Breathing Health(ier) Amid Rapid Urbanization

Challenges and opportunities related to tackling the primary contributors of Dhaka's air pollution

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Introduction

Poet Dilruba Ahmed captures an image of a street scene in Dhaka, Bangladesh, through the eyes of a visitor in her 2011 award winning poem "Dhaka Dust" ending with,

> "Dust sifts into your lungs and sinks—feline,
> black, to remain long after you leave."
> Dilruba Ahmed†

These words evoke a feeling of connectedness to the intense sensory experience of navigating through the turmoil that is Dhaka. They are also an accurate portrayal of the physiology of breathing in Dhaka when air pollution levels are high. With elevated awareness of air pollution's health effects, efforts are increasingly being made to reduce it for the health of the city's population.

This information brief summarizes ambient air quality issues in Bangladesh and their known health effects. It also provides a review of the primary source of Dhaka's air pollution--traditional brick kilns—and its secondary key contributors--road and construction dust and vehicle emissions.

For each of these major contributors, changes required to reduce harmful air pollution levels are outlined. Most of the identified solutions are widely recognized and many are currently being implemented. Yet, rapid and coordinated action is necessary to achieve meaningful reductions in pollution.

Doing so could substantially improve Bangladesh's air quality, and consequently the nation's health, without stifling economic growth.

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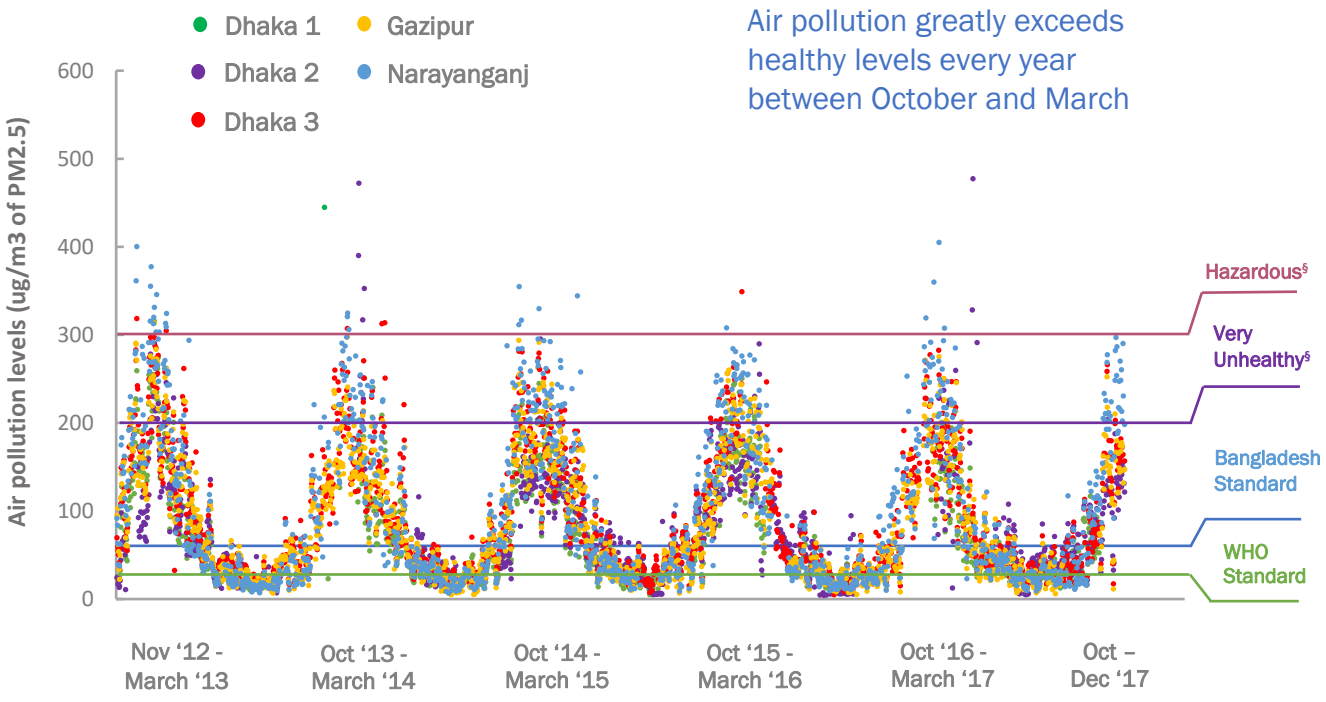
† Dilruba Ahmed is the author of the collection of poems titled *Dhaka Dust* published by Graywolf in 2011. *Dhaka Dust* won the 2010 Bakeless Literary Prize for poetry.

