigation efforts that prioritize the regulation of coal-fired power plants and diesel-fueled traffic in LMICs.

TOXIC SITES

Analytical work on land-based pollution is focused on assessing the impacts of toxic sites on human health and the economy in LMICs. Funding from PMEH was instrumental in the development of the first global Toxic-Sites Identification Program database. Two previously completed baseline reports on toxic sites in Bangladesh and Tanzania identify industrial and informal pollution sources, highlight information gaps, and provide recommendations to improve the government's capacity to effectively control pollution. In addition, three guidance manuals were produced that establish strategies for assessing exposure and health outcomes at contaminated sites in LMICs, including tanneries, gold mining, and lead-acid battery-recycling factories.

Several papers on land-based pollution were completed and will be submitted to peer-reviewed journals in 2020. One of them raises awareness about knowledge gaps in estimating public-health impacts from land-based pollution. Other papers provide evidence-based guidelines for sampling ULAB, ASGM, and other toxic contaminated sites and for appraising health impacts from exposure to land-based pollution.

POLLUTION MANAGEMENT AND CITY COMPETITIVENESS

PMEH is working to better understand the linkages between pollution management and the prosperity of cities. To this end, PMEH analytics at the global, regional, and local levels have produced multiple reports to establish these linkages. Findings from these reports have demonstrated that pollution increases inequality and has a negative impact on the health and development of a city's human capital, city growth, employment growth, and worker productivity.

Regional analytics indicate that pollution also has a negative impact on the performance of African businesses. Deep-dive assessments were completed in four cities in Bangladesh, Liberia, Tanzania, and Uganda. Information from these assessments is being used to inform urban planning programs in each city. Finally, a toolkit was completed that highlights the best practices of pollution management in highly competitive cities.

COMMUNICATIONS AND KNOWLEDGE MANAGEMENT

In 2019, knowledge, learning, and results from PMEH analytical work were shared both locally and internationally. A global exchange workshop took place in November 2019 in Rhein, Germany, to share experiences and best practices from AQM programs. In October 2019, international experts from six countries gathered for a workshop in Washington, DC, aimed at strengthening the capacity of officials of the government of India to reach the AQM goals that were set in the country's National Clean Air Programme.

Participants at the October 2019 Washington, DC, workshop shared their experiences on how their respective countries tackle air pollution. Finally, workshops were organized in Kampala, Uganda, to share results of the completed city-competitiveness reports. Key recommendations from these reports are helping to inform the strategic urban plan for the city to better manage pollution.

NOTES

1. Program for Results (PforR) is a World Bank financing instrument that uses a country's own institutions and processes, linking disbursement of funds directly to the achievement of specific program results. PforR supports government programs and helps leverage World Bank development assistance by fostering partnerships and aligning development partners' goals and results that can lead to greater development effectiveness. For more information, see https://www.worldbank.org/en/programs/program-for-results-financing.

2. See: Heger, Martin, David J. Wheeler, and Craig M. Meisner. 2019. *Motor Vehicle Density and Air Pollution in Greater Cairo: Fuel Subsidy Removal & Metro Line Extension and their Effect on Congestion and Pollution*. Washington, DC: World Bank Group. http://documents. See also Larsen, Bjorn. 2019. *Arab Republic of Egypt: Cost of Environmental Degradation –*

Air and Water Pollution. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/32513

3. See: Pinder, Robert W., Jacqueline M. Klopp, Gary Kleiman, Gayle S. W. Hagler, Yewande Awe, and Sara Terry. 2019. "Opportunities and Challenges for Filling the Air Quality Data Gap in Low- and Middle-Income Countries." *Atmospheric Environment* 215: 116794. https://doi.org/10.1016/j.atmosenv.2019.06.032.

4. See: Alvarado, Matthew J., Amy E. Mcvey, Jennifer D. Hegarty, Eben S. Cross, Christa A. Hasenkopf, Richard Lynch, Edward J. Kennelly, Timothy B. Onasch, Yewande Awe, Ernesto Sánchez-Triana, and Gary Kleiman. 2019. "Evaluating the Use of Satellite Observations to Supplement Ground-Level Air Quality Data in Selected Cities in Low- and Middle-Income Countries." *Atmospheric Environment* 218: 117016. DOI: 10.1016/j.atmosenv.2019.117016

5. See: Ostro, Bart, Joseph V. Spadaro, Sophie Gumy, Pierpaolo Mudu, Yewande Awe, Francesco Forastiere, and Annette Peters. 2018. "Assessing the Recent Estimates of the Global Burden of Disease for Ambient Air Pollution: Methodological Changes and Implications for Low- and Middle-Income Countries." *Environmental Research* 166: 713–25.

REFERENCES

Croitoru, Lelia, Jiyoun Christina Chang, and Andrew Kelly. 2019. *The Cost of Air Pollution in Lagos* (English). Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/980031575616020127/The-Cost-of-Air-Pollution-in-Lagos.

Landrigan, Philip J., Richard Fuller, Nereus J. R. Acosta, Olusoji Adeyi, Robert Arnold, Niladri (Nil) Basu, Abdoulaye Bibi Baldé, Roberto Bertollini, Stephan Bose-O'Reilly, Jo I. Boufford, Patrick N. Breysse, Thomas Chiles, Chulabhorn Mahidol, Awa M. Coll-Seck, Maureen L. Cropper, Julius Fobil, Valentin Fuster, Michael Greenstone, Andy Haines, David Hanrahan, David Hunter, Mukesh Khare, Alan Krupnick, Bruce Lanphear, Bindu Lohani, Keith Martin, Karen V. Mathiasen, Maureen A. McTeer, Christopher J. L. Murray, Johanita D. Ndahimananjara, Frederica Perera, Janez Potočnik, Alexander S. Preker, Jairam Ramesh, Johan Rockström, Carlos Salinas, Leona D. Samson, Karti Sandilya, Peter D. Sly, Kirk R. Smith, Achim Steiner, Richard B. Stewart, William A. Suk, Onno C. P. van Schayck, Gautam N. Yadama, Kandeh Yumkella, and Ma Zhong. 2018. "The Lancet Commission on Pollution and Health." *Lancet* 391 (10119): 462–512. https://doi.org/10.1016/s0140-6736(17)32345-0.

“The World Bank support has been important to help us activate the Knowledge Network this year. The international perspectives brought into discussions are helping to accelerate learning and build confidence for the airshed-based approach we need to take to improve air quality throughout India.”

Prof. S. N. Tripathi, Professor and Head, Department of Civil Engineering, Indian Institute of Technology, Kanpur, and National Nodal Faculty of the NCAP Knowledge Network.

STRENGTHENED AIR-QUALITY MANAGEMENT

SECTION OVERVIEW

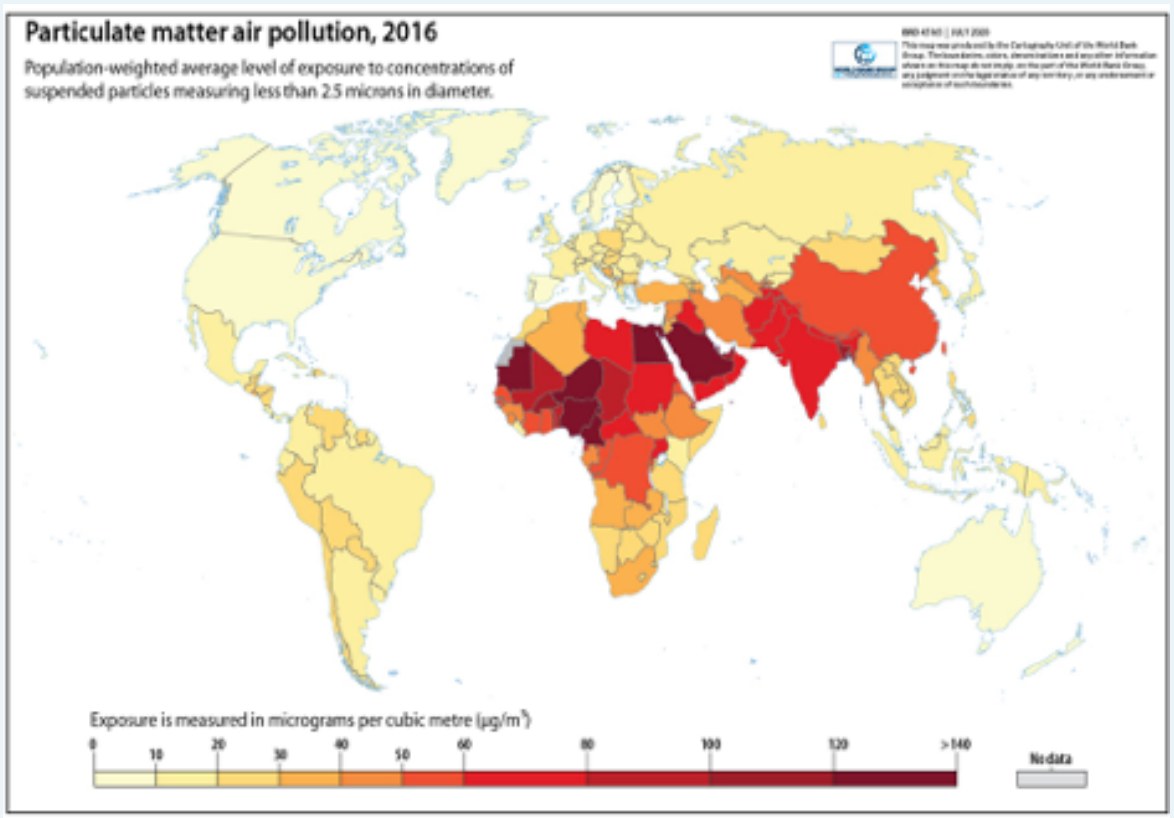
2019 marked a year of breakthroughs for PMEH, with PMEH program activities contributing to reductions of air pollution, resulting in regional investments in air-quality management, and an expansion of program activities across partner countries. In China, PMEH support contributed to the reduction of outdoor concentrations of $PM_{2.5}$ air pollution by more than 40 percent in the targeted region—an outcome demonstrating that large-scale impacts can be realized in a short timeframe with focused and aggressive air-quality management efforts. Secondly, in many countries, there is a new, palpable level of ownership as local governments are empowered and emboldened by the new information that they have on key sources of air pollution and cost-effective abatement interventions. In Egypt, PMEH analytical work provided a compelling rationale to prioritize air-quality management and further strengthen action to reduce air pollution. Government support for AQM planning in India has led to the launch of the National Clean Air Programme.

In addition, many countries have expressed that PMEH's analytical support allowed officials in the ministries to take initiative and engage more meaningfully in discussions on air-quality management in technical and policy forums. These outcomes demonstrate that PMEH analytical work empowers local governments to make evidence-based decisions that improve the quality of life of their citizens. Finally, successful technical assistance and capacity building have led to the regional expansion of activities to manage air quality: China is replicating AQM interventions within 26 prefectures and two cities. In India, initial work in Delhi is expanding to multiple states across the country to reduce air pollution across the Indo-Gangetic Plain. Expanded interventions mean that more people will benefit from PMEH support of AQM efforts and that countries have a greater local capacity to reduce air pollution affecting their citizens.

INTRODUCTION

As the world's single largest environmental health risk, air pollution—specifically $PM_{2.5}$—has been linked to numerous diseases including asthma, heart attacks, strokes, lung cancer, and other lung diseases, among other diseases (WHO 2018). The most-vulnerable populations affected by adverse health consequences of chronic exposure to air pollution are children, pregnant women, and the elderly (WHO 2019). In children, air pollution leads to lower birth weight, lowered immunity, impaired lung capacity, delayed development, and reduced intelligence (Kurt et al. 2016), making for a difficult start to life. Because of these health risks, the World Health Organization (WHO) has developed international air-quality guidelines to provide guidance on threshold limits for key air pollutants that pose health risks. However, social inequalities exist within and between countries with regard to air-pollution exposure. These inequalities mean that the poorest populations in LMICs are the most negatively affected by air pollution (see figure 1). LMICs can experience levels of air-pollution exposure that are 4–5 times higher than in high-income countries.[1] Furthermore, while the percentage of people living in low-pollution areas slightly increased in 2017, the percentage of people living in highly polluted areas—the majority in LMICs—remained the same.

FIGURE 1 MAP OF EXPOSURE TO PARTICULATE MATTER AIR POLLUTION ($PM_{2.5}$) ACROSS THE GLOBE



Source: Our World in Data. Data based on World Bank Development Indicators 2019.[2]

Air pollution not only causes illness and premature death but also presents an obstacle to sustainable development. Reducing deaths related to air pollution is recognized as a key target in the Sustainable Development Goals. The health impacts of air pollution on a population have a direct effect on the economy. Illness from air pollution limits worker productivity and increases the healthcare expenses of today's and future generations. Based on PMEH analytical work, the estimated cost of health damages associated with ambient $PM_{2.5}$ air pollution in 2016 was $5.7 trillion or 4.8 percent of GDP (World Bank, forthcoming). Poor air quality not only affects the health of people and the economy, but also the environment. Since air pollution is a major contributor to climate change, improving air quality provides co-benefits for the climate, ecosystem, and biodiversity (Thurston and Bell 2014). Thus, taking action to improve air pollution also creates beneficial social, economic, health, and environmental impacts.

To respond to the international call for action to reduce air pollution, the WHO set the aspirational goal to reduce air pollution by two-thirds by 2030. However, achieving these targets requires strong analytical underpinnings. Countries need to be able to design and implement data-driven air-quality management plans that include ground-level air-quality monitoring, a thorough knowledge of air-pollution sources, and identification of cost-effective policies and investments to reduce air pollution.

Governments have increasingly recognized the importance of reducing air pollution, and many have set targets related to air-quality management. PMEH supports LMICs to strengthen AQM planning and reduce air pollution by providing technical assistance to countries that are at different stages of designing their own AQM plans. Initial efforts have focused on identifying gaps in cost-effective implementation plans and building local capacity to manage air pollution. The aim of this technical support is to move countries towards local ownership of scalable and evidence-based AQM plans that will effectively reduce air pollution. To this end, there are two overarching goals of the PMEH AQM program:

PMEH AQM program's overarching goal (1): Develop evidence-based air-quality management plans

PMEH focuses on strengthening the capacity of selected countries to reduce air pollution through the development of evidence-based AQM plans. PMEH support enables countries to identify cost-effective strategies to reduce illness and premature deaths from air pollution. To achieve this goal, PMEH has approached AQM plan development with the following elements:

- **AIR-QUALITY MONITORING** The systematic and long-term assessment of air-pollution levels by ground-level measurements of the quantity and types of certain pollutants in ambient air.
- **AIR-EMISSIONS INVENTORY** The estimates of emissions from various pollution sources, which can help to target regulatory actions to reduce air pollution.
- **SOURCE-APPORTIONMENT ANALYSIS** The identification of key sources that contribute to ambient air pollution concentrations. This process influences the design of control strategies, creates options to address those sources, and enables a cost-benefit analysis of those options.

