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Evidence Paper

Air Pollution in Bangladesh
Drivers, Impacts and Solutions

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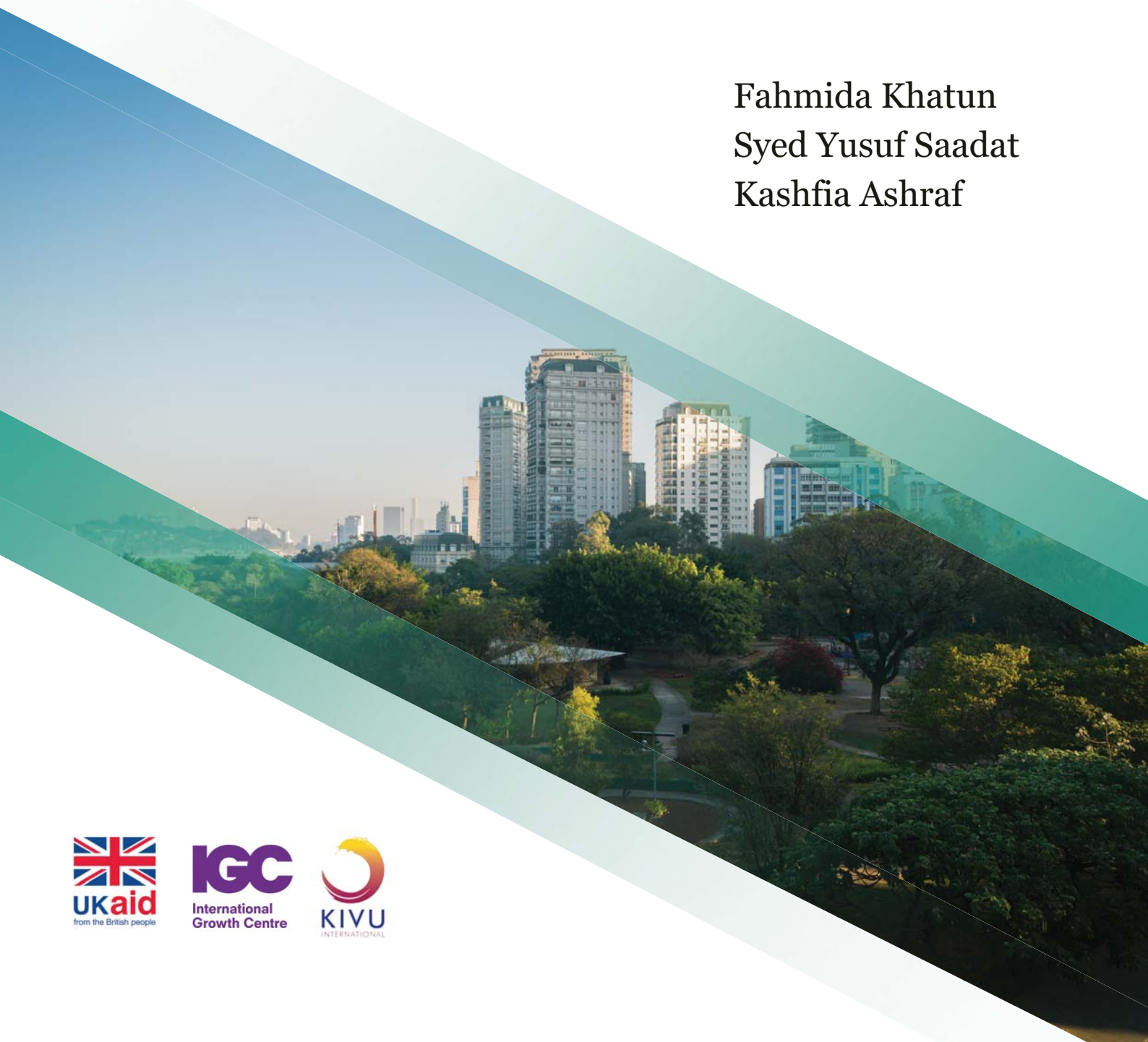