Air Quality in Bangladesh

Air pollution levels become excessively high during the winter months (October-March) in Bangladesh. The Bangladesh Department of Environment's Clean Air and Sustainable Environment (CASE) project has been tracking and reporting average daily air quality readings from eight major cities across the country since 2012‡. All sites report unhealthy§ levels of air pollution, particularly in the winter months. The data are published daily on the CASE Project's website. Because the numbers reported are average pollution levels over 24 hours, the highest levels reached each day are not reflected.

Five years of air pollution data representing Greater Dhaka are presented below in Figure 1. These data are sourced from the CASE Project's three locations in Dhaka City, and monitoring stations in adjacent Gazipur and Narayanganj Districts.

Figure 1. Air Pollution Levels in Greater Dhaka 2012-2017



Data sourced from Bangladesh Department of Environment
Ministry of Environment, Forest and Climate Change

‡ CASE Project: http://case.doe.gov.bd/. See Air Quality Index.
§ The widely used U.S. Air Quality Index assigns the categories of Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, Very Unhealthy and Hazardous based on the associated degree of health concern.

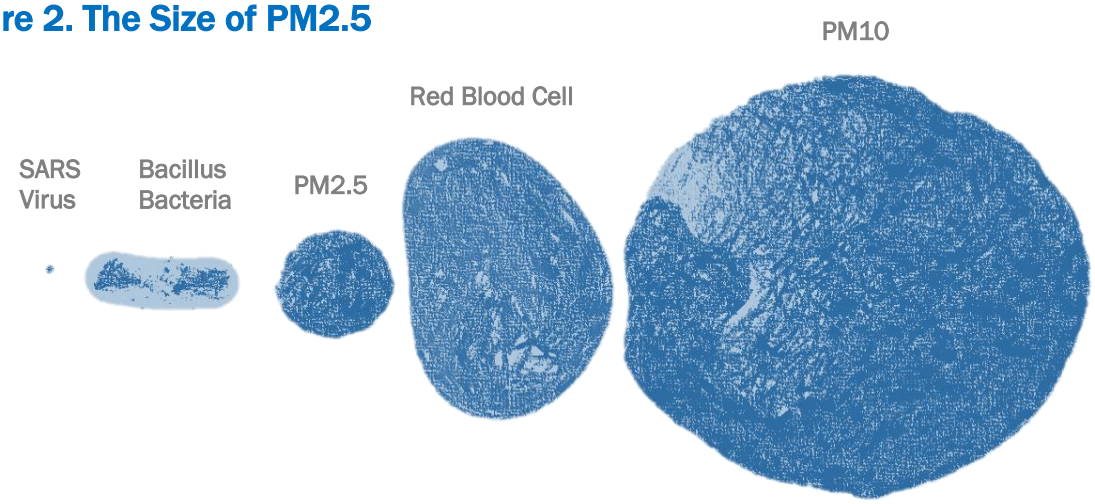
Fine Particulate Matter: The Main Pollutant

The chart on the previous page depicts concentrations of fine particulate matter measured in the air, generally referred to as PM2.5. Countries establish acceptable levels of PM2.5 based on recommendations from the World Health Organization (WHO), as well as guidance from environmental health experts.

What is PM2.5?

- PM2.5 refers to particles in the air that are smaller than 2.5 microns (1/1,000,000th of a meter) in diameter (Figure 2).
- These particles are made up of different mixtures of organic and inorganic matter, namely sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water.
- Particles this tiny can travel deep into the lungs, and pass through the alveoli into the bloodstream.
- The presence of PM2.5 as an airborne pollutant is measured in terms of micrograms per cubic meter (ug/m^3) of air[1].

Figure 2. The Size of PM2.5



Papathanasiou, S. (2017). See The Air: The essential guide for optimal air quality in your life.

WHO's standards for PM2.5 are listed in the table on the following page, together with national standards for Bangladesh China, India and Thailand. Annual and 24-hour thresholds are used, which allows for some high pollution periods balanced by periods of low pollution. WHO standards are based on the best available scientific evidence of the health effects of human exposure to PM2.5.

Figure 3. Standards for PM2.5 Concentrations

Air quality standards for Bangladesh, China, India and Thailand are higher than those recommended by WHO.

	WHO	Bangladesh	China	India	Thailand
Annual average (ug/m³)	10	15	35	40	25
24-hour average (ug/m³)	25	65	75	60	50

Joss, M.K. et al. (2017). Time to harmonize national ambient air quality standards. *International Journal of Public Health* 62(4): 453–462

The PM2.5 levels in Dhaka surpass Bangladesh's acceptable 24-hour limits by 2.5-5 times for six months each year. The capital city's annual PM2.5 average is eight times higher than that recommended by WHO[2,3]. Dhaka's air quality is of particular concern due to its large and swiftly growing population, which is expected to reach 27 million by 2030[4,5].