- **HEALTH-IMPACT ASSESSMENT** A review of the health implications of air pollution and the likely prospects of improving health outcomes by adopting certain measures. The health-impact assessment uses local data that translate air-quality improvements into anticipated public-health benefits and is important for public policy.
- **INTERACTIONS BETWEEN AQM AND SHORT-LIVED CLIMATE POLLUTANTS AND GREENHOUSE GASES** The identification of the portion of fine-particulate pollution that is black carbon versus organic carbon. This analysis also identifies source categories that are principally responsible for black-carbon emissions so that these pollutants can be appropriately prioritized as part of a cost-benefit analysis. This is a key step in reducing short-term climate pollutants and greenhouse gases.
- **COST-BENEFIT ANALYSIS** This analysis considers the costs of options for abating air pollution and the multiple benefits of reducing air pollution (for example, public health, food and energy security, and climate co-benefits, as well as economic benefits). A cost-benefit analysis is central for informing decision-making and selection of any regulatory controls or standards that can improve air quality.
- **STAKEHOLDER ENGAGMENT** Trainings, workshops, and knowledge-exchange meetings to build local capacity and ensure universal alignment of planned priorities.

PMEH AQM program's overarching goal (2): Reduce short-term climate pollutants and levels of greenhouse gases

PMEH is helping to raise the profile of the co-benefits of reducing climate pollutants in the AQM planning process. Many air pollutants with negative health impacts share common sources with greenhouse gases and short-lived climate pollutants. Thus, solutions to improve air quality can lead to the reduction of climate pollutants including greenhouse gas emissions and short-lived climate pollutants. Such solutions create co-benefits between AQM planning and commitments pledged by countries under the Paris Agreement in 2015. The PMEH program supports policy leaders in making an explicit link between air pollution, public health, and climate-change mitigation.

COUNTRY UPDATES

The scope of PMEH activities includes analytical work to collect and process air-quality data as well as source-apportionment studies to identify pollution sources and their relative contributions to pollution concentrations. Activities also include health-impact assessments, cost-effectiveness evaluations, and stakeholder analyses to develop evidence-based AQM plans. This section highlights the progress that has been made in establishing AQM plans in selected cities in China, Egypt, Ghana, India, Nigeria, South Africa, and Vietnam.

CHINA

As a heavy industrial zone, Beijing and its surrounding Jing-Jin-Ji region have experienced significant air-pollution levels. In 2013, air-pollution levels were ten times higher than the WHO air-quality guideline values. As a result, the government made the decision to achieve the target of reducing $PM_{2.5}$ by 25 percent in the region. Over the past few years, the government has initiated efforts to reduce air pollution in the region to a target of 25 percent. However, in 2015, the Chinese government recognized a major gap in AQM knowledge that was preventing achievement of this target. The government reached out to the World Bank for assistance, seeking international knowledge to strengthen AQM policy implementation. PMEH also assisted the government with analytical work and regional coordination to strengthen AQM policies and enforcement capacity. The PMEH program is working in partnership with the Ministry of Ecology and Environment, and is regionally focused on the cities of Beijing, Tianjin, Hebei, and surrounding provinces (the expanded Jing-Jin-Ji metropolitan region, the national capital region of China).

Analytical and technical support from PMEH has been pivotal in developing a large-scale program that received loan funding from the World Bank. PMEH facilitated technical dialogues and analytics at the national level. It also engaged the Hebei province as a pioneer to upgrade its emissions inventory and adopt an internationally approved methodology for cost-effectiveness analysis. This work has enhanced the application of nine Chinese technical guidelines for emissions inventories by integrating international good practices. PMEH has also helped to strengthen local capacity by providing training for local technical teams and conducting a cost-effectiveness analysis for future policy work. PMEH supported a knowledge exchange and developed and piloted ultra-low emissions standards for industrial pollutants in the iron and steel sector in Hebei. These efforts led to nationwide adoption in 2019.

In 2019, PMEH support to China has continued to target knowledge gaps, particularly cost-effective interventions and the identification of policy recommendations for AQM planning. In December 2019, Hebei Province became the first province to issue policy guidance based on a cost-effectiveness analysis for the 2021–2025 AQM plan. These guidelines were built upon technical assistance provided by PMEH and Global Environment Facility grant funding. Local capacity building enabled over 130 central and regional-level senior government officials to participate in a study tour and focused workshops. In addition, 780 staff, consisting of 300 researchers and 480 enforcement officers in Hebei, received technical training on environmental monitoring and enforcement.

While China has made noteworthy progress, work remains to be done. The current levels of air pollution in the Jing-Jin-Ji region are still over 1.7 times higher than WHO's least-stringent recommended air-quality levels. PMEH will continue to provide analytics, training, and support for scaling up programs in other regions. Mechanisms are now in place to generate reports on the emissions situations of Beijing, Tianjin, and 26 other cities in Hebei, Shanxi, and Henan provinces. Scenario analysis using the GAINS model is also underway. This analysis will result in a report on the co-benefit and health-impact assessments of the latest air-quality action plan.

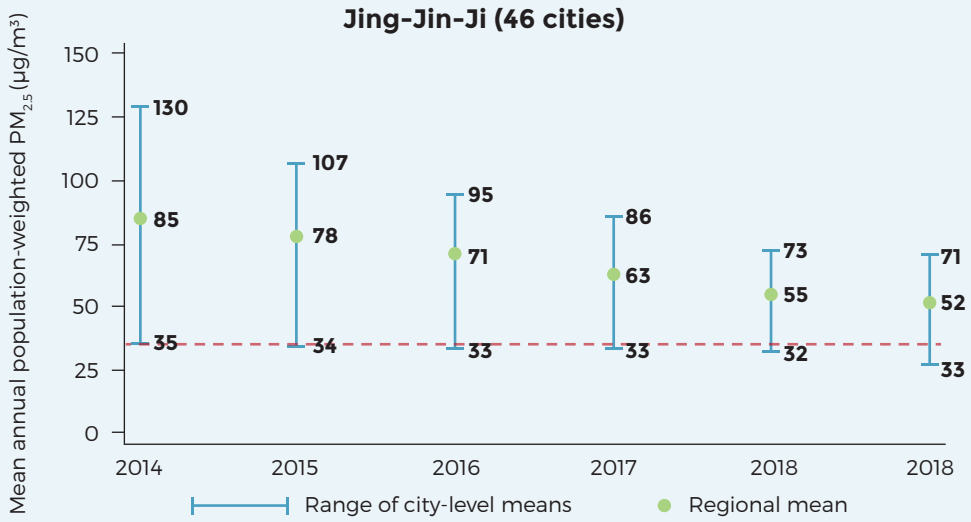
Finally, policy recommendations are being prepared for the regional AQM plan and the 14th Five-Year Plan.

Achieving the interim success in the Jing-Jin-Ji region has required vast investments. It is increasingly challenging and more costly to sustain results and further close the gap to meet national air-quality standards. As a next step, PMEH work will conduct a cost-effective analysis of AQM interventions with enhanced granularity at the city-level (26 prefectures and 2 cities). The outputs of this analytical work will inform the upcoming Jing-Jin-Ji 2021–2025 air-quality action plan with an integrated cost-effectiveness analysis.

2019 achievements in China

- Between 2014 and 2019, the **Jing-Jin-Ji region and Hebei province have reduced air-pollution concentration by more than 40 percent** (figure 2).
- As a conservative estimate, the China program's engagement in Hebei Province delivered **4.4 million tons of CO_2 reduction per year,** addressing global climate impact, through the deployment of clean stoves and electric buses. This is **equivalent to taking 860,000 cars off the road.**
- A study estimated that implementation of China's National Air Policy Plan reduced excess deaths due to air pollution by 370,000, a considerable share of which are within the Jing-Jin-Ji region. Interventions in Hebei addressed the core of the air-pollution source, since Hebei contributed 70 percent of the pollution in the Jing-Jin-Ji region.

FIGURE 2 REDUCTION IN AIR POLLUTION ($PM_{2.5}$) IN THE JING-JIN-JI REGION FROM 2014 TO 2019



Source: World Bank.

Note: Analysis based on data from China National Environmental Monitoring Center, Ministry of Ecology and Environment.

Source: Dafei Huang, World Bank.

EGYPT

Based on a recent PMEH report, the cost of air pollution in Egypt is equivalent to 2.5 percent of Egypt's GDP (Larsen 2019). Compared to other PMEH countries, Egypt has relatively more advanced air-quality management practices that are among the strongest on the continent. PMEH has been working in partnership with the Egyptian Environmental Affairs Agency, and with the Ministries of Finance, Health, and Transport on the Greater Cairo area.

The goal of PMEH's Cairo program is to provide a solid analytical foundation for the transition between pilot and full-scale air-quality operations. The PMEH team is improving the local capacity of AQM planning, including air-pollution monitoring and source-apportionment analysis. Through this analytical work, the Egyptian Environmental Affairs Agency will be able to produce a comprehensive AQM Plan for Cairo in 2021 and strengthen integration of climate and air-quality planning.

In 2019, PMEH supported analytical work that resulted in three significant published reports (figure 3). PMEH funding will enable the government to procure equipment for air-quality monitoring that will strengthen the analytical capacity for a source-apportionment analysis planned for 2020. Most importantly, PMEH's foundational analytical and policy support has directly led to a request from the government of Egypt for a $200 million loan that will be transformational in developing a framework for the country. This framework will integrate planning for both climate issues and air-quality management.

The loan will aim to enhance air-quality decision-support systems including rapid-response mechanisms (such as school or factory closings and encouraging self-protective actions for sensitive groups), and air-quality forecasting to identify when these institutional responses may be needed. The loan will also strengthen integrated solid-waste management in the Greater

Cairo area, including addressing burning of municipal waste. Finally, the loan will help reduce vehicular emissions from the Cairo Transportation Authority bus fleet.

A modeling effort is planned for late 2020 and 2021 that would seek to confirm the key source of pollution affecting the Greater Cairo area and identify strategies to address climate and air-quality challenges in the form of an integrated climate and air-quality action plan. This cost-effectiveness study will help the government develop an AQM plan that targets the key pollution sources and is consistent with its commitments to the Paris Agreement.

Plans for the government's scaled AQM program will integrate climate and air-quality inventories, modeling, and economic analysis to formulate a single action plan that addresses both the transportation and solid-waste sectors.

FIGURE 3 REPORTS COMPLETED BY PMEH ANALYTICAL WORK THAT SUPPORTED AQM PLANNING IN EGYPT

Following are brief notes about the publications (left to right) depicted above:

Motor Vehicle Density and Air Pollution in Greater Cairo: How Did Fuel Subsidy Removal and Metro Line Extension Affect Congestion and Pollution? Developed based on satellite retrieval of vehicle counts that were combined with data from ground-based air-quality monitoring and information about known policies.

Particulate Matter Ambient Air Pollution and Respiratory Disease in Egypt. Developed based on the completed health-impact assessment.

Arab Republic of Egypt: Cost of Environmental Degradation – Air and Water Pollution. Developed based on analysis of the local impact of air pollution on health, with valuation of negative health effects.

GHANA

In 2017, Ghana had an estimated 16,000 deaths from air pollution, with an associated annual cost of approximately $2 billion (equivalent to 4.2 percent of GDP) (World Bank, forthcoming). Government leaders in Ghana and international partners agree on the urgency of addressing air pollution and have made AQM a key priority. In 2018, with assistance from the PMEH and other international partners, the government of Ghana launched its first AQM plan for the Greater Accra Metropolitan Area. The government has made progress implementing this plan over the past two years. In Ghana, PMEH has partnered with the Ghana Environmental Protection Agency (EPA Ghana) to focus on AQM planning for the Greater Accra Metropolitan Area.

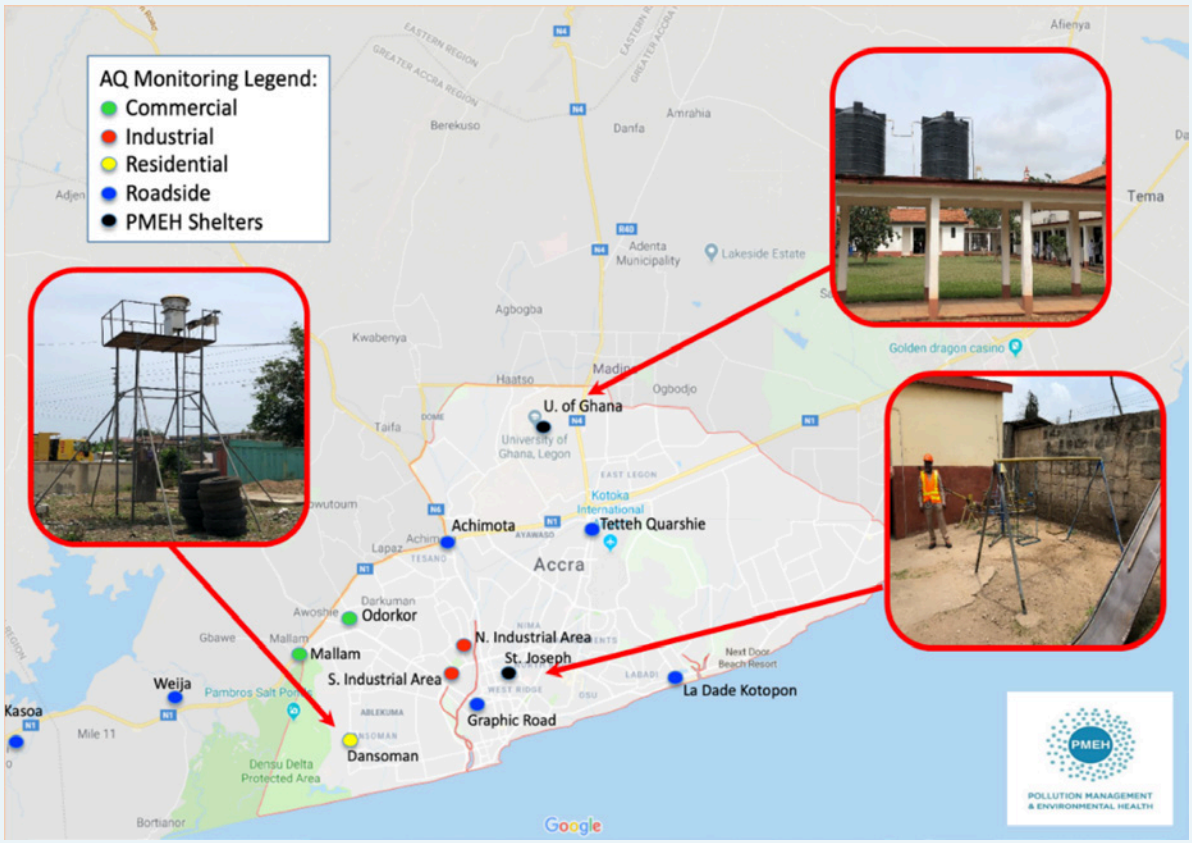
PMEH's primary objective in Ghana is to improve capacity for the collection, validation, and analysis of quality-controlled data on air quality. This work serves to enhance the underlying database that will inform future updates of the AQM plan for the Greater Accra Metropolitan Area. These efforts build on past support from several other international donors that have already engaged in various aspects of AQM planning, including the launch of the preliminary AQM plan.