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AIR POLLUTION IN BANGLADESH

DRIVERS, IMPACTS, AND SOLUTIONS

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Publisher

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ABSTRACT

Bangladesh, particularly its capital city Dhaka, has been on the top of the mantle for having the worst air quality in the world. Economic development induced by rapid industrialisation, urbanisation and energy consumption is responsible for the degradation of air quality in major cities of Bangladesh. This imposes huge economic and social cost, along with the burden of diseases when citizens are exposed to poor air for a prolonged period. Key pollutants such as particulate matter (PM2.5 and PM10), sulfur dioxide (SO2), oxides of nitrogen (NOX), ozone (O3), carbon monoxide (CO), and lead (Pb), are responsible for degrading the air quality and imposing substantial threat on human health, environment, and the economy of the country. Effective policies and actions by the government, private sector and other stakeholders are paramount to improve the air quality, and eliminate the threat on human health, environment, and the economy of Bangladesh.

AUTHORS' ACKNOWLEDGEMENT

This study has been conducted by the Centre for Policy Dialogue (CPD). The paper is authored by *Dr Fahmida Khatun*, Executive Director, CPD; *Mr Syed Yusuf Saadat*, Research Fellow, CPD; and *Ms Kashfia Ashraf*, former Programme Associate (research), CPD.

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CONTENT

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ACRONYMS

AQI	Air Quality Index
AQLI	Air Quality Life Index
BNAAQS	Bangladesh National Ambient Air Quality Standard
CASE	Clean Air and Sustainable Environment
CNG	Compressed Natural Gas
CPD	Centre for Policy Dialogue
DoE	Department of Environment
GBD	Global Burden of Diseases
GDP	Gross Domestic Product
GoB	Government of Bangladesh
LDC	Least Developed Country
LPG	Liquefied Petroleum Gas
NAAQS	National Ambient Air Quality Standards
NCAP	National Clean Air Programme
PM	Particulate Matter
SPM	Suspended Particulate Matter
US EPA	The United States Environmental Protection Agency
WHO	World Health Organization's

1. INTRODUCTION

Air pollution occurs when contaminants or pollutant chemicals, present in the air, endangers human health or welfare, and has other negative environmental impacts (EPA, 2008). The rise in ambient air pollution in urban cities is a grave concern for many countries in the world. Similarly, Bangladesh is facing a rise in air pollution in recent years, due to the increase in industrialisation, and energy consumption in major cities, while causing serious health, economic, environment and climate related concerns. The degradation of air quality in urban areas mainly arises due to an upsurge in urban population, motor vehicles, construction activities, biomass burning, and unplanned brick production (DoE & the World Bank, 2018). The rise in economic growth and development comes at a cost of degrading the air quality of the country. If right policy actions and measures are not taken, then the problem of air pollution may worsen, posing a more detrimental threat to human health, environment, and the economy.

Key pollutants present in the air, such as particulate matter (PM2.5 and PM10), sulfur dioxide (SO2), oxides of nitrogen (NOX), ozone (O3), carbon monoxide (CO), and lead (Pb), are responsible for degrading the air quality with time and location, and also for causing harm to human health and environment (DoE & the World Bank, 2018). Among these pollutants, fine Particulate Matter (PM) like PM2.5 and PM10, which have an aerodynamic diameter less than 2.5 µm and 10 µm respectively, have comparatively higher concentration in the air and are major source of mortality from respiratory, cardiovascular, and other types of diseases (Majumder, et al., 2020). These fine particles, when suspended in the air, are mixed with other organic and inorganic particles like dust, pollens, soot, smoke, and liquid droplets that can penetrate deep into the respiratory system, and inflict adverse health risks (DoE & the World Bank, 2018). Vehicular emission, coal-fired power plants, brick kilns, industrial emissions, road dust, and construction activities are major emission sources of PM in urban cities (Hossain, Majumder, Islam & Nayeem, 2019; Majumder, et al., 2020). According to the annual Air Quality Life Index (AQLI) report of 2022, Bangladesh's average concentration of PM2.5 increased by 13.1 per cent to 75 µg/m3 during 2019-2020 (Greenstone, Hasenkopf, & Lee, 2022). This is 5 times higher than the annual National Ambient Air Quality Standards (NAAQS) of 15 µg/m3 and 15 times higher than the World Health Organization's (WHO) guideline of 5 µg/m3 (DoE, 2005; DoE and the World Bank, 2018). Particulate matter emission levels in Asian cities often exceed WHO guidelines (Schwela, et al., 2006). Most cities in Bangladesh including Dhaka, Chittagong, Khulna, Rangpur, and Gazipur far exceed the WHO guideline for PM2.5 concentration, shortening the lifespan of the people living in these regions (Greenstone, 2022).