Levels of Gaseous Pollutants are Acceptable

In addition to PM2.5, other common air pollutants are coarse particulate matter (PM10), ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Of these, in Bangladesh, only PM10 levels surpass those prescribed by both the Government of Bangladesh and WHO. Gaseous pollutants—O_3, NO_2 and SO_2—remain predominantly within national standards and thus do not pose an environmental health risk.

That these pollutants have remained within prescribed limits, despite rapid urbanization, is attributed to various regulations instituted by the government beginning in the early 1990s. Over this decade, compressed natural gas was introduced to the transportation sector as a cleaner fuel alternative. In 1999, lead was removed from gasoline. Subsequently, two-stroke engines were phased out from Dhaka's roads. As a result of these measures, the overall contribution of vehicle emissions—the primary source of gaseous pollutants—dropped significantly[6].

Why Air Quality Matters

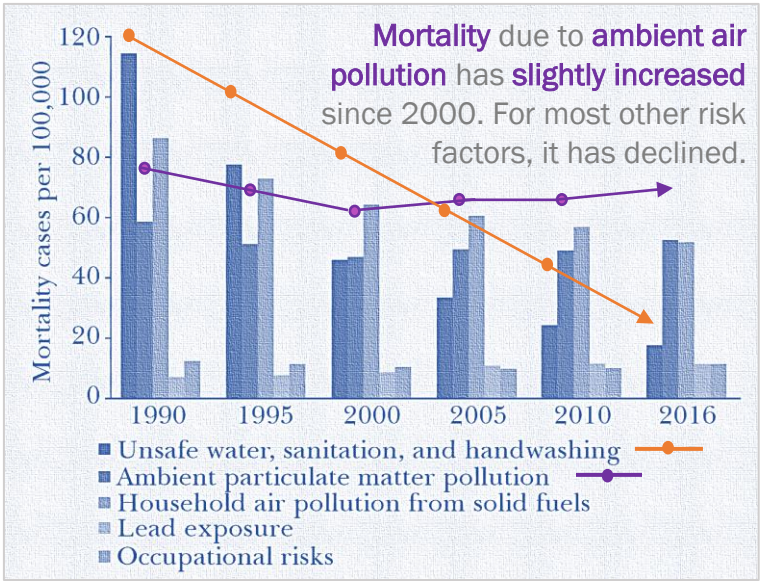
Health Effects

A large and growing body of scientific evidence documents the health impacts of human exposure to PM2.5. It covers short-term and long-term effects as well as different effects on children and adults. For adults, exposure to PM2.5 increases the risk of premature death from heart disease resulting from clogged arteries. It also elevates the risk of premature death from stroke, chronic obstructive pulmonary disease, and lung cancers. Even short-term exposure (of a single day or as little as one or more hours of PM2.5) is significantly associated with increased morbidity and mortality for cardiovascular and respiratory conditions[7].

Among children, exposure to PM2.5 increases the risk of acute lower respiratory infections and asthma, and leads to reduced lung functionality. PM2.5 exposure has be linked to infant bronchiolitis, which is inflamation and congestion in the small airways in the lungs. Significant associations between PM2.5 exposure during pregnancy and premature birth and low birth weight have also been found[8,9] .

According to World Bank estimates, in 2015 alone over 30,000 people died in Bangladesh's urban areas due to exposure to PM2.5. Illness and mortality due to ambient air pollution is on an upward trend, following the pattern of rapid urbanization. Parallel to this, risks due to unsafe water, sanitation and hygiene have declined over the past 30 years as a result of effective public health interventions (Figure 4)[2].

Figure 4. Mortality Trends in Bangladesh by Different Environmental Risk Factors



Source: World Bank[1]

On average in Bangladesh, sustained PM2.5 exposure shortens one's lifespan by more than four years[10]. Globally, it is deadlier than smoking, three times

deadlier than AIDS, tuberculosis and malaria combined, and 15 times deadlier than conflict, war and terrorism[11]. These facts are illustrated in Figures 5 and 6.