The year 2019 was transformational for environmental protection in Ghana. The World Bank and EPA Ghana signed a memorandum of understanding, which allowed the World Bank to lead a consortium of local and international organizations and experts working on air-pollution issues in Ghana. Since household air pollution is a major environmental health risk in Accra, PMEH funding is being used to improve the emissions inventory by characterizing emissions from residential cooking with biomass fuels. In 2019, the PMEH team conducted a gap analysis to assess the capacity for air-quality monitoring and AQM laboratory needs. The PMEH program has supported the development of a data-acquisition plan, monitoring protocols, and training. This support will assist EPA Ghana in achieving its objective of providing continuously monitored air-quality data to the public and improve the underlying database for future AQM plans.

Improving continuous monitoring of particulate matter to understand pollution sources in Greater Accra

As part of efforts to monitor air quality, PMEH is funding the deployment of black-carbon monitors that will produce a primary data report in 2020 (see figure 4). PMEH initiated deployment of equipment to continuously monitor particulate matter and black carbon in three selected sites, supplementing the existing 12-site network across Accra that was established by EPA Ghana. Continuous measurements are needed to understand the temporal and spatial characteristics of pollution. This continuous monitoring along with additional monitoring for source-apportionment studies will take place in 2020 and beyond.

FIGURE 4 PMEH-SUPPORTED SELECTED FOCAL SITES FOR AIR-QUALITY MONITORING IN ACCRA



Source: World Bank.

Note: Indicated above are selected sites for the continuous measurement of particulate matter and black carbon. These measurements will help in understanding the spatial and temporal aspects of pollution and will help identify pollution sources. The 12 existing sites (colored dots) constitute the existing monitoring network that regularly measures background concentrations of particulate matter.

INDIA

India remains as one of the most polluted countries in the world. In 2016, India had over a million deaths from air pollution. PMEH in India is part of a larger World Bank engagement on AQM with the government of India that goes back several decades. India has received strategic support with PMEH funds since 2015. PMEH is partnering with the Ministry of Environment, Forestry and Climate Change; the Central Pollution Control Board; state pollution control boards; and scientific and technical universities. Initial support focused on Delhi and the National Capital Region but has since evolved to focus on broader and more systemic needs at the national and regional levels in the states of Bihar and West Bengal and the states in the Indo-Gangetic Plain region. The Indo-Gangetic plain is the northern and the most densely populated area of India. It is also the most polluted region in India with high levels of poverty and low-socioeconomic

development. PMEH is also providing targeted technical support to Uttar Pradesh focused on the integration of the central and eastern plains.

PMEH funding was instrumental in the development of India's National Clean Air Programme by bringing in international experts to provide technical assistance. In early 2019, India launched the National Clean Air Programme. This comprehensive and ambitious strategy outlines India's plan to integrate AQM at the federal, state, and city levels. The strategy also integrates air-quality targets with climate-change goals by mainstreaming existing climate-related policies and programs including the National Action Plan on Climate Change. Strategies for mitigating short-lived climate pollutants (SLCPs) are being integrated into the revised national AQM planning guidelines as well as into national-level policy dialogues. This work prompted a formal request from the Indian government to the World Bank for a $5 million technical assistance program for air-quality management from 2019 to 2021.

National-level work has led to expansion of regional programming. In 2019, the PMEH team started collaboration and knowledge exchange at an airshed level across the seven Indo-Gangetic Plain States and Urban Territories, and more in-depth work with two states in Bihar and West Bengal. This expanded effort will strengthen the capacity of relevant Indian institutions for AQM planning and implementation. That expanded effort is testament to the government's commitment to air-pollution reduction. In 2019, PMEH support also strengthened the design of the air-quality monitoring and source-apportionment network in Delhi and the National Capital Region, the air-quality forecasting system, and cost-effectiveness estimations. These existing systems will be used as a model for the expansion of networks in other states.

India's National Clean Air Programme (NCAP)

Goal Meet the prescribed standards for annual average ambient air quality at all locations in the country in a long-term timeframe.

Target From 2019 to 2024, reduce $PM_{2.5}$ and PM_{10} concentrations by 20 percent to 30 percent.

- Covers both medium-term (2019–2024) and long-term (20–25 years) horizons.
- Prioritizes urgent action across 23 states with 122 cities that are out of compliance with National Air-Quality Standards.

NCAP attributes

- Consolidates fragmented AQM efforts into one national program with a set target for reducing air pollution by 2024 and beyond.
- Integrates the Indian government's existing policies and programs across a variety of sectors (climate change, waste, energy, transport, crop-residue management, and so forth).
- Mentions state plans, and regional and transboundary strategies.

- Recognizes that AQM planning is an evolving process with leeway for the refinement of plans.
- The AQM planning approach includes most of the key elements needed for success.
- Acknowledges the need for capacity building and knowledge exchange.

NCAP accomplishments

- Expansion of an extensive network for air-quality monitoring by state pollution-control boards.
- Because of the national plan, states have greatly accelerated preparation of comprehensive city AQM plans and have begun undertaking studies to understand the PM sources.
- The national plan has provided some stimulus to undertake an emissions inventory, and health assessments have been initiated to understand the impacts of air pollution.
- International experiences and best practices are being sought by states to improve AQM planning, and states are sharing knowledge through a National Knowledge Network.
- The national plan provides the basis for aggregation to state-level plans and the basis to establish mechanisms moving to a wider airshed-based planning system.

NIGERIA

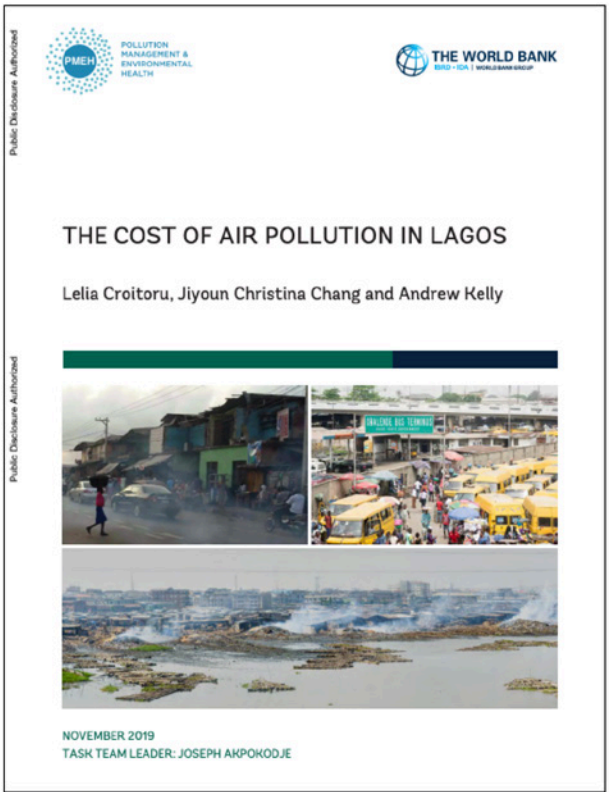
With the largest population in Africa, Nigeria has the highest death toll attributable to ambient air pollution in the region at 140,500 in 2016. The World Bank has been working with the government of Lagos State over the past decade to reduce transportation-based pollution. The PMEH's support recognizes that there is a major knowledge gap in understanding which pollution sources contribute to the region's ambient air pollution. To successfully manage air pollution, the city of Lagos requires continuous, long-term ground-level measurements of ambient air quality, a comprehensive inventory of emissions, and mapping of the major pollution sources. The PMEH program in Nigeria aims to support the Lagos State government by strengthening data collection. In 2018, a needs assessment was conducted, and a Data Sharing and Data Development Committee was established to facilitate data collection and sharing of information. Preliminary air-quality monitoring has commenced in Lagos. Continued air-quality monitoring for establishing an air-quality baseline and informing source-apportionment analysis are about to begin, as is the development of an emissions inventory for pollutants such as $PM_{2.5}$ and SLCPs.

In 2019, PMEH analyzed the cost of health damage from air pollution in Lagos and published the findings in its report *The Cost of Air Pollution in Lagos*. A related knowledge exchange for selected Nigerian government officials was held with specialists from China, Italy, and the US to share information about best practices in air-quality management. Together, the report and knowledge exchange were successful in building the evidence for the Lagos State government

to prioritize air-quality monitoring and take action to implement the different elements of AQM planning with PMEH support. In 2019, network locations for monitoring ambient air quality and SLCP were selected, and the government approved the initiation of long-term monitoring of air quality and SCLP. A rapid needs assessment focused on health facilities was also conducted to understand existing data gaps, and two background reports were prepared, which will serve to inform a health assessment. Finally, an institutional arrangement was established to identify all stakeholders, and a detailed stakeholder and institutional analysis will be undertaken to identify key members of the local AQM coordination team, which will prepare materials to inform stakeholders about the results of PMEH AQM work. These actions are filling key information gaps and establishing the quality-backed monitoring procedures needed to develop an evidence-based AQM plan for the city of Lagos.

Key findings from the study of the cost of air pollution in Lagos

- The health cost of air pollution in Lagos state is estimated at $2.1 billion (equivalent to 1.3 percent of Lagos State's GDP).
- Exposure to ambient air pollution is responsible for 11,200 deaths (the highest among countries in West Africa).
- Children under 5 account for 60 percent of all deaths resulting from lower respiratory infections.



SOUTH AFRICA

South Africa is a hotspot for poor air quality in southern Africa. In 2016, there were 22,917 deaths related to air pollution across the country. South Africa already has statutory requirements in place for AQM planning for every large city. PMEH and GIZ are working in collaboration with the South Africa National Department of Environment and Forestry. The goal of PMEH support is to enable the three cities of the Greater Johannesburg Area to enhance future AQM plans to include critical aspects that are not currently required by statute. GIZ is working with the cities of Tshwane and Johannesburg on developing city-level emissions inventories. PMEH is supplementing these efforts with an emissions inventory for the city of Ekurhuleni in addition to providing support for source-apportionment and cost-effectiveness analyses.

PMEH supported a detailed gap analysis to identify the strength of South African AQM planning capabilities and requirements to achieve its air-pollution objectives. As a result, AQM plans resulted in a more data-driven understanding of air-pollution problems in the area. In 2019, PMEH reached agreements with the government on the scope of a cost-effectiveness analysis and source-apportionment study that will include a health-data review. Air-quality monitoring will include black-carbon monitors that will provide greater insight into the source and quantity of fine-particle pollution. This knowledge will shed light on the key sources of air pollution that contribute the most to climate change. In addition, the use of the GAINS model for cost-effectiveness will allow the cities to identify control measures that most cost-effectively reduce the impacts on health and climate change simultaneously.

VIETNAM

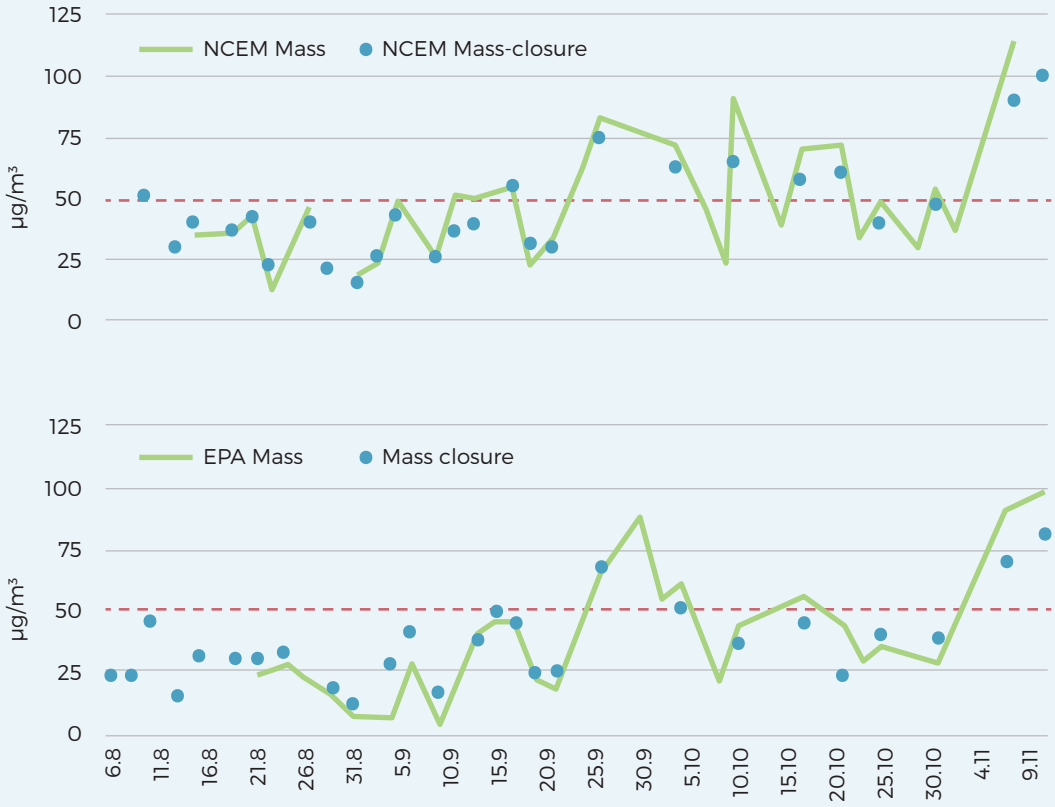
Urban areas in Vietnam are experiencing rapid growth. As a result, there has been an increase in construction, industrial production, and the use of motor vehicles. Ambient air pollution was responsible for 34,232 deaths across the country in 2016. In Vietnam, PMEH is working with the Ministry of Natural Resources and Environment and its Pollution Control Department, the Hanoi Environmental Protection Agency, and local Departments of Natural Resources and Environment to complete AQM plans for the Greater Hanoi Metropolitan Area, including the city of Hanoi and Bắc Ninh and Hung Yên provinces. The goal of the PMEH program in Vietnam is to strengthen the capacity of the government to develop an evidence-based understanding of emissions sources and the costs of measures to control air pollution. This work will enable the government to create a cost-effective, full-scale, air-quality model and AQM plan that can be implemented at the city and national levels. Climate co-benefits are fully integrated into the model, including mitigation of greenhouse gases and short-lived climate pollutants. PMEH and the government of Vietnam held a multisector technical workshop in 2018 to present results from GAINS modelling that was used to inform the development of the Vietnam GAINS model in 2019.