The degree of air pollution in many developing countries is so severe that it has been identified as a major risk factor (Rahman & Al-Muyeed, 2005). East Asian, Southeast Asian, and South Asian countries and regions suffered from highest annual average PM2.5 concentrations weighted by population. Some Asian countries ranked the highest in terms of particulate matter pollution in the world (Schwela, et al., 2006). According to the IQAir report of 2021, Bangladesh ranked first in terms of annual average PM2.5 concentrations weighted by population (76.9 µg/m3), followed by Chad (75.9 µg/m3), Pakistan (66.8 µg/m3), Tajikistan (59.4 µg/m3) and India (58.1 µg/m3) (IQAir, 2021). Additionally, Dhaka was ranked second for having the most polluted air in the world after New Delhi for the worst average annual PM2.5 concentration in the regional capital city ranking in 2021 (IQAir, 2021). The severity of air pollution problems in these developing cities reflects the degree and speed of their economic growth, as well as their effectiveness to manage and improve the air quality (Schwela, et al., 2006). In Dhaka city, more than 10 million people are exposed to poor quality of air, whereas in other cities such as Chittagong, Gazipur, Narayanganj and Khulna, the number of people affected are approximately more than 3 million, 2 million, 0.9 million, and 0.7 million respectively (BBS, 2022). These Bangladeshi cities have extremely poor air quality compared to other cities in Asian and South Asin regions, causing serious health and economic concern for people in these regions.

2. TRENDS OF AIR POLLUTION IN BANGLADESHI CITIES

The Air Quality Index (AQI) is an index used to show the status of the ambient air quality of a particular area. It also informs the general public about the condition of the air quality of a certain area or city (DoE, 2021). The AQI is measured based on five key pollutants: PM (PM2.5 and PM10), NO2, SO2,

CO, and O3 (DoE, 2021). The AQI gives us an idea of how clean or polluted the air is around us, and how much concerned we should be about our health when we are breathing the air. It helps alert the sensitive groups and prepare them to take necessary precautions (Hossain, et al., 2021). The United States Environmental Protection Agency (US EPA) was the first to develop this framework, which has now been adapted by various countries including Bangladesh, to meet the environmental standards set by their respective environmental protection agencies (DoE and the World Bank, 2018). In Bangladesh, the value of AQI is divided into six different categories, ranging between 0 to 500, and calculated on the basis of the concentration of pollutants in an area. The value of AQI and the level of air pollution are directly proportional, i.e., the higher the AQI, the higher is the intensity of air pollution, corresponding to higher health concern (Hossain, et al., 2021). The categories of AQI are different for different countries. For instance, In Bangladesh, if the value of AQI ranges between 0–50, it falls under "good" category, 51–100 under "moderate" category, 101–150 under "caution" category, 151–200 under the "unhealthy" category, 201–300 under the "very unhealthy" category, and 301–500 under the "extremely unhealthy" category (DoE and the World Bank, 2018). Sensitive groups of people with mild or acute health problems should take necessary precaution while leaving their houses when the AQI is above 100. Besides, prolonged exposure to toxic air may create health complications, reducing the average lifespan of people (AQLI, 2022).