Figure 5. Years of Life Lost to Particulate Pollution by Country

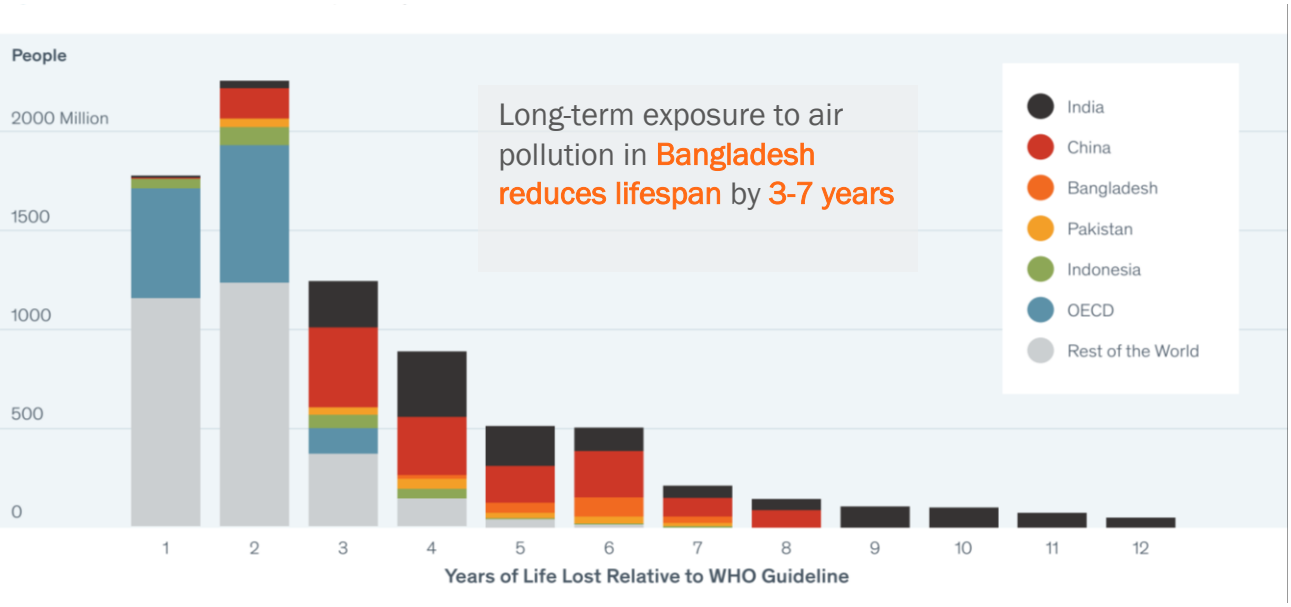
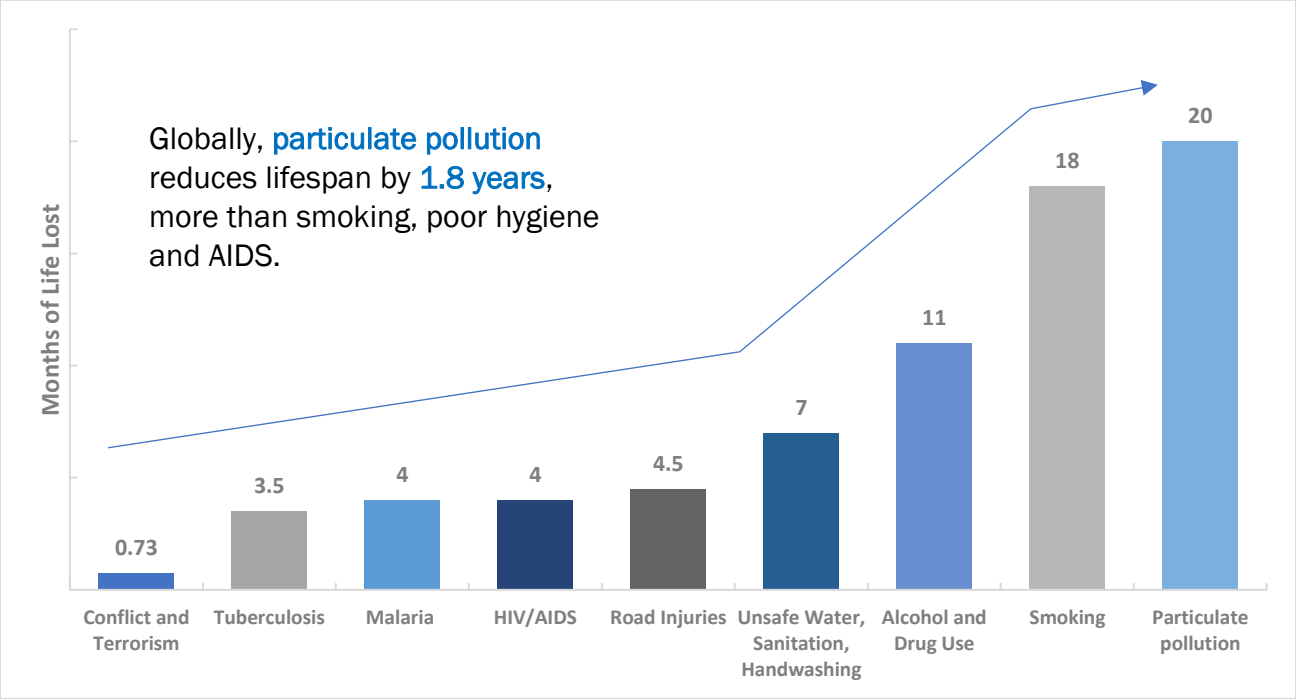