In September 2019, a contract was signed for the verification and addition of an emissions inventory as well as a training on the GAINS AQM Vietnam model for government officials. The

Vietnam GAINS model has been fully developed by drawing on the GAINS global databases and comparable countries in Asia. The results of the first training workshop on the updated emissions inventory for the Vietnam PMEH GAINS model were reported in Vietnam news media in May 2019.

For source apportionment, four samplers were deployed to the Hanoi EPA and the Northern Center of Environmental Monitoring in August 2019. Sampling campaigns started in August and will last a full year to take into account seasonality. Environmental authorities are now releasing Hanoi's air-quality data in real time and have produced early results (figure 5). The Vietnam GAINS model that was developed is currently being calibrated based on the updated emissions inventory and the one-year source-apportionment monitoring that has been ongoing since August 2019.

FIGURE 5 $PM_{2.5}$ CONCENTRATION LEVELS FROM THE TWO STATIONS IN HANOI, AUGUST 2019



Sources: Based on data from IHME (2018) and GBD 2017 Risk factors collaborators (2018).

Notes: IHD = ischemic heart disease; LRI = lower respiratory infections; COPD = chronic obstructive pulmonary disease.

Early results from source-apportionment studies in Vietnam

The photographs below depict source-apportionment particulate-matter samplers and training on source-apportionment analysis.

Source: World Bank.

LESSONS LEARNED IN AQM PLANNING

While each country in the PMEH program is at a different stage of AQM planning, respective governments have made significant progress over the past few years. While many different factors contribute to the overall success of program implementation, major breakthroughs have occurred that enabled governments to make key decisions and prioritize the management of air pollution. Some of the key factors for success are highlighted below.

Government readiness for implementation. In China, the government's AQM program was funded through specific budget lines to enable implementation even before the loan was disbursed. The program leveraged the government's earmarked resources of $3 billion from the national and provincial governments that demonstrated their commitment to pollution management. The lending instrument allowed the government to operate through existing governance systems and used inputs from the World Bank to enhance best practices. In this way, the program also ensured the effectiveness of fiscal spending.

Local empowerment requires clear roles and responsibilities. A factor that became critical in China was an established and fully functional institutional arrangement in the government with clear roles and accountabilities. It was essential that the implementing partner within the local government had the mandate and capacity to coordinate the multisectoral program. In China, designating the governor of the province to be the champion of the program allowed for the necessary high-level engagement and authority to conciliate challenging tradeoffs. This enabled clear communication and empowered key stakeholders to make decisions.

Capacity building requires multilevel coordination. Air-pollution management has traditionally been delegated to underfunded environment ministries, which frequently lack the power to mandate the broad-based changes required to adequately combat air pollution.

However, tackling the air-pollution challenge requires coordination and agreement by multiple agencies that are sometimes not accustomed to working together. In South Africa, PMEH designed an inclusive and successful program that was based on discussions and key inputs that were derived from agencies at city and sectoral levels.

Quality data are essential for effective decision-making. Knowledge-sharing workshops and analytical support played a crucial role in finding common ground of understanding, building policy dialogue, and closing knowledge gaps and implementation-capacity gaps. In Egypt and Nigeria, the publication of reports that demonstrated the health cost of air pollution was instrumental in influencing the decision to make an investment in large-scale pollution management in Egypt and to prioritize AQM management in Nigeria. In China, the systematization of data collection was fundamental to persuade the government to dedicate the significant funding required to improve air quality in the Jing-Jin-Ji area.

Creation of incentive-based monitoring and evaluation are motivating factors for achieving results. Financial incentives proved to be key in the China program design. Although central and provincial governments were already devoting significant resources to the air-pollution challenge, results were not immediately clear. The introduction of disbursement-linked indicators as a part of the monitoring and evaluation plan, along with a clear monitoring and tracking system, facilitated the optimization of clear and achievable targets.

Scientists and regulatory practitioners need to collaborate. In India, it was recognized that expanding the capacity for AQM required the breaking of silos between regulatory practitioners, academia, and policy leaders to improve the evidence-based standard for AQM. A National Knowledge Network was established by the Ministry of Environment, Forests and Climate Change to achieve this by matching each state pollution-control board with a university knowledge partner. One of the key goals was to geographically spread and expand the number of entities across India with AQM capacity. Subgroups of the National Knowledge Network were also established to promote regional exchange across geographically distinct areas. This enabled the inclusion of local-level knowledge in the regulatory and scientific research agenda.

Cross-jurisdictional collaboration plays a key role in strengthening capacities for AQM. PMEH supported the successful formation of the Indo-Gangetic Plain Sub-Group of the National Knowledge Network connecting seven states across the most polluted part of India into a specific capacity-building program. Bringing together university and Pollution Control Board capacities has brought stakeholders to collaborate and share knowledge with other nascent institutions. The efforts from the capacity-building program resulted in the launch of a process for multistate-airshed modeling that will help with cross-jurisdictional decision-making to improve air quality across states interconnected by a common air space.

NOTES

1. Health Effects Institute. 2019. "How Clean Is Your Air? State of Global Air/2019." Boston MA, (accessed January 16, 2020). https://www.stateofglobalair.org/air

2. Reproduced from https://ourworldindata.org/outdoor-air-pollution. Data sourced from World Development Indicators, World Bank. https://datacatalog.worldbank.org/dataset/world-development-indicators

3. Unless otherwise noted, all country mortality estimates are from the WHO Global Health Observatory Data Repository. https://apps.who.int/gho/data/view.main.BODAMBIENTAIRDTHS

REFERENCES

Health Effects Institute. 2019. *State of Global Air/2019: A Special Report on Global Exposure to Air Pollution and Its Disease Burden*. Boston, MA: Health Effects Institute. ISSN 2578-6873 https://www.stateofglobalair.org/sites/default/files/soga_2019_report.pdf

Kurt, Ozlem, Jingjing Zhang, and Kent E. Pinkerton. 2016. "Pulmonary Health Effects of Air Pollution." *Curr Opin Pulm Med* 22 (2): 138–43. doi:10.1097/MCP.0000000000000248

Larsen, Bjorn. 2019. *Arab Republic of Egypt: Cost of Environmental Degradation – Air and Water Pollution*. Washington, DC: World Bank. https://openknowledge.worldbank. org/handle/10986/32513

Thurston, G. D., and M. L. Bell. 2014. "The Human Health Co-benefits of Air Quality Improvements Associated with Climate Change Mitigation." In *Global Climate Change and Public Health, Respiratory Medicine 7*, edited by Kent E. Pinkerton and William N. Rom.

WHO (World Health Organization). 2014. "7 Million Premature Deaths Annually Linked to Air Pollution." Press Release, March 2014 (accessed July 23, 2014). https://www.who.int/mediacentre/news/releases/2014/air-pollution/en/

WHO (World Health Organization). 2018. "Ambient (Outdoor) Air Pollution." https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

WHO (World Health Organization). 2019. "Health Consequences of Air Pollution on Populations." (Accessed January 14, 2020), https://www.who.int/news-room/detail/15-11-2019-what-are-healthconsequences-of-air-pollution-on-populations

World Bank. Forthcoming. *Global Cost of Ambient $PM_{2.5}$ Air Pollution in 2016*. Washington, DC: World Bank.

STRENGTHENED ANALYTICS

SECTION OVERVIEW

PMEH supports the strengthening of the knowledge base for informing action to abate air pollution and pollution caused by toxic, contaminated land sites. Good air-quality monitoring is fundamental for effective air-quality management. In many LMICs, however, air-quality monitoring is weak or nonexistent. The PMEH analytical program examines issues associated with reliable air-quality monitoring in LMICs, assesses the potential for applying satellite technology for measuring air quality, and studies aspects related to estimation of health effects of air pollution in LMICs.

With increasing industrialization comes increased production and use of chemicals, which in many LMICs leads to creation of polluted toxic sites and increased risks to health. Lack of data that connect polluted sites to specific environmental, health, and economic impacts is a barrier to proper land-pollution abatement. Tools and approaches to identify toxic sites, and stronger evidence of linkages between land-based pollution and its adverse impacts, are therefore critical.

Cities are engines of growth and competitiveness of countries. However, as urbanization and economic activity grow, pollution may threaten cities' competitiveness. The PMEH analytical program examines linkages between pollution and competitiveness through empirical analysis, assessment of institutional aspects related to pollution management in selected cities, and tools for effectively managing pollution while strengthening competitiveness.

INTRODUCTION

PMEH's analytical component aims to build the evidence base for improving pollution management and environmental health by increasing stakeholders' understanding of the links between pollution, public health, economic productivity, and associated costs in LMICs. To this end, PMEH supports analytical work on cutting-edge topics that enable World Bank client countries to make key policy decisions regarding pollution management and environmental health. This analytical work also fills knowledge gaps and thereby allows World Bank operational teams to more effectively support clients' efforts to reduce pollution.

The three areas of analytical work supported by PMEH center on

- **Air Quality** Improving air-quality monitoring and estimation of the health risks and effects of ambient air pollution in LMICs
- **Toxic Sites** Improving the evidence base for assessing the impacts of contaminated toxic sites on human health and the economy in LMICs
- **Pollution Management and Competitive Cities** Generating knowledge, increasing capacity, and producing tools to support decision-making at the city and national levels.

AIR QUALITY

SECTION OVERVIEW

PMEH analytical work estimated the global cost of health damages related to ambient air pollution in 2016 at $5.7 trillion, equivalent to 4.8 percent of global GDP. About 87 percent of that cost was due to premature death and 13 percent to illness. The cost was highest in South Asia (7.3% of GDP), followed by East Asia and the Pacific (5.7%), Europe and Central Asia (4.5%), the Middle East and North Africa (3.6 percent), North America (3.3%), Sub-Saharan Africa (3.0%), and Latin America and the Caribbean (2.3%). LMICs disproportionately bear the largest health and economic burden of air pollution—one of the world's most significant health risks. PMEH has addressed a major methodological issue related to this burden by identifying challenges to accurately measuring air pollution in LMICs.

One of the most important evaluations of the health impacts of air pollution is the Global Burden of Disease study. Estimates from that study serve as the basis for funding and policy decisions around the world. In that and related global studies, the estimates of health impacts of air pollution are typically based on the assumptions that all constituents of fine particles, and fine particles from different pollution sources, are equally toxic.

However, evidence from PMEH analytical work demonstrates that some constituents and sources of air pollution, notably fossil-fuel combustion, are more toxic than others. The most harmful sources are coal-fired power plants and diesel-fueled vehicles. Efforts to control air pollution that prioritize $PM_{2.5}$ emissions reductions from these sources are most likely to return greater health benefits than broad efforts that do not consider the source and composition of air pollution. In addition, dust, another component of particulate pollution, has a substantial health impact and should continue to be included in future estimates.

PMEH aims to fill essential gaps to improve the reliability of future global and local studies of air pollution. Based on studies in selected LMIC cities, PMEH has demonstrated that the use of satellite-derived estimates of air pollution ($PM_{2.5}$) in LMICs is associated with significant errors and therefore unreliable in such contexts. Findings from PMEH studies have also highlighted a large disparity in ground-level monitoring between high- and low-income countries and the need to strengthen and establish ground-level networks for monitoring air quality in LMICs. The dearth of well-operated and maintained networks for monitoring air quality that can provide reliable air-quality measurements undermines estimates of the disease burden of air pollution and precludes the design and implementation of economically effective interventions to abate ambient air pollution in LMICs.

INTRODUCTION

Air pollution is recognized today as one of the most significant health risks affecting the planet, and LMICs disproportionately bear the largest health and economic burden of air pollution. However, these countries lack reliable data for monitoring air quality that would enable them to make informed and economically effective decisions regarding air-pollution control. Furthermore, the reliability of data for monitoring air quality requires quality control, which is typically not adequate.

Without sound data, the nature and extent of air pollution's health impacts in a city or country, which inform major policy decisions, cannot be reliably estimated. The objective of the PMEH-funded analytical work on air quality is to strengthen the knowledge base for improving air-quality monitoring as well as the estimation of health risks from ambient air pollution in LMICs. As many cities in LMICs have recognized the importance of mitigating air pollution, there is a need to improve data monitoring and quality control to make evidence-based decisions for controlling air pollution.