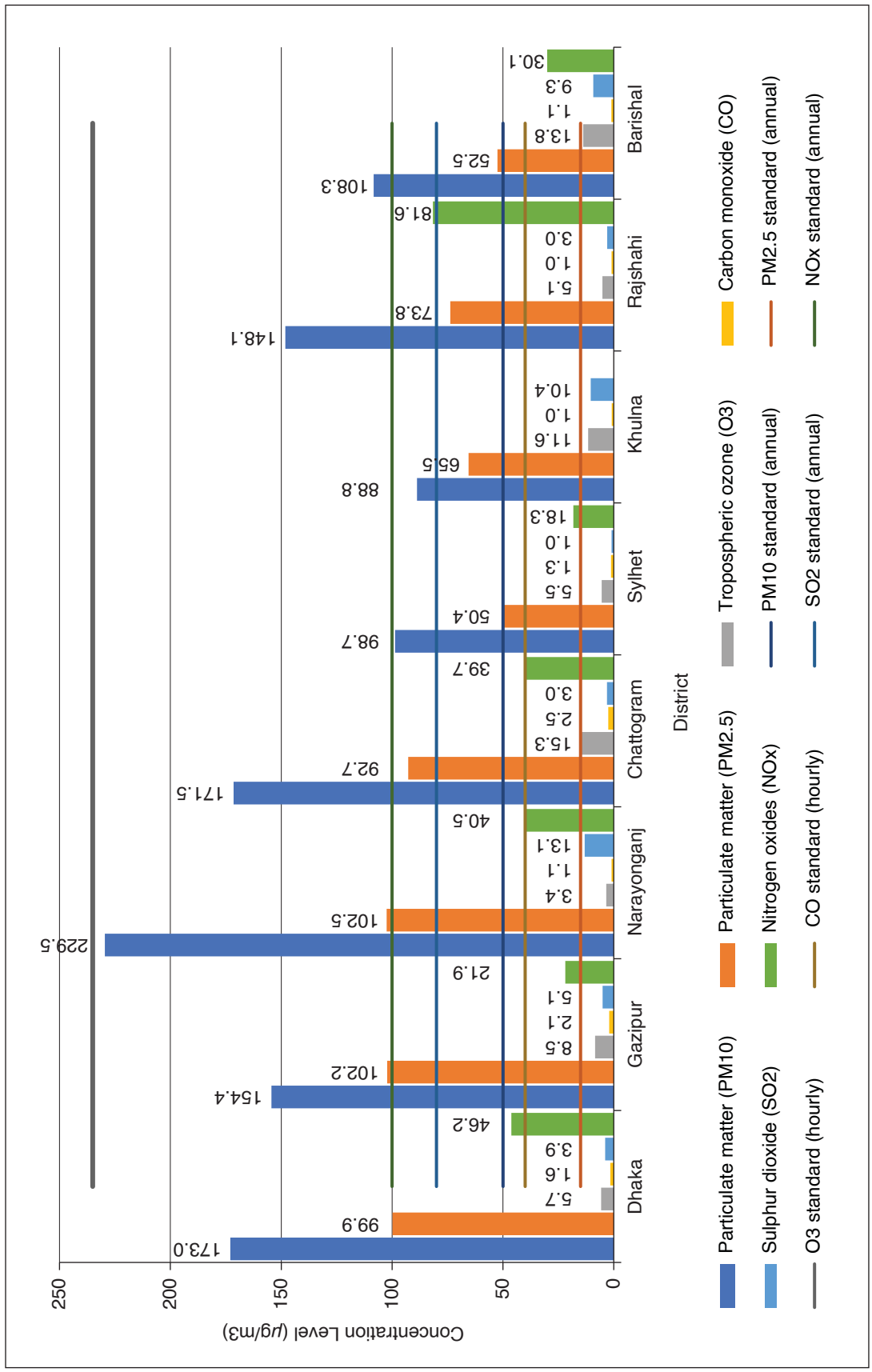
As different districts have different kinds of activities, the pollution level also varies accordingly. Figure 1 illustrates the air quality of eight different districts of Bangladesh in 2019, where we can observe the trends of individual pollutants such as PM, sulfur dioxide, nitrogen oxides, ozone, and carbon monoxide. Among these six pollutants, the average concentration of PM10 was the highest, ranging from 88 µg/m3 to 230 µg/m3, followed by PM2.5 and NOx. Narayanganj had the highest pollution with extremely high concentration of PMs (PM10 and PM2.5) of 230 µg/m3 and 103 µg/m3 respectively, besides Dhaka, Chattogram, and Gazipur (DoE, 2020). Both concentrations of PM10 and PM2.5 have been exceeded beyond the Bangladesh National Ambient Air Quality Standard (BNAAQS). On the other hand, Sylhet and Khulna had comparatively lower concentration of pollutants, with lower levels of PM10, PM2.5, and CO. The reason for high concentration in Narayanganj, Gazipur, Chattogram and Dhaka may be due to the ongoing construction projects and the government's mega projects like Metro Rail, Padma Rail Link, Matarbari Coal Power Plant, highways, and other road construction activities.