Figure 6. Global Average Months of Life Lost by Cause of Death



Source (Figures 5 & 6): Air Quality Life Index

Climate Effects

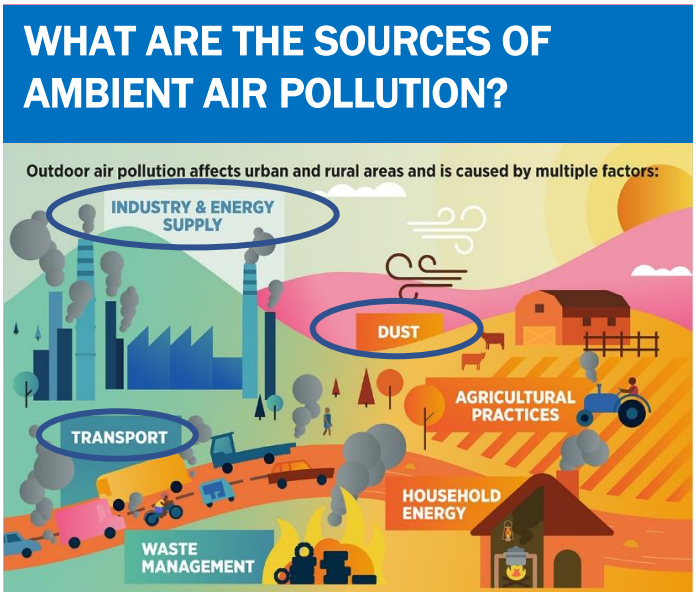
Pollution also accelerates climate change. Particulate matter and gaseous pollutants that are harmful to human health are also the primary sources of greenhouse gases and short-lived climate pollutants. Black carbon, identified as potentially the second most harmful climate pollutant (next to carbon dioxide) makes up 10-30% of PM2.5[12].

In the atmosphere, black carbon absorbs sunlight and generates heat, influencing regional cloud formation and rainfall. On snow and ice, the heat it generates accelerates melting. As a short-lived climate pollutant, black carbon remains in the atmosphere for one to four weeks. Thus, reducing black carbon in the environment is expected to create immediate reductions in warming[13].

What Can be Done to Reduce Air Pollution?

To address harmful air pollution, the primary sources of the pollution, and options for reducing them, must be identified. For the capital city, Dhaka, the brick kiln industry is responsible for 58% of the ambient air pollution. Dust and vehicles are the two most important additional sources, responsible for 15.3% and 10.4% respectively[6]. Figure 7 depicts the primary sources of air pollution globally, with those most relevant in Bangladesh circled.

Figure 7: Sources of Outdoor Air Pollution



Source: World Health Organization

The Brick Kiln Industry

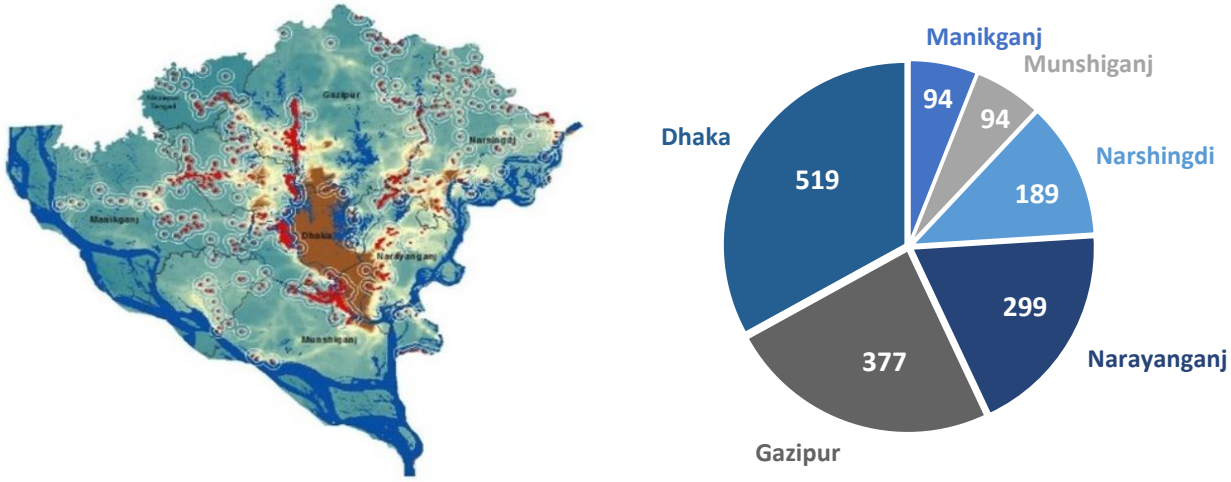
Coal-fired brick factories are the largest source of outdoor air pollution both in the Dhaka Metropolitan Are and around the country. Most bricks are produced

in Bangladesh using a firing process that burns low quality coal (sourced from India). As a result of incomplete combustion, the emissions from the coal firing process produce large amounts of PM2.5 and carbon dioxide. A significant portion of the PM2.5 is black carbon.