Focal areas of PMEH air-quality analytical work are

- Harmonization of air-quality monitoring procedures in LMICs
- Evaluation of the performance of satellites for air-quality measurements in LMICs
- Strengthening the knowledge base for estimating the health impacts of ambient air pollution

HARMONIZATION OF PROCEDURES FOR AIR-QUALITY MONITORING IN LOW- AND MIDDLE-INCOME COUNTRIES

One of the major challenges in air-quality monitoring is the variation in methods and protocols for measuring ambient air pollution. These methods can differ across countries and regions, presenting challenges for obtaining reliable air-quality data. A PMEH report examines the state of air-quality monitoring in LMICs and proposes a classification of LMICs, based on their capacity for monitoring air quality. A second report targeted at policy makers examines how gaps in air-quality data in LMICs may be filled. Based on this work, the PMEH co-authored the article, "Opportunities and Challenges for Filling the Air-Quality Data Gap in Low- and Middle-Income Countries," which was published in the peer-reviewed international journal *Atmospheric Environment*.[1]

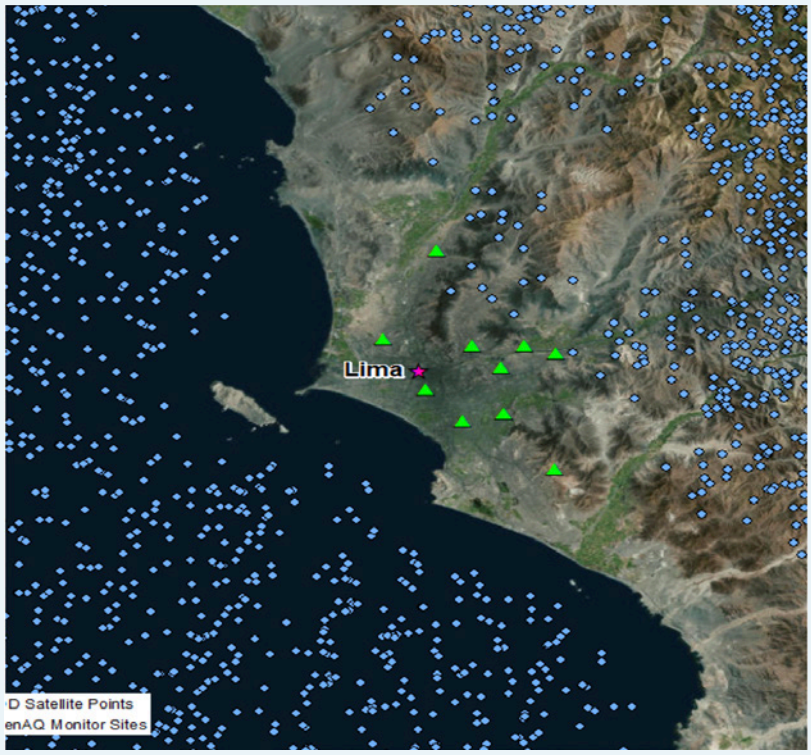
Programs for monitoring air quality must be based on well-defined monitoring objectives and must take into account a country's implementation capacity. Based on international standards from successful programs, the PMEH report proposes guidelines for the methods, quality control, and sustainability in the collection of air-pollution data, as well as the public availability of the data. Information from that report can be used as a basis for developing context-appropriate guidance and protocols for air-quality monitoring in LMICs.

EVALUATION OF THE PERFORMANCE OF SATELLITES FOR AIR-QUALITY MEASUREMENTS IN LOW- AND MIDDLE-INCOME COUNTRIES

Satellite-derived measurements of air pollution have been used in estimating air-quality levels in high-income countries, where a dense network of ground-level air-pollution monitors exists. However, there are particular challenges that satellites face in measuring air pollution, for example in high-altitude and coastal cities (figure 6). In LMICs, where ground-level monitoring networks are weak or nonexistent, little information is known about the accuracy of satellite-derived data for estimating air-quality levels. This PMEH analytical work examined the use of satellite-based measurements compared to ground-level air-quality monitoring in selected cities in LMICs.

The findings of the analytical work demonstrated that satellite data were associated with errors ranging from 21% to 85% for daily average air-pollution ($PM_{2.5}$) concentrations at a given location in some cities (figure 7). As a result, satellite-derived air-quality measurements cannot replace well-run and maintained ground-level monitoring systems in most LMICs (figure 7). However, satellite data could serve in some LMICs to supplement ground-level monitoring networks for air pollution, which should be determined on a case-by-case basis. This analytical work also tests methods for bringing satellite measurements into closer agreement with ground-level monitoring data, considering the shortcomings and advantages of satellite measurements to improve human-exposure assessment. Based on this work, a report was produced and an article, "The Use of Satellite Observations to Supplement Ground-level Air Quality Data in Low- and Middle-Income Countries," was published in the peer-reviewed international journal *Atmospheric Environment*.[2]

FIGURE 6 AEROSOL OPTICAL DEPTH DATA AND GROUND-LEVEL MONITORING SITES OVER LIMA, PERU



Note: Most data over the city are obscured by persistent clouds.

STRENGTHENING THE KNOWLEDGE BASE FOR ESTIMATING THE HEALTH IMPACTS OF AMBIENT AIR POLLUTION

Global cost of ambient air pollution

The Global Burden of Disease study estimated that 4.1 million people died from ambient air pollution in 2016. The health impacts that result from the illnesses and premature deaths due to air pollution also take an economic toll. PMEH analytical work estimated that the global cost related to health damages of ambient ($PM_{2.5}$) air pollution in 2016 was $5.7 trillion, equivalent to 4.8 percent of global GDP. Of the total cost, 87 percent was due to premature death, while 13 percent was from illness. By region, the cost was highest in South Asia at 7.3 percent of GDP, followed by East Asia and the Pacific (5.7 percent), Europe and Central Asia (4.5 percent), the

Middle East and North Africa (3.6 percent), North America (3.3 percent), Sub-Saharan Africa (3.0 percent), and Latin American and the Caribbean (2.3 percent), as shown in figure 8.

The report also highlighted the need for better ground-level monitoring of air pollution in low-income countries. As shown in figure 9 and figure 10, in high-income countries, there is one ground-level monitor per 300,000 people.[3] In contrast, low-income countries only have one ground-level monitor per 54 million people. The lack of ground-level monitoring results in less accurate estimates of exposure of air pollution, which in turn preclude accurate estimates of the health burden of air pollution and subsequent costs on society.

FIGURE 7 ERROR IN SATELLITE-DERIVED MEASUREMENTS OF AIR QUALITY ($PM_{2.5}$) IN SELECTED CITIES IN LMICS

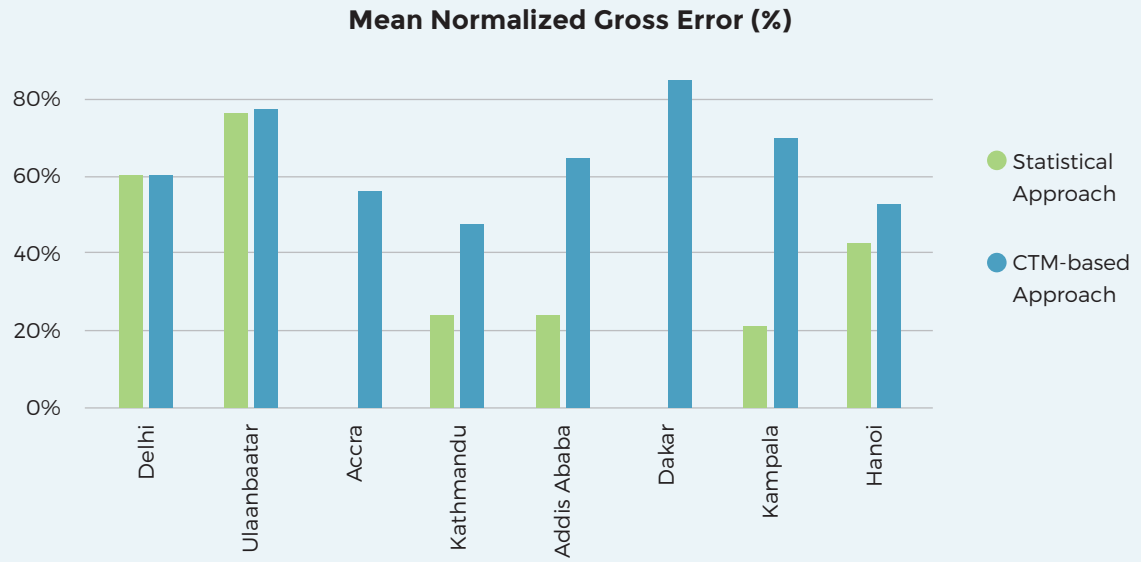
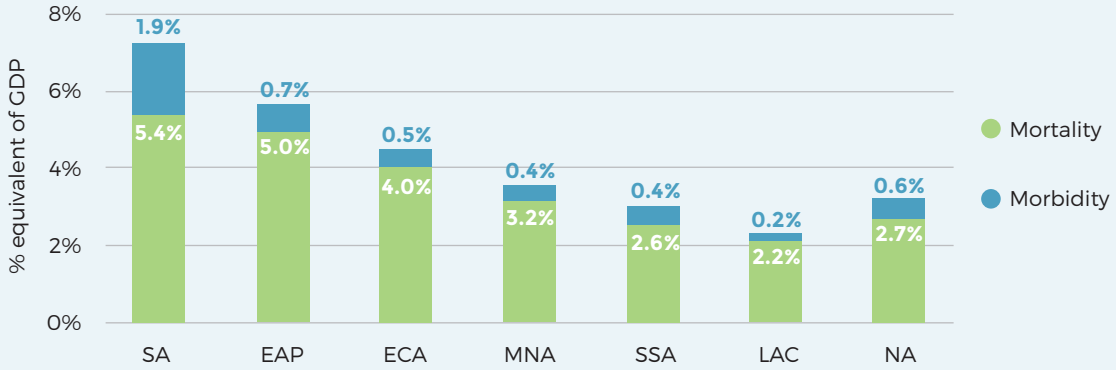
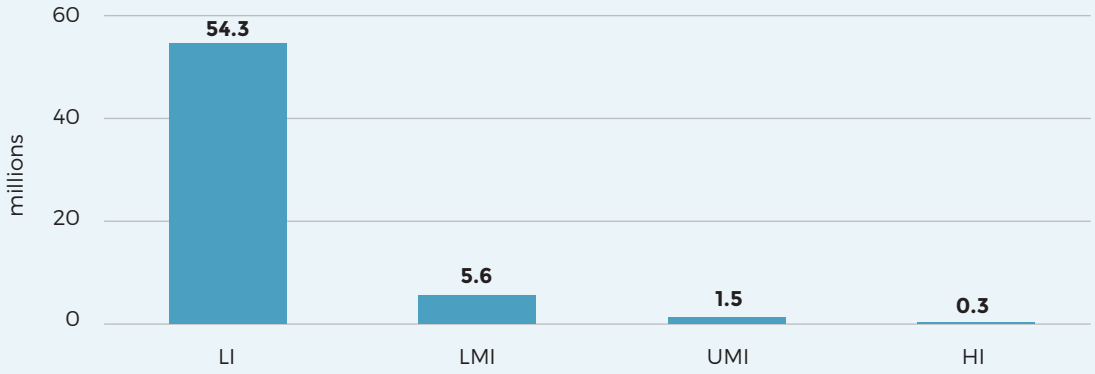


FIGURE 8 ANNUAL COST OF HEALTH DAMAGE FROM AMBIENT $PM_{2.5}$ EXPOSURE, % EQUIVALENT OF GDP IN 2016 BY REGION



Note: EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and Caribbean MNA = Middle East and North Africa, NA = North America; SA = South Asia; SSA = Sub-Saharan Africa.

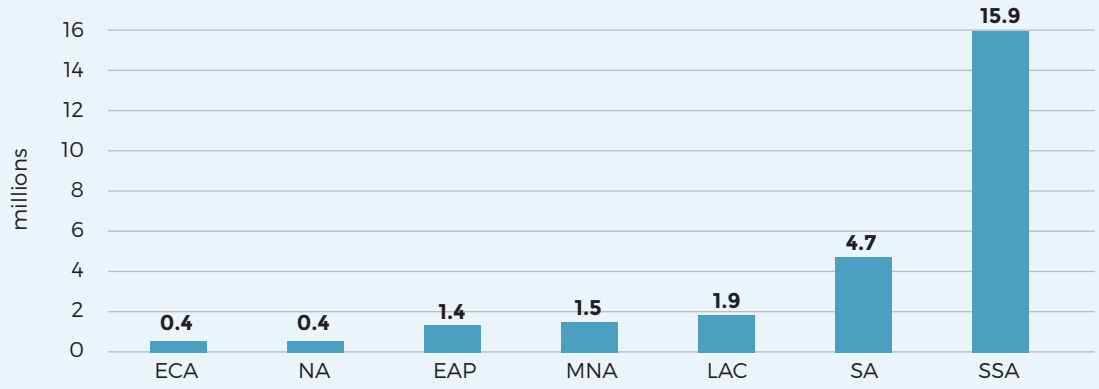
FIGURE 9 MILLION PEOPLE PER GROUND-LEVEL MONITORING STATION BY COUNTRY INCOME LEVEL



Source: Based on data from WHO Global Ambient Air Quality Database 2016.

Note: LI = low-income countries; LMI = lower middle-income countries; UMI = upper middle-income countries; and HI = high-income countries. Categories based on World Bank income classification.

FIGURE 10 MILLION PEOPLE PER GROUND-LEVEL MONITORING STATION BY REGION



Health effects from exposure to constituents and sources of fine particulate matter air pollution

Fine particulate matter pollution, commonly known as $PM_{2.5}$, is the most dangerous air pollutant to health; its size is 1/30th the diameter of a human hair. Particulate matter can come from natural sources (such as dust storms and ocean spray) as well as anthropogenic, or human-made, sources (such as the burning of fossil fuels in industries, transportation, and the burning of agricultural residues). Global studies on the health impacts of air pollution that are based on the measurement of $PM_{2.5}$ typically assume that all particles are equally toxic.

However, there is evidence that adverse health effects of $PM_{2.5}$ can vary depending on its source and chemical composition.

The findings of a PMEH report indicate that $PM_{2.5}$ from coal-burning power plants and diesel-fueled vehicles was the air pollutant most consistently associated with cardiovascular deaths, especially heart disease, which is the leading cause of death worldwide. Specifically, particulate sulfur, or sulfate, typically from coal burning, is among the most toxic if not the most toxic chemical constituent of $PM_{2.5}$. Sulfate is associated with adverse health effects including additional hospital admissions and death. This PMEH report points out the need for efforts that estimate the disease burden of ambient air pollution, as well as ambient air pollution-control efforts in LMICs, to account for both the contributing sources of $PM_{2.5}$ and the toxicity of the $PM_{2.5}$ from each source. Furthermore, these findings signal the need for air-pollution reduction efforts in LMICs to prioritize the monitoring and regulation of air pollution from fossil-fuel combustion, notably coal burning and diesel-fueled vehicles. Targeting these sources is most likely to return greater health benefits than broad efforts that do not consider $PM_{2.5}$ sources and composition.

Implications of exposure to dust on the burden of disease from air pollution

Natural dust is one of the main components of particulate-matter pollution. However, little is known about the health impacts of the dust component of particulate matter air pollution. Studies to estimate the health impacts of particulate matter assume that dust is as harmful to health as other components of particulate matter. This report examines the public-health impacts of both coarse and fine dust particle exposure at varying distances from the origins of the dust. Findings indicate that coarse dust particles significantly downwind from their original source can affect cardiovascular deaths. There were also weaker associations with respiratory deaths. In addition, strong evidence links dust particles to pulmonary illnesses, including asthma and chronic obstructive pulmonary disease. Findings from this report indicate that pending further studies, efforts to quantify global and local health impacts of ambient air pollution should not exclude the contribution of dust from the measurement of $PM_{2.5}$ concentrations. The PMEH report highlights the importance of improving ground-level air-quality monitoring in LMICs to support better characterization of the health impacts of dust. Since dust can be a major source of ambient air pollution, particularly in LMICs that experience frequent and severe dust episodes, awareness of its impacts can provide important information for public air-quality alerts and potential mitigation.