Amongst the major pollutants, ambient PM has the highest concentration in the air, which is highly detrimental to both human health, biodiversity, and economy (Begum, 2016). Figure 2 represents the local air quality of Bangladesh from 2015 till 2019, where the concentration of key pollutants like PM10, PM2.5, O3, NOX, SO2, and CO are shown. We can observe that the concentration levels of PM10 and PM2.5 are the highest, far exceeding the annual BNAAQS which is set for PM10 and PM2.5 at 50 µg/m3 and 15 µg/m3 respectively (DoE and the World Bank, 2018). Concentration levels of other pollutants like O3, NOx, CO, and SO2 have been lower than their respective BNAAQS set by the government of Bangladesh. Moreover, the concentration level of PM has increased over the years. PM10 level in 2015 was 126.5 µg/m3 which rose to 145.6 µg/m3 in 2019 and the PM2.5 level was 70.7 µg/m3 in 2015 which increased to 80.4 µg/m3 in 2019. Concentration of ozone also increased slightly from 7 µg/m3 to 10.5 µg/m3 from 2015 to 2019 respectively (DoE, 2020). Emissions of CO, SO2, O3, and NOx remained below the national standards, however PM10 and PM2.5 have been far exceeding the national standard over these five years.

The average ambient matter pollution has been rising steadily over the years. In 1995, the concentration was 51.6 µg/m3 which rose by 23 per cent to 63.4 µg/m3 in 2019 (GDB, 2021) (Figure 3). Rising concentration of PM may have serious short-term health implications causing asthma, bronchitis, lung cancer, eye and nasal irritation, along with long-term threats such as visual impairment and lung cancer. Besides health implication, the rise in ambient particulate matter pollution has also affected the economy and the environment greatly (Dechezlepr tre, Rivers, & Stadler, 2020).