Due to a lack of naturally occurring stone in the deltaic region, bricks are a vital construction material. Nationally, there are at least 4,500 traditional kilns. Most are small-scale and informally operated, posing a challenge for enforcing industry regulations. Each year, the industry produces about 17 billion bricks, generating close to 15 million tons of CO_2. The industry's annual growth rate is estimated to be in the range of 2-6%[3,14]. A recent mapping conducted located 1,572 brick fields in the Greater Dhaka area (Figure 8).

Figure 8. Brick Kiln Clusters in Greater Dhaka

Brick kilns, marked in red on the map and numbered in the pie chart, are concentrated in **Dhaka (33%), Gazipur (24%) and Narayanganj (19%)** districts.



Islam, A. (2016). Spatial Patterns and Location Risks of Brickfields in Greater Dhaka Region in 2015. DOT N'ARC.

The brick kiln industry poses other social and environmental challenges in addition to pollution. Kiln workers are predominantly poor seasonal migrants. Child labor is not uncommon. The valuable clay topsoil used for brick production causes extensive damage to agricultural lands. Finally, wood (as well as other scrap material) is used as kindling, or for the firing process if coal is not available, which contributes to forest degradation[14]. Efforts to transform the industry must address these issues as well as harmful air pollution.

Industry Changes as a Result of Government Regulation

The Bangladesh Government has instituted two successful industry regulations. The first was a push in 2002 to convert Bull's Trench Kilns to Fixed Chimney Kilns with a 120ft chimney, making them more efficient and less polluting. More recently, another push was initiated to convert Fixed Chimney Kilns to ZigZag Kilns, which further increase efficiency and reduce pollution. To date, more than 70% of Fixed Chimney Kilns have been converted. Modest overall reductions in PM2.5, including black carbon, have been documented following these conversions[14]. However, they are far from what is needed. Inconsistent compliance with intended lower emission standards (<200 mg/m^3 of PM) across converted kilns has also been documented[2]. More intensive monitoring and technical assistance is necessary in this area to improve health and protect the environment. Technical information about technology options for reducing brick kiln emissions can be found in the below links**.

Investments Made by Development Partners

The United Nations Development Programme, The World Bank, the Climate and Clean Air Coalition, the Asian Development Bank, and others have invested close to $150 million U.S. dollars over the past 10 years to support the introduction of cleaner and more efficient brick production and/or alternative building materials. The work has resulted in the establishment of at least 20 automated clean-technology brick factories, ongoing work to build traditional kiln owners' capacity to adapt to new technology, and the development of a variety of cost effective and market ready non-fired bricks. See footnote for links to some of these projects.††

Opportunities to Invest in Non-Fired Bricks

Non-fired bricks are a viable no-pollution alternative to fired bricks in Bangladesh. The national Housing and Building Research Institute has pioneered and tested various options that use locally available renewable resources such as non-mineral course and fine sand, dredged river sand, fly

** Factsheets About Brick Kilns in South and South East Asian (2014) I Chemical and Thermodynamic Processes in Clay Brick Firing Technologies and Associated Atmospheric Emissions Metrics-A Review (2017)
†† GREEN Brick I CASE Project I Brick Kiln Financing I Brick Kiln Efficiency Project I JICA Project.

ash, gravel, stone dust, and industrial and construction waste. Cement and clay are also raw materials for various types of non-fired bricks.

The Government and development partners should direct more resources toward all of these efforts to bring them to scale.

Road and Construction Dust

Experts at the Department of Environment predict that while the brick production sector's contribution toward PM2.5 may have decreased somewhat in recent years, road and construction dust have likely increased. As a river delta, most of Bangladesh's landmass is made up of sediment deposits. Much of this consists of various classes of sand. As a result, when the sand is disturbed due to passing vehicles, or due to construction, dust is suspended into the air[15].

In Dhaka, dust pollution is a serious problem, contributing to (at least) 15% of the city's air pollution[6]. To absorb Dhaka's rapid population growth, both planned and unplanned construction proliferate, growing at over 5% each year[14]. From the development of major urban infrastructure, such as that carried out under the Dhaka Mass Rapid Transit Project, to the surge of new multi-story apartment buildings, to the continual spread of informal settlements, construction is an ever-present aspect of Dhaka's landscape[16]. Furthermore, the city's growing fleet of vehicles (which doubled between 2010 and 2018[17]) resuspend dust that sits on paved, partially paved and unpaved roadways and roadsides[15].