Strengthening the foundations for estimating global mortality from ambient air pollution in LMICs

Over the last two decades, the Global Burden of Disease study has become a standard model for estimating the global health impact of ambient air pollution. The health impact estimates have changed over time as the underlying methodology has evolved. These changing estimates confuse consumers of the information, reducing their level of confidence in the estimated health burden of air pollution. This is particularly the case for estimates in LMICs where there is

likely to be less expertise and resources available to provide their own assessment of the global estimates. PMEH's analytical work reviewed the methodological inputs of the Global Burden of Disease estimates to shed light on why these estimates have changed over time.

The PMEH findings indicate that the observed changes in global premature deaths from air pollution were due to improvements in the methodology used and not errors. The methodological changes relate to assessment of air-pollution exposure, the development of risk functions that relate $PM_{2.5}$ to mortality, and demographic changes, However, the lack of ground-level monitoring in several regions—notably the Middle East and Northern Africa, Sub-Saharan Africa, and South Asia—has resulted in poorer predictions of $PM_{2.5}$ air pollution concentrations relative to high-income and other regions. The report points out the need for greater transparency in documenting and reporting changes in methodological inputs and their impacts on mortality estimates in future Global Burden of Disease studies. This includes the reporting of uncertainty associated with the death estimates for specific countries. The PMEH report also calls for strengthening air-quality monitoring through establishment of reliable ground-level air-pollution monitoring networks in LMICs. Based on the above work, a journal article, "Assessing the Recent Estimates of the Global Burden of Disease for Ambient Air Pollution: Methodological Changes and Implications for Low- and Middle-Income Countries," was published in the peer-reviewed journal *Environmental Research*.

NOTES

1. Pinder, Robert W., Jacqueline M. Klopp, Gary Kleiman, Gayle S. W. Hagler, Yewande Awe, and Sara Terry. 2019. "Opportunities and Challenges for Filling the Air Quality Data Gap in Low- and Middle-Income Countries." *Atmospheric Environment* 215: 116794. https://doi.org/10.1016/j.atmosenv.2019.06.032.

2. Alvarado, Matthew J., Amy E. Mcvey, Jennifer D. Hegarty, Eben S. Cross, Christa A. Hasenkopf, Richard Lynch, Edward J. Kennelly, Timothy B. Onasch, Yewande Awe, Ernesto Sánchez-Triana, and Gary Kleiman. 2019. "Evaluating the Use of Satellite Observations to Supplement Ground-Level Air Quality Data in Selected Cities in Low- and Middle-Income Countries." *Atmospheric Environment* 218: 117016. https://doi.org/10.1016/j.atmosenv.2019.117016.

3. The numbers of monitors are based on the WHO Global Ambient Air Quality Database released in 2016. Since the preparation of the PMEH report, the WHO has released its 2018 version of the WHO Global Ambient Air Quality Database, which was used by the GBD 2017 study. The 2018 version includes nearly 10,000 ground monitors in nearly 4,400 locations in 108 countries. This represents a substantial improvement in global coverage, although 76 percent of the increase in $PM_{2.5}$ monitors was in high-income countries. Regarding $PM_{2.5}$ monitors, there were 64 million people per ground monitor in low-income countries and 29 million per ground monitor in Sub-Saharan Africa, in contrast to about 370,000 people per monitor in high-income countries. These results continue to underscore the need for establishing and strengthening ground-level monitoring networks in LMICs.

TOXIC-SITES IDENTIFICATION AND LAND-BASED POLLUTION

SECTION OVERVIEW

With the rise of industrialization in LMICs, growing pollution and contaminated sites are reaching a critical scale. Policy leaders need to be equipped with the knowledge and tools to mitigate toxic sites and protect the public's health. PMEH analytical work has helped to establish the first global toxic-site database and conduct detailed toxic-site mapping in Bangladesh and Tanzania. These baseline mapping reports, along with the global database, enable local governments to have greater knowledge about the location of polluted areas in their countries. Many of the contaminated sites in LMICs are from small-scale industrial operations that are common, but often operate in an informal and unregulated manner.

PMEH has worked to create guidance manuals that assess the exposure and health outcomes from small-scale industrial operations including leather tanneries, gold mining, and lead-acid battery recycling. These guidance manuals support policy leaders and researchers to develop the evidence base on the public-health impacts of these small-scale industries so mitigation efforts can be prioritized. Allocating resources to mitigate toxic sites requires an understanding of both the health and economic impacts of the polluted areas.

PMEH analytical work has identified crucial knowledge gaps in linking public-health problems with land-based pollution. In addition, PMEH has developed guidelines to improve the estimates of illness and premature death from exposure to land-based pollutants associated with localized industries and their associated costs. This analytical work fills fundamental knowledge gaps that are unique to toxic sites in LMICs. Through these efforts, local policy leaders will be able to quantify the health and economic impacts of small-scale industries, locate the sites across their countries, and allocate resources for their mitigation.

INTRODUCTION

Cities across the globe are becoming more crowded; the majority of this growth is in LMICs. Without environmental regulation, rapid urbanization is changing the environmental landscape. Unsustainable urban development and increasing industrialization are leading to a rise in environmental health issues. Industrial activities involve chemical production that often leads to an increase in sites for toxic waste and an increase in polluted lands. Despite the known environmental health hazards, toxic sites often lack attention and mitigation due to the

lack of data connecting these sites to specific environmental, health, and economic impacts. PMEH analytical work is focused on building the evidence base for improving pollution management and environmental health by increasing stakeholder's understanding of the links between pollution, public health, economic productivity, and associated costs in LMICs. The goals of PMEH analytical work on land-based pollution are to (i) strengthen the tools and approaches to identify toxic sites, and (ii) increase the evidence regarding the linkages between land-based pollution and its health and economic impacts. Two components underpin PMEH's analytical work to address these challenges:

- **Toxic-Sites Identification Program** to improve the identification of toxic sites around the globe and support countries in the identification of toxic sites to increase governments' capacity to develop national action plans addressing land-based pollution.
- **Health and Economic Impacts of Land-Based Pollution** to identify knowledge gaps and to improve methods for assessing the health and economic impacts of contaminated sites and land-based pollution, so governments can intervene more effectively.

TOXIC-SITES IDENTIFICATION PROGRAM

The objective of the toxic-sites identification program is to better characterize the extent and severity of land-based pollution in selected countries. A second objective is to increase the capacity of policy leaders to identify, prioritize, and manage toxic sites according to their health and environmental effects. Funding from PMEH has helped to develop a global toxic-sites database map that is now publicly accessible.[1]

PMEH has worked to improve transparency regarding toxic sites across the globe, especially in LMICs where there is a lack of knowledge about small-scale, informal industries. Abating toxic land pollution requires identifying and mapping the location of the polluted areas. To validate information on this database and characterize the human-health risks of toxic sites, a rapid-assessment protocol was created and used to identify and assess contaminated sites in LMICs.

The PMEH-supported database will increase the knowledge and understanding of the underlying drivers of chemical pollution in LMICs and serve as a tool for authorities to make informed decisions on remediation interventions. A two-day training workshop to demonstrate the use of the database and site-screening tools was held in Dar es Salaam, where several government officials, members of civil society organizations, university students, World Bank representatives, and investigators participated. The tools are currently being used in global project operations supported by the European Commission and the United States Agency for International Development (USAID), among others.

Baseline reports on toxic sites in Bangladesh and Tanzania

Funding from PMEH has also assisted specific countries in taking initial action to improve their knowledge of existing toxic sites and the impact they have on public health. Through this

work, PMEH screened over 200 suspected sites in Bangladesh and Tanzania and created baseline reports with recommended actions.

In Tanzania, screening efforts identified mercury, lead, chromium, and pesticides at the different industrial sites. The assessment also singled out gold mining (see figure 11) as a significant concern both for laborers and nearby populations who are at risk from chemicals discharged to soil, water, and air. The knowledge from this baseline report will help to identify other areas for assessment and provide recommended actions on how to address the contaminated sites.

FIGURE 11 ARTISANAL SMALL-SCALE GOLD-MINING SITES SCREENED

Note: A woman artisan is shown working without protective equipment at a pond contaminated with mercury where gold is processed. A man holds a baby nearby who can be exposed to mercury pollution at Nyakafuru Gold Mine in Bukombe District, Geita Region, Tanzania.

In Bangladesh, a baseline assessment, focused on industrial sites, found lead, arsenic, chromium, and cadmium chemical residues that affected surrounding residential areas. Lead-acid battery manufacturing and repair, as well as gold recycling from jewelry operations were the industries identified as the greatest concern. Lead in surrounding residential areas was often 20 times the safety threshold. Recommendations from the baseline report in Bangladesh are being used to create pollution-control measures in many industries including paper, textile, garment, shipbreaking, fertilizer production, iron and steel production, pharmaceuticals, tanneries, and the informal recycling of used lead-acid batteries.

HEALTH AND ECONOMIC IMPACTS OF LAND-BASED POLLUTION

In LMICs, there are many informal and small-scale industrial processes that often escape the regulation that larger-scale operations face. However, these industries represent a significant source of employment for millions of people. Without regulation, pollution from these small-scale industries can endanger its workers and the surrounding community. Just as the effort to identify contaminated sites is at an early stage, so is the exploration to understand the resulting health impacts on nearby populations. To support this growing area of research, PMEH analytical work focused on the knowledge gaps that link land-based pollution to public-health impacts. In addition, PMEH created guidelines to improve research methods and recommended standards for measuring the health and economic impacts of land-based

pollution. The knowledge generated through this program will increase governments' capacity to improve action plans to address land-based pollution in LMICs. Improved knowledge and understanding of the effects of toxic pollutants on the population's health will inform and stimulate policy leaders to address current issues and develop plans to improve the well-being of their citizens in a sustainable way.

Guidance manuals for assessing exposures and health outcomes at contaminated sites in LMICs

Many studies have documented exposure and a variety of health outcomes from contaminated sites, but taking action remains a challenge. Recommendations for authorities are unclear, due to differences in study design, data-collection strategies, contaminants evaluated, laboratory methods, target populations, and analytical approaches across studies and locations. International donor agencies such as the World Bank and others rely on these kinds of studies to justify resource allocation to targeted sources of exposure that may be associated with adverse health outcomes in specific populations. Additionally, these studies are needed to seamlessly link to socioeconomic and demographic data and analyses collected under different programs and with entirely different objectives. Although information on typical exposure factors is available in the literature, this information has traditionally been collected for high-income countries and may not be reliable or accurate for assessing exposures in LMICs.

To understand the health and economic impacts of small-scale industrial operations in LMICs, PMEH identified three key industries—tanneries, gold mining, and lead-acid battery recycling—that lacked regulation. PMEH-supported research assessed existing methodologies and the extent to which they could be used in LMICs to estimate pollution exposure among these industries and the resulting health outcomes.

PMEH-supported research will inform efforts to assess the relationship between environmental contamination, exposure, and health outcomes related to a subset of contaminants originating from these industries. PMEH analytical work will also be used to develop tools that can build local research capacity to conduct sampling that ensures a consistent methodology across sites, contaminants, and geographic areas to ensure comparability across sites. Identified gaps that need to be filled include the development of a protocol to measure potential toxic pathways, including the collection of environmental samples from dust, soil, water, and agricultural (root-grown vegetables and fish) sources.

Guidelines for data collection, environmental sampling, and the analyses at small-scale artisanal gold mining to evaluate health impacts

From extraction to refinement, the gold-mining process involves the use of toxic chemicals. Gold mining involves the crushing, milling, and refining of sediments. These processes release toxic lead, mercury, and arsenic particles into the air and water where they can be inhaled, ingested, or come in contact with people's skin. The primary toxin of concern is mercury followed by smaller amounts of lead and arsenic that enter the air, soil, and surface water

during various phases of the mining process. Mercury is released during the burning process and emitted into the atmosphere, where it oxidizes and deposits into soil, lakes, and rivers. Mercury can build up in large quantities in aquatic life and lead to significant exposures in individuals who consume fish and shellfish. Another known toxin, lead, can be ground into dust and released into the air. Dry milling, which is commonly employed during the gold-processing stage, tends to magnify the production of lead dust. Even when processing occurs away from residential areas, there is a risk to communities, since miners often return home with clothes contaminated with lead. These guidelines detail the methodology for data collection, environmental and biological sampling, and the analysis that should be used at gold-mining sites to link environmental contamination to human exposures and health outcomes.

Guidelines for data collection, environmental sampling, and analyses at small-scale tanneries to evaluate health impacts

Tanning leather is a resource-intensive process that generates a significant number of by-products, solid waste materials, and large amounts of wastewater. These byproducts can contain chromium, lead, arsenic, and cadmium. These metals will persist in the environment in their original form and are likely to be found in soil, dust, water, and some agricultural products. Onsite storage of solid waste can leach into surface and groundwater. Solid waste byproducts that contain contaminated chemical residue are often repurposed in different ways including livestock feed and fertilizer for agricultural crops. Other times, the waste is incinerated, releasing toxic chemicals into the air, posing a danger to workers and the surrounding community. There are a few different pathways for chemical exposure. Workers can be directly exposed by inhaling vapors released during tanning, finishing, and dyeing, or when these chemicals come into contact with skin. Populations may be indirectly exposed to contaminants present in contaminated water used to irrigate crops or in soils where livestock graze. These guidelines detail the methodology for the data collection, environmental and biological sampling, and the analyses that should be used at tanneries to link environmental contamination to human exposures and health outcomes.

Guidelines for data collection, environmental sampling, and the analyses at lead-acid battery-recycling facilities to evaluate health impacts

Lead-acid battery recycling consists of dismantling and recycling used batteries, usually acquired from motor vehicles. Contaminants encountered during the battery-recycling process primarily arise from the battery components themselves and include lead, arsenic, and cadmium. These metals can be released into the soil after the batteries are dismantled and discharged as solid waste and wastewater during the separation of components in a water bath. Lead is then smelted and refined, which can release toxic vapor and particulate dust. Skin contact, incidental ingestion, and inhalation of contaminated dust are the primary exposure pathways of the toxins. However, direct ingestion of lead is the primary toxin of concern, and children under 10 are the most vulnerable. Skin exposures can occur when people bathe, swim, and wash clothes or dishes in contaminated surface or groundwater sources. These PMEH

guidelines detail the methodology for data collection, environmental and biological sampling, and the analyses that should be used at lead-acid battery-recycling facilities to evaluate linkages between environmental contamination, human exposures, and health outcomes.