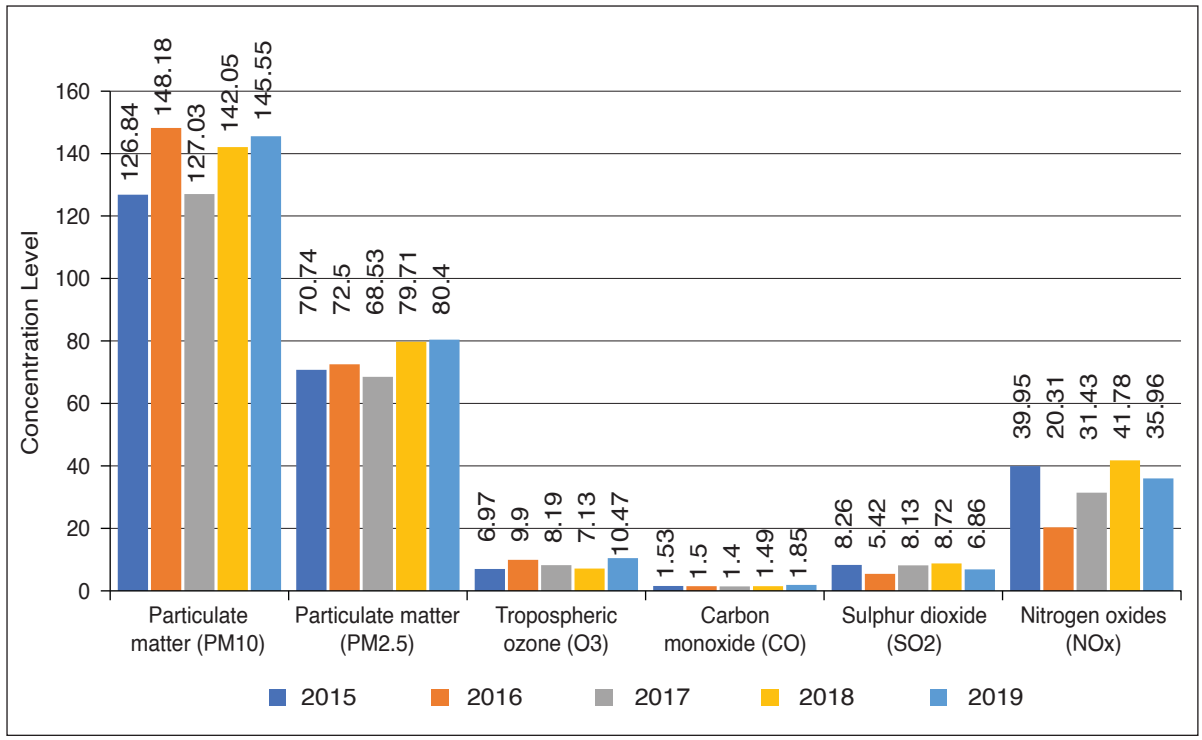
Variation and trend of air pollution is influenced by meteorological and seasonal factors. The concentration of pollutants in the air may vary in different seasons due to the influence of meteorological factors, such as rainfall, wind direction, wind speed, humidity, and temperature (Majumder, Nayet al., 2020). During drier winter seasons, the air quality was observed to

Figure 1: Air Quality by District in 2019



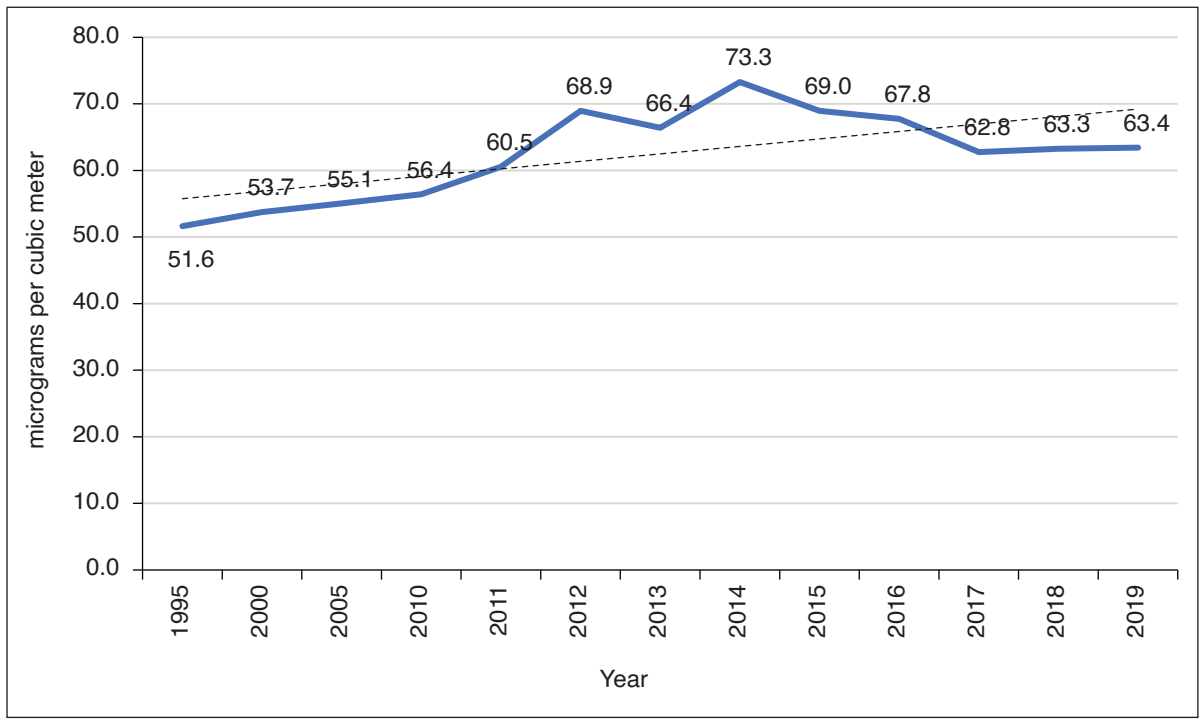
Source: Authors' illustration based on data from Department of Environment (DoE, 2020).