Prevention and mitigation measures exist for both road and construction dust[18]. In fact, employing these measures is among the "Top 25 Clean Air Measures" recommended for Asia in a 2019 report published by the United Nations Environment Program[19].

The measures include:

- Cover exposed roadsides with pavement or vegetation[‡‡]
- Regularly sweep and wash roadways

[‡‡] The city of Rajshahi, Bangladesh has received recognition for paving and planting vegetation to cover exposed areas around roadways, thereby reducing dust and encouraging more walking and cycling. See Grahan-Harrison. (2016). Rajshahi: the city that took on air pollution—and won. *The Guardian.*

- Enclose construction sites, and spray water when dust is generated
- Cover construction materials
- Wash the wheels of construction site vehicles before they enter public roads

Vehicles and Transportation

Prior to the regulations made two decades ago to introduce compressed natural gas, remove lead from gasoline and phase out two-stroke engines, vehicle emissions were responsible for up to 50% of Dhaka's particulate pollution[15]. Now, they constitute 10.4%. However, at their current levels, vehicle emissions are still considerably harmful to human health and the environment. In addition, reducing them will yield "co-benefits" for the city's residents by easing congestion and commuting times. The necessary actions include modernizing options for mass public transportation, improving roadways, limiting the number of vehicles on the roads, and enforcing vehicle fitness standards.

The Dhaka Mass Rapid Transit Project is currently under construction and the first completed metro rail line, "Line 6", is due to become operational in 2022. Line 6 will run from Uttara to Motijheel, a distance of 41 km that should take 40 minutes from one terminus to another. Co-funded by a low-interest loan from the Japan International Co-operation Agency (JICA), it is anticipated that the line will be able to carry 60,000 passengers an hour, for a total of around 500,000 people a day[20]. A further four lines are planned, with the system due for completion by 2035.

Having a well-organized, modern bus system is another crucial piece of the transport puzzle. However, there are powerful vested interests committed to maintaining the current outdated system that is polluting, unsafe and challenging for the public to navigate[21]. A series of student-led protests in August 2018 drew international attention to this issue[22].

Looking at the big picture though, mass rapid transit only provides part of the solution. Experience from other countries indicates that better mass transit may not in itself reduce vehicle congestion. This is due to the possibility of latent demand not captured in current demand estimates, which the full metro rail system may not be able to alleviate. In addition, some drivers may choose

to continue to drive, and to further do so during peak hours when they previously didn't, thereby limiting or canceling out the expected reduced congestion[23,24].

Multiple roadway improvement projects are also underway, including[25]:

- Dhaka Elevated Expressway
- Upgrading of Dhaka Bypass to 4 Lane (Madanpur-Debogram-Bhulta-Joydebpur)
- A flyover from Santinagar to Mawa Road via 4th (New) Bridge over Buriganga River
- The Dhaka-Chittagong Access Controlled Highway
- Improvement of Hatirjheel (Rampura Bridge)-Shekherjaiga-Amulia-Demra Road

Apart from these, other key investments needed include maintaining roadways clear of vendors; instituting special lanes for bicycles, rickshaws, and/or service vehicles; potentially introducing area pricing by charging drivers to enter certain zones; and developing quotas for the number of vehicles allowed on the road. More attention must also be given to strictly enforcing national vehicle fitness standards—thereby reducing emissions and improving road safety—and to phasing out highly polluting vehicles[19, 26].

The Way Forward

Air pollution is widely recognized as the largest environmental health risk in Bangladesh and globally. It is responsible for an estimated 40,000 premature deaths in the country's urban areas each year and reduces life expectancy on average by 3-7 years. National regulatory efforts have yielded results. However, progress has largely been cancelled out by continued urban growth. A much stronger, tightly coordinated and well-funded approach is needed to reduce pollution and improve health. Tackling pollution will also have the co-benefit of reducing global warming.

The causes, effects and solutions to air pollution are known. Further, recent evidence from Asia dispels the common myth that high air pollution is an unavoidable phase of development progress. As an example, China has achieved substantial reductions in air pollution while maintaining high economic growth[19]. China's work over the past decade to reduce air pollution

provides an excellent case study from which lessons can be drawn for Bangladesh.

China Case Study on Air Pollution Reduction

Following two decades of high levels of air pollution and mounting public concern, China's Premier declared a "War on Pollution" in 2014. Close to $400 billion US dollars were committed toward pollution reduction, 31% of which was committed by the city of Beijing. An Air Pollution Prevention and Control Law and a National Air Quality Action Plan were already in existence at the time. Implementation strategies included incentivizing local government officials by tying promotions to both environmental audits and economic performance, prohibiting new coal-fired plants in some regions and requiring existing coal plants to reduce emissions or be replaced with natural gas, increasing renewable energy generation, restricting the number of cars on the road in large cities, and increasing transparency and better enforcing emissions standards.