Framework to support health-impact analysis for toxic contaminated sites

Following the industry-specific guidance manuals, PMEH also developed global guidelines to standardize health-impact assessments for small-scale industries in LMICs. This particular PMEH publication serves as a guide for researchers to evaluate the magnitude of pollutant exposure and estimate resulting health impacts from land-based pollutants associated with localized industries.

Part 1 of these guidelines presents a set of conceptual models describing qualitative linkages between sources, chemicals, environmental pathways, exposure pathways, and health outcomes across these three industry sectors, but with applicability to other activities.

Part 2 of these guidelines provides recommendations on the most-appropriate and cost-effective sampling and analysis methods to ensure the collection of representative population-level data, sample-size recommendations for each type of pollutant and environmental media, biological sampling data, household survey data, and health-outcome data.

Resulting data are used to support consistent, comparable, and standardized community-risk and health-impact assessments at contaminated sites in LMICs. The data then link to subsequent economic-burden analyses and risk-management decision-making with respect to options for site cleanup and risk mitigation in the most cost-effective and efficient manner. Adherence to this framework will facilitate comparisons and meta-analyses across studies by standardizing data-collection efforts. Standardizing the health-impact assessment methods across small-scale industries enables future researchers to better characterize the true societal burden created by these industries and make the economic case for remediation.

NOTES

1. www.contaminatedsites.org

POLLUTION MANAGEMENT AND COMPETITIVE CITIES

SECTION OVERVIEW

It is essential that city growth and pollution management are conducted in harmony to maintain city competitiveness. However, there are limited data about the relationship between growth and pollution and when and where to intervene. To examine this relationship, PMEH conducted analytical work at the global, regional, and city levels to examine the effect of pollution on city competitiveness. Outcomes from these reports have demonstrated that pollution increases inequality and has a negative impact on the health and development of a city's human capital, city growth, employment growth, and worker productivity. A report on private companies in Africa indicates that pollution also has a negative impact on the performance of African industries. The findings from the three analyses at the global and regional levels have been integrated into a policy note that provides broader urban planning recommendations for policy leaders. A toolkit was also completed that describes highly competitive cities' best practices in pollution management.

While this analytical work examines the overarching concepts of city competitiveness, local-level assessments have revealed significant findings that are being used to improve urban planning in Bangladesh, Liberia, Tanzania, and Uganda. In Dhaka, data from deep-dive analytics are influencing policy interventions that reduce air and water pollution to improve worker productivity in factories. Findings from analytical work that link poor air quality to the productivity of companies in Kampala are being incorporated into the upcoming city development strategy. In Zanzibar, baseline studies on pollution are being used to improve wastewater management and beach cleaning to increase tourism in the area. In Liberia, an economic analysis highlighting the environmental and public-health challenges of the Duala market, one of the most important economic zones of the region, is being used to improve the market's performance and productivity. This work demonstrates that changes in pollution management can have a direct impact on the health, productivity, and ultimately competitiveness of urban areas in LMICs.

INTRODUCTION

Cities are essential engines for growth in productivity and economic development. As people congregate, cities produce technology and innovation. This leads to the creation of jobs that build individual wealth and reduce poverty. With increased global mobility, cities have to compete for talent, resources, and funding. Cities that succeed in attracting new businesses, workers, and investment are often identified as competitive cities. When workers and

businesses coexist in harmony, cities often perform above their national average, generate jobs, and increase income to their citizens. However, as rapid urbanization and economic growth go hand in hand, the negative effects of increased population density can lead to congestion, pollution, and urban sprawl that can threaten a city's competitiveness. In an effort to reduce poverty and increase prosperity, cities must maintain a balance between attracting industry to maintain competitiveness, on the one hand, while preventing congestion and pollution that could hinder economic growth, on the other hand. Despite the rise in urbanization across the globe, there are limited data available to assess the impact of pollution on a city's competitiveness. Governments use economic and environmental data to make urban-planning decisions. These decisions have the potential to increase a city's competitiveness, thereby increasing economic growth and reducing poverty. PMEH has committed its analytical work to building the knowledge base for cities to increase competitiveness through pollution management with the following two objectives:

- Demonstrate the links between pollution and city competitiveness; and
- Provide evidence-based tools for effectively managing pollution and strengthening city competitiveness.

This PMEH program advances knowledge generation, decision support, and implementation planning with government stakeholders at the city and national levels. The program also aims to foster a better understanding of pollution-management reforms and the related investments needed to improve economic competitiveness.

LINKING POLLUTION AND CITY COMPETITIVENESS

Impact of pollution on the labor force

PMEH funding led to the publication of the literature review Does Pollution Hinder Urban Competitiveness?[1] that examines the key values of a labor force that can either contribute to or inhibit a city's economic growth. The review also investigates how these values are affected by pollution. Key findings from this work demonstrate that pollution has a negative impact on all the values of a strong labor force including the population's health, productivity, and equality of opportunity. Children who are sick learn less in school and as a result struggle to achieve their full productive potential. At the same time, highly polluted cities have more trouble attracting qualified workers, and companies may need to pay them more. Pollution also has a negative effect on workers' productivity by limiting their ability to perform or increasing the number of days lost due to sickness. Finally, pollution increases inequality in living standards, because skilled workers can opt to work in less-polluted cities, while less-skilled workers will have to remain in areas with worse air quality, where their productivity will be negatively affected, increasing the gap between these two groups.

Findings from this review show that lower levels of air and water pollution provide a competitive advantage in attracting people and jobs. The policy implication from this report

advocates for increasing environmental regulation to reduce the economic costs of pollution on the labor force. If more cities in LMICs view environmental protection as a competitive strategy, they will be able to decrease inequality, create jobs, and ultimately reduce poverty.

Impact of air pollution on city growth

As the population grows in urban areas, so does congestion, crime, industry, and pollution. These challenges are more difficult to tackle in LMICs where a lack of resources and capacity prevents fast action. PMEH conducted a study—Pollution and City Competitiveness: A Descriptive Analysis[2]—that explores the connection between air pollution and the growth of a city. This analysis examines how growing cities can overcome increasing pollution levels and avoid the problems that jeopardize their competitiveness. Most cities often follow a certain path in the relationship between air-pollution levels and city growth. At first, when cities are at the earlier stages of development and mostly centered on agriculture and early industrial activities, pollution is often low. As cities start transitioning to heavier industrial activity, pollution levels start to rise, and cities reach a second stage characterized by fast industrialization and high pollution. In the third stage, cities learn to manage pollution and its levels start to decrease, while the cities continue to grow.

While this path is the most common in the growth and development of a city, it is not the only path. If city-level policy efforts are proactive and focused on ecosystem and health protection, then it is possible to manage pollution through the growth transition and avoid this trajectory.

Impact of pollution on business productivity in Africa

Businesses that are more productive tend to locate in an environment where they can maximize profits. While growing cities attract more businesses, the business environment can, in turn, make an impact on the productivity of workers and thus the profitability of the company. The African continent is home to the world's fastest-growing cities; however, air pollution in these growing urban areas has also increased to dangerous levels. PMEH conducted a regional-level analysis—The Effects of Pollution and Business Environment on Firm Productivity in Africa[3]—to examine the link between air pollution and the business environment. The study found that rising air-pollution levels negatively affect both worker productivity and employment growth. African companies are also affected slightly differently than in other areas. For African businesses, the negative effects of air pollution on productivity occur earlier, at lower concentrations of pollution, than in other places. As a result of these findings, African cities have an opportunity to change the trajectory. While these cities are experiencing fast growth, air-pollution levels have not yet reached the high levels experienced in places like China and India. With proactive development, these cities have the ability to avoid the negative economic and environmental impacts of unplanned growth.

DEEP DIVES

Impact of air pollution on company productivity in Kampala, Uganda

PMEH partnered with a local university in Kampala to investigate the impact of air pollution on the productivity of businesses in the city. The study found that air-pollution levels were highest seasonally during the dry season and daily during times of peak traffic. On average, businesses tended to be clustered in more-polluted areas. Analytical work from this project has initiated discussions with the city of Kampala to incorporate recommendations into their upcoming Kampala City Development Strategy. This work has also led to the development of a mobile application that can now be used by citizens to view and control air quality and take preventive measures.[4]

The images to the right depict static and mobile monitors deployed in Kampala to record air-pollution measurements that were then linked with data on companies in Kampala to assess possible relationships between air pollution and productivity.

Source: World Bank.

Impact of air pollution on worker productivity in Dhaka, Bangladesh

In Bangladesh, PMEH is working with the government to transform Dhaka into a prosperous and livable city by investigating the impact air pollution has on worker productivity. To study the impacts of air-pollution management, the team conducted an intervention in which air filters were installed in a factory to reduce air pollution by 20 percent. Worker productivity at the factory with the intervention was compared to a similar factory that did not have air filters. An increase in productivity was observed in the factory with air filters compared to the factory without filters. Findings from this study are being included in the Dhaka Metropolitan Development Transformation Platform. This local policy platform is a strategic framework for orienting investment priorities across different subcenters in the Dhaka metro area based on urban growth and livability measures. PMEH's work complements the city's strategy and highlights priority areas for policy interventions to reduce air and water pollution and develop a pipeline of needed investments across the city.

Links between environmental quality and tourism in Zanzibar, Tanzania

The World Bank is planning to finance a lending project in Tanzania that aims to improve living conditions and promote local economic development through sustainable tourism in Zanzibar. PMEH conducted a study to understand how both the community's and visitors' perceptions of pollution affect tourism in the area. This analytical work serves as the baseline study for future

World Bank lending activities. Findings indicate that tourists who assigned a higher cleanliness rating were more willing to return to Zanzibar. The most negative perceptions of tourism in the area were associated with some type of pollution. The areas of Zanzibar that require the greatest improvement are waste and wastewater management, as well as beach cleaning. Successful enforcement of pollution policies and regulations with increased community awareness could help to reduce pollution and change the perception of visitors to the area.

Impact of pollution on market productivity in Monrovia, Liberia

PMEH analytical work in Monrovia focused on the evaluation of the different sources of pollution and their impacts on the performance and productivity of the Duala market. The Duala market is one of the most important economic zones of the Greater Monrovia metropolitan area. However, the market faces extensive congestion challenges that compound the pressure on the fragile ecosystem. In addition, inadequate market infrastructure is dramatically increasing the risks of public-health emergencies. Market infrastructure and service mapping revealed that 72–89 percent of vendors operate informally. These informal vendors have expanded beyond the market boundaries to more than 11 times the size of the market. Improved market management could lead to a 3-fold to 7-fold increase in market revenue. One of the biggest challenges affecting the market is a lack of sanitation facilities, which leads to higher instances of illness and missed work opportunities. There is also a high rate of perishable food waste on a daily basis. Addressing food loss and improving solid-waste management could increase gross profit by 9 percent. Improving the market conditions will require a clearer arrangement of the institutional responsibilities between national and local entities. Market managers also need to address financing shortfalls that adversely affect market productivity. PMEH's work has assisted in defining an argument for investments in the market as well as possible interventions that could be financed by the World Bank and other donors. Recommendations from this study will continue to be implemented through the proposed Monrovia Integrated Development Project, which is currently under preparation by the World Bank.

EVIDENCE-BASED TOOLS FOR EFFECTIVELY MANAGING POLLUTION

Framework for pollution management and city competitiveness

Urban planners and environmental managers globally are increasingly recognizing the need to adopt more-integrated approaches that promote green urban development. Based on the city competitiveness analytical work, PMEH developed a toolkit for urban planners to support the implementation of pollution-management programs and guide cities to become more competitive and livable. A report, *A Framework for Pollution Management and City Competitiveness*, was developed that proposes an improved framework for integrating pollution management as a component for city competitiveness. The report describes the main characteristics of a competitive city, the costs of pollution on cities, and the economic benefits of managing pollution. The toolkit also includes best practices from cities that have been successful in managing pollution.

Best practices and cases of competitive cities

Cities use different approaches to implement pollution-control and environmental-protection programs. This section of the framework presents the best practices from cities that have successfully developed different programs with the same goal of improving pollution while enhancing competitiveness. All of the programs had a positive effect on the economy through improved health benefits, new job opportunities, enhanced industry efficiencies, and the ability to attract companies and foster innovation. In all cases, cities strengthened regulations and enforcement of pollution management, environmental protections, and urban-development policies. Successful cities also built local capacity for policy implementation and invested in human capital. Each program had clear roles and responsibilities for institutions and coordinated efforts across different stakeholders including local governments, civil society, and the private sector. Multi-stakeholder coordination enabled cities to develop transparent information systems that raise awareness of environmental issues and engage citizens in preventive and protective actions. The following cities were profiled from high-, middle-, and low-income countries that have been successful in managing pollution:

- Copenhagen, Denmark, for transport and air-pollution management
- Vancouver, Canada, for transport and air-pollution management
- Kawasaki, Japan, for industrial air pollution
- Muangklang, Thailand, for waste management
- Baku, Azerbaijan, for waste management and hazardous-waste management
- Kitakyushu, Japan, as a Sustainable City
- São Paulo, Brazil, as an interesting case of a megacity that still struggles with severe air pollution

PMEH analytical work linking pollution with city competitiveness has produced evidence that cities with a large and productive labor market tend to grow faster and become competitive, but pollution can threaten that path. Polluted cities may end up attracting more 'dirty' industries, making the problem worse. Environmental regulations help to manage pollution; however, designing and implementing policies in LMICs can be challenging. Cities that successfully manage pollution levels have been shown to have a proactive attitude toward these issues. Thus, there is a clear opportunity for cities in the early stages of development. Cities that are growing fast, attracting people and businesses, and facing the natural challenge of increasing density are at a critical point. These cities have the chance to plan ahead, take action, and face these challenges with an emphasis on pollution control. By strategically focusing on sustainable urban growth, these cities can transform their environment and position themselves as competitive cities. Through proactive action, cities can successfully increase the productivity of businesses, attract cleaner industries, and improve the quality of life for their residents.