Figure 2: Local Air Quality of Bangladesh 2015–2019



Source: Authors' illustration based on data from the Department of Environment (DoE, 2020).

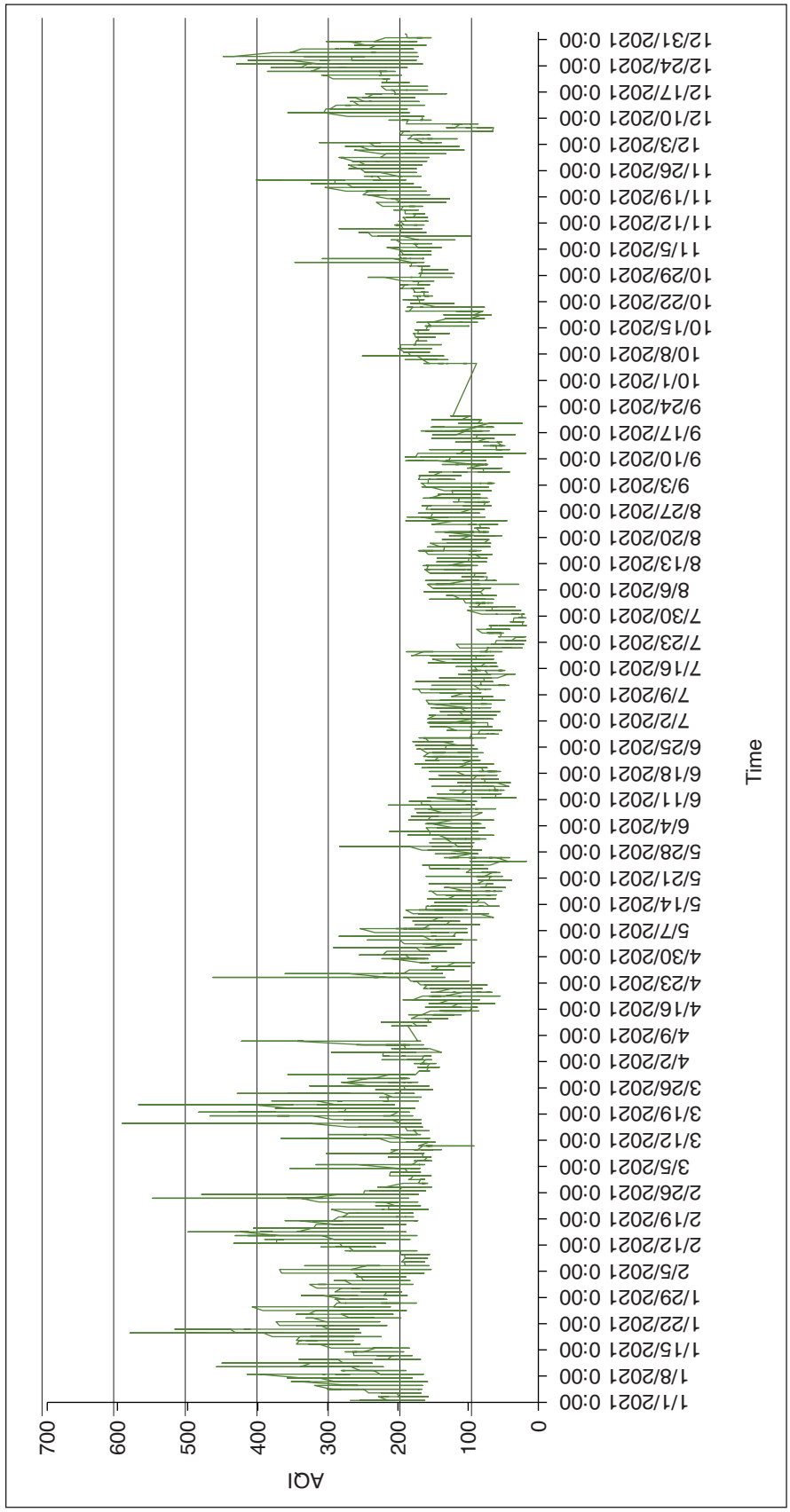
Figure 3: Average Ambient Particulate Matter Pollution of Bangladesh