It further implemented a vast network of stations to monitor air quality in more than 400 cities. The monitoring data from these stations was central for the development of policy and regulatory frameworks, as well as for monitoring progress. Between 2013 and 2016, the country saw an average decline in particulate pollution of 12%. This equates to a gain in life expectancy of 0.5 years. In Henan Province, a 20% decline was achieved, resulting in an overall life expectancy gain of 1.3 years, if sustained. In its latest Five-Year Plan, China committed to increasing non-fossil energy use to at least 20% by 2030[10,11].

Government, industry, civil society and development partners all have a role to play in reducing air pollution. The work that needs to be done is characterized by the four principles of leadership, collaboration, knowledge and innovation.

- **Leadership** on air pollution reduction, at all levels of government (including mayors), is critical for success. It should be included in

national and city-level planning processes. Leaders are central for both regulation enforcement and for negotiating solutions when facing tough resistance. They do this by building the public's knowledge and upholding a vision for a more livable city.

- Collaboration across sectors—environment, health, energy, finance, and transportation—is an essential precursor for effective progress. Collaboration must bring together the public and private sectors as well. Air pollution is not just an environmental issue. Its causes, effects and solutions touch all of these sectors, and no one sector can successfully go it alone. One concept envisaged for facilitating cross-sectoral collaboration is to institute environmental management units within each relevant ministry and department[2].

- Knowledge about air pollution and its effects is relatively low in Bangladesh. In general, the public is aware that there is a significant pollution problem, but isn't well versed in what the impacts are or how to address the problem. Awareness of the specifics of pollution levels, sources, impacts and solutions is the first step toward change.

- Innovation can catalyze change. Perhaps a private sector partnership could be formed that incentivizes brick kiln owners to reduce emissions. Or perhaps a more affordable, scalable brick production technique that uses locally available, renewable resources could be designed. Or, a social scheme to use paraprofessionals to monitor highly polluting kilns could be put into place. Whatever the innovation, there are effective local solutions that have not yet been thought of or implemented.

A Call to Action

The table below outlines actions to be taken by key stakeholders. They are a synthesis of recommendations from select relevant publications. These include Air Pollution in Asia and the Pacific, Science-based Solutions (UNEP 2019), The Lancet Commission on pollution and health (Lancet 2018), Enhancing Opportunities for Clean and Resilient Growth in Urban Bangladesh (World Bank 2018), and the Guidance Framework for Better Air Quality in Asian Cities (Clean Air Asia 2016).

Table 1. Recommended Actions

WHO	KEY STAKEHOLDERS	WHAT
Government	• Prime Minister's Office • Planning Commission • Ministries, Departments, Directorates and Agencies responsible for Environment, Health, Energy, Finance and Transport • City Corporation Leadership	Clean Air Action Plans • Develop and implement national and city-level Clean Air Action Plans with targets and timetables for PM2.5 reduction Enforce Pollution Regulations • Enforce existing regulations for brick kilns, dust control and vehicle emissions and incorporate the "polluter pays" principle—increase DoE staffing to do so Financial Incentives • Halt financial incentives that support highly polluting kilns and that enable "Business as Usual" in the transportation sector • Provide financial incentives for the purchase and production of low and no-pollution bricks, an efficient bus system and cleaner roadways
Business and Industry	• Brick kiln owners • Real estate developers • Builders • Bus companies • Bus owners	Innovate • Explore, test and bring to scale new, creative solutions to reduce brick kiln emissions Build Partnerships • Forge strategic partnerships that can catalyze change (e.g., a public private partnership to provide seed funding for improving kiln conversions, or to reward builders who source certified low-pollution bricks) Adapt • Accept and adapt to the reality that Business as Usual will not continue to work

WHO	KEY STAKEHOLDERS	WHAT
Development Partners	• Donors • Foundations • Non-governmental organizations • Other social investors	**Funding** • Elevate the priority of air pollution reduction in funding commitments by either significantly expanding current climate change and non-communicable disease portfolios, or establishing new funding mechanisms **Technical Assistance** • Provide technical assistance to national and city government agencies for the development and effective implementation of their Clean Air Action Plans • Support local research on air pollution, including health effects and solutions
Civil Society	• Community organizations and groups • Journalists/the media • Private citizens	**Information** • Generate improved local knowledge of air pollution sources, effects and solutions—consult the wealth of information and resources on air pollution available in the Asia region and globally when doing this **Accountability** • Hold leaders and polluting industries accountable for their responsibility in creating and resolving the pollution problem

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