NOTES

1. See: Kahn, Matthew Edwin, Nancy L. Gracia, and Maria E. Soppelsa. 2019. "Does Pollution Hinder Urban Competitiveness?" Policy Research Working Paper 8739. Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/961131550092253676/Does-Pollution-Hinder-Urban-Competitiveness This report has been accepted for publication in *Journal of Economic Surveys*.

2. See: Lozano, Nancy, and Maria E. Soppelsa. 2019. "Pollution and City Competitiveness: A Descriptive Analysis." Policy Research Working Paper 8740. Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/115861550150961022/Pollution-and-City-Competitiveness-A-Descriptive-Analysis Some of the findings of this report were included in the version of the paper submitted to *Journal of Economic Surveys*.

3. See: Soppelsa, Maria, Nancy G. Lozano, and Colin L. Xu. 2019. "The Effects of Pollution and Business Environment on Firm Productivity in Africa." Policy Research Working Paper 8834. Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/850371556630917519/The-Effects-of-Pollution-and-Business-Environment-on-Firm-Productivity-in-Africa

4. https://www.airqo.net/

COMMUNICATIONS AND KNOWLEDGE MANAGEMENT

SECTION OVERVIEW

A key PMEH program activity is the dissemination of knowledge and the promotion of pollution-management and environmental-health issues among policy makers, business partners, city leaders, and the general public. From its inception, PMEH has put significant efforts into sharing and making widely available the knowledge and findings acquired through PMEH's AQM operations and analytical work. As part of these activities, PMEH works with BreatheLife, a global campaign mobilizing cities and individuals to protect human health and the planet from the effects of air pollution.

In June 2019, PMEH's China program supported two delegations of policy leaders and technical experts to visit Austria to learn about GAINS applications and implications for cost-effectiveness studies. An October 2019 workshop in Washington, DC, brought together international experts from Chile, China, the EU, Germany, Mexico, and the US to share their experience on how their countries are tackling air pollution. A three-day November 2019 workshop brought together the PMEH Secretariat, PMEH country team members, donors, and government officials to share global experiences of successful programs for air-quality management; the workshop was organized by GIZ. To date, four technical workshops presented findings from analytical work on pollution management and city competitiveness: two in Kampala and two in Washington, DC. PMEH partnered with the Korea Environmental Industry & Technology Institute to bring together innovators, pollution-management authorities, and water-quality experts to explore emerging innovative technologies for improving pollution management around the world.

The World Bank's Environment, Natural Resources and Blue Economy Global Practice, with support from PMEH, partnered with the US Environmental Protection Agency to develop an online training course on air-quality management. The course is designed for professionals, students, government officials, and partners in LMICs to gain a better understanding of air pollution and issues relating to air-quality management, and nearly 350 people have benefited from this course so far. With the progression of analytical work and program activities, PMEH continues to update its website with new videos, articles, and published documents. Two PMEH reports and three PMEH working papers have been downloaded a total of over 5,500 times.

INTRODUCTION

An important component of the PMEH program is dissemination of knowledge and promotion of pollution-management and environmental-health issues among policymakers, business partners, city leaders, and the general public. PMEH is involved in promoting communications, social media, and knowledge exchange at global and local events in World Bank client countries. PMEH also has ongoing engagement through information sessions and workshops that promote findings from PMEH analytical work that push forward the dialogue on pollution management.

The World Bank team participated in the first WHO Global Conference on Air Pollution and Health. This important summit attracted more than 900 participants and resulted in nearly 70 countries, cities, UN organizations, intergovernmental organizations, and civil societies committing to actions to reduce deaths from air pollution. PMEH exhibited nine presentations, including one which previewed the World Bank report on the costs and benefits of policies for improving air quality and examined synergies and trade-offs between air pollution and climate-change mitigation. Continuing the dialogue from this event in 2019, PMEH organized multiple knowledge exchanges to facilitate the sharing of best practices in air-pollution management. Key stakeholders from World Bank client countries were able to learn from international experts and integrate findings into policies and regulations in their own countries.

Recognizing the need to enhance the sustainability of PMEH support, the PMEH Steering Committee in 2019 requested that communications target high-level policy decision-makers, highlight the outcomes of PMEH-supported work on climate and air pollution, and underscore the importance of addressing air pollution. Engagement with decision-makers has been occurring throughout the PMEH program and will be ramped up in the short term.

GLOBAL EVENTS AND CAMPAIGNS

BREATHELIFE CAMPAIGN

PMEH is an active member of BreatheLife, a global campaign launched to mobilize cities and individuals to protect human health and the planet from the effects of air pollution. The strategy of the campaign is to provide a platform for cities to share best practices and demonstrate progress in their journey to meeting World Health Organization (WHO) air-quality targets by 2030. The campaign works with municipalities to expand monitoring efforts that can keep citizens informed and facilitate sustainable urban development. Through this network, PMEH is sharing knowledge, analytical work, and success stories from program activities.

KNOWLEDGE-EXCHANGE WORKSHOPS AND INFORMATIONAL SESSIONS ON AIR-QUALITY MANAGEMENT

Since the beginning of the program, PMEH has put significant efforts into sharing and broadly disseminating the knowledge and findings acquired through its AQM operations and analytical work. In 2019, more than 21 lunchtime information sessions on specific in-country PMEH activities were held with video conferencing and options for remote access.

Air-quality management: Learning from international experiences

An October 2019 workshop in Washington, DC, brought together international experts from Chile, the European Union, Germany, Mexico, and the United States to share their experience on how their countries are tackling air pollution. Presentations focused on (i) institutional structures to implement an airshed-based management approach, (ii) legislative and regulatory instruments to incentivize state governments to implement air-quality management plans, and

(iii) the role of pollution charges and market-based instruments in helping to achieve air-quality standards.

EXCHANGE WORKSHOP ON EXPERIENCES WITH AIR-QUALITY MANAGEMENT

GIZ organized an event in November 2019 to share global experiences of successful programs for air-quality management. The three-day workshop brought together government officials, donors, PMEH country team members, and the PMEH Secretariat. Participants met in Eltville and Rhein, Germany, to discuss their experiences with AQM implementation and learn about new methods and opportunities for greater impacts in their respective programs. Presentations covered topics such as scaling up AQM interventions; overviews of air quality in the different cities; GAINS and new, national environmental-protection legislation on AQM in Vietnam; and the LEAP-IBC integrated assessment tool for climate-related emissions and air pollutants in Ghana. There were also presentations on the results of PMEH analytical work on air-quality monitoring using satellite data and ground-level monitoring stations, chemical speciation, and the methodology from the Global Burden of Disease. World Bank team members also shared success stories from countries—including China, Mexico, Mongolia, and Peru—that have been able to achieve significant reductions in particulate matter in less than a decade.

Air-pollution control in India: Learning from best practices

An October 2019 workshop in Washington, DC, brought together international experts to share their experience on best practices with AQM policy design and implementation. Based on international expertise, this workshop helped to build the Indian government's capacity to create policies and regulations on air-quality management. Information from this workshop is helping the government of India reach the goals for air-pollution reduction that were set as a part of the National Clean Air Programme that was launched in 2019.

China program knowledge exchange

In June 2019, the China program supported two delegations of policy leaders and technical experts to visit Austria to learn about the application of the GAINS model and its implications for cost-effectiveness studies. The tour was designed for policy leaders and technical experts to develop a common understanding of European AQM policy making and technical methodology. The delegation shared information regarding the AQM experiences of European countries and institutions in Austria, with a focus of learning about regional and local AQM and applications of cost-effectiveness analysis. This was the Chinese government's second official mission to Europe to exchange experiences on the AQM topics supported by PMEH.

WORKSHOPS AND INFORMATIONAL SESSIONS ON AIR POLLUTION AND FIRM PRODUCTIVITY IN KAMPALA

Four technical workshops were conducted to present research findings from analytical work on pollution management and city competitiveness. Two workshops were organized in Kampala to

discuss the scope and relevance of the deep-dive analytical work on city competitiveness with national and local authorities. The first workshop, held in December 2018, focused on exploring key challenges of firm success in Uganda and was attended by representatives of the National Environmental Management Authority, Uganda Cleaner Production Center, and representatives of Kampala Capital City Authority. The second workshop, in March 2019, presented the AirQo mobile application project by Makerere University and the deployment of a network of low-cost air-quality monitors in Kampala. This workshop included representatives of the Kampala Capital City Authority, National Environmental Management Authority, and a representative of the US ambassador.

Two workshops were also organized in Washington, DC. The first focused on the links between urban pollution and city competitiveness. The second was held in May 2019 and presented the ongoing research on firm productivity and pollution in Uganda.

The knowledge exchanged in these workshops has had significant operational impacts. The Kampala Capital City Authority is using the recommendations from this work as an input into their strategic urban plan for the city, which is currently under preparation. One of the recommendations to develop an air-quality analytics dashboard has already been implemented. Recommendations from this work are also currently being used to build consensus with local stakeholders on the management of pollution sources in Kampala. Based on the deep-dive research in Uganda, a blog on the data efforts has been drafted and sent for inclusion in the pipeline of the sustainable cities World Bank blog.

DISRUPTIVE TECHNOLOGIES FOR POLLUTION MANAGEMENT

PMEH partnered with the Korea Environmental Industry & Technology Institute to bring together innovators, pollution-management authorities, and water-quality experts to explore some of the innovative technologies that are emerging to improve pollution management around the world.

PMEH in the news

The image to the left depicts a May 2019 report in a Vietnamese


ENVIRONMENT

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GAINS model to help alleviate air pollution in northern localities

The usage rights of greenhouse gas and air pollution interactions and synergies (GAINS) model has been transferred to the Departments of Natural Resources and Environment (DoNREs) of Hanoi, Bac Ninh, and Hung Yen.

Source: VietNamNet Online Newspaper report, "GAINS Model to Help Alleviate Air Pollution," May 2019. https://english.vietnamnet.vn/fms/environment/221336/gains-model-to-help-alleviate-air-pollution-in-northern-localities.html

news source informing on the results of the first training and workshop for the updated emissions inventory of the Vietnam PMEH GAINS model.

ONLINE COUSE: INTRODUCTION TO AIR-QUALITY MANAGEMENT

The World Bank's Environment, Natural Resources and Blue Economy Global Practice, with partial support from PMEH, developed an online training course on air-quality management. The course examines the key approaches for reducing air pollution and provides the foundation for designing programs to manage air quality in LMICs. The course is available through the World Bank's open learning campus platform, with free and open access to the public. It is designed for professionals, students, government officials, and partners in LMICs to gain a better understanding of air pollution and issues relating to air-quality management.

DIGITAL KNOWLEDGE MANAGEMENT

With the progression of analytical work and program activities, PMEH continues to update its website with new videos, articles, and published documents. In 2019, several PMEH reports were posted online, including the following:

- *Egypt: Cost of Environmental Degradation of Air and Water Pollution*
- *Motor Vehicle Density and Air Pollution in Greater Cairo: Fuel Subsidy Removal & Metro Line Extension and their Effect on Congestion and Pollution*

The PMEH publications were downloaded over 10,000 times.

FINANCIAL OVERVIEW

The PMEH multi-donor trust fund was established in November 2014. Donors include Germany's Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU); Norway's Ministry of Foreign Affairs; and the United Kingdom's Department for International Development (DFID) and Department for Business, Energy & Industrial Strategy (BEIS). PMEH was initially convened as a six-year multi-donor trust fund; however, the PMEH Steering Committee extended the program by one year to allow certain countries enough time to complete air-quality monitoring and other program components. The PMEH trust fund is scheduled to close in December 2021.

The PMEH program has seven countries participating in programs on climate and air-quality management, as well as components for analytics and dissemination activities. Relevant expenditures by component are listed in the table below. In 2019, the PMEH Steering Committee endorsed the workplans and the allocation of budget for the country AQM tasks. The Steering Committee endorsed Bank Executed Trust Fund Grant (BETF) budget allocations for AQM tasks for $15,705,000. In addition, the Steering Committee endorsed the budget allocations for procurement of capital goods through recipient-executed trust funds for Egypt ($750,000) and South Africa ($1,000,000). The table below summarizes PMEH's Financial Report for 2019.

PMEH EXPENDITURES AND COMMITMENTS 2019

Expenditure Category	Total Expenditures by Dec. 31, 2019	Commitments by Dec. 31, 2019	Expenditures + Commitments by Dec. 31, 2019
1. Air-Quality Management Component			
China – Hebei region: Climate and Air-Quality Management	1,702,844	50,982	1,753,826
Egypt – Cairo: Climate and Air-Quality Management	425,069	190,006	615,075
Ghana – Accra: Climate and Air-Quality Management	509,042	167,850	676,892
India – Climate and Air-Quality Management	734,985	32,625	767,610
Nigeria – Lagos: Climate and Air-Quality Management	1,395,492	28,408	1,423,900
South Africa – Johannesburg: Climate and Air-Quality Management	318,178	17,730	335,908
Vietnam – Hanoi: Climate and Air-Quality Management	464,487	236,070	700,557
Subtotal Component 1	**5,550,098**	**723,671**	**6,273,769**

2. Analytics			
2.1 Air-Quality Monitoring and Health Risks and Effects	1,004,331	4,147	1,008,478
2.2 Land-Based Pollution	–	–	–
2.2.1 Toxic-Site Identification	756,774	239,889	996,664
2.2.2 Land-Based Pollution: Health and Economic Effects	805,405	113,600	919,005
2.3 Pollution Management and the Making of Prosperous Cities	705,365	82,053	787,418
Subtotal Component 2	**3,271,876**	**439,689**	**3,711,565**
3. Dissemination	**1,274,829**	**3,420**	**1,278,249**

PMEH CONTRIBUTIONS

	Original Trustee TF072335	Parallel Trustee TF072732	Total
A. Actual Funds Received from Donors	14,303,989	8,408,000	22,711,989
Germany: BMU		8,408,000	8,408,000
Norway: Ministry of Foreign Affairs	7,313,764	–	7,313,764
United Kingdom: BEIS (1st Tranche of Promissory Note)	2,463,945	–	2,463,945
United Kingdom: DFID	4,526,280	–	4,526,280

PMEH

POLLUTION MANAGEMENT & ENVIRONMENTAL HEALTH

The Pollution Management and Environmental Health (PMEH) multi-donor partnership, established in 2014 and administered by the World Bank, supports countries in managing air quality and toxic sites and generates cutting-edge knowledge and guidance to reduce pollution for public health, poverty reduction, economic growth, and environmental and climate co-benefits.

Check out the latest program updates, resources, and more at **www.worldbank.org/pmeh**

Website: **www.worldbank.org/pmeh**
Contact: **PMEH@worldbank.org**