Source: Authors' illustration based on data from Global Burden of Disease (GDB, 2021).

be worse than other seasons, with high concentration of PM and other pollutants in the atmosphere. On the other hand, during monsoon season, it was observed that the concentration of pollutants in the air was comparatively lower (Majumder, et al., 2020). Dhaka's air quality is also susceptible to large seasonal variation (Islam, et al., 2015). High AQI was persistent in Dhaka during the cold months of January, February and March, whereas the value of AQI was the lowest during monsoon in the months of July, August and September (Figure 4). With relatively low temperature and little rainfall in winter, the concentration of pollutants intensifies as a large amount of dust particles, aerodynamic particles, and gases from anthropogenic activities and sources such as brick kilns, vehicles, industries, and construction sites, are released (Islam, et al., 2015). These particles float in the air and mixes with other gaseous pollutants, deteriorating air quality. In a study, it was found that, every day, 500 metric tons of dust settle on land and around 2000 metric tons of dust float in the sky in Dhaka city during winter.

Figure 4: Seasonal Variation of the Air Quality of Dhaka City in 2021



Source: Authors' illustration based on data US Embassy (US Embassy, 2022).

3. DRIVERS OF AIR POLLUTION IN BANGLADESHI CITIES

Economic development in many developing countries has been accompanied by rapid growth in urbanisation, industrialsation, motorisation and an influx of population migrating from rural areas to urban areas. Any economy's growth and development induce greater consumption of energy which, therefore, has an impact on the air quality. Fossil fuels such as coal, oil and natural gas, and biomass are the main sources of the following: pollutant emissions from vehicles (such as cars, bus, trucks, auto-taxi, bikes); brick kilns; construction sites; coal-fired powerplant; agricultural activities; and other daily household activities in urban cities (Schwela, et al., 2006). These key drivers are responsible for damaging the air quality of the country.

3.1 Vehicular emission

The level of motorisation in Bangladesh has been growing over the years. With rising gross domestic product (GDP) growth, the per capita income of people is also rising, exacerbating the use of public and private motor vehicles for transportation. The number of motor vehicles registered in Dhaka city increased by 283 per cent, from 1.30 million in 2009 to 5.01 million in 2021 (BRTA, 2022). Emission from vehicles has been disproportionately high in recent years. Poorly maintained vehicles, adulterated fuels, improper traffic and road management, and inadequate parking space are some of the factory's contributing to the high emissions from vehicles. In Bangladesh, majority of the cars and buses used for transportation are imported from other Asian countries, where failure to comply with emission standard and safety requirement of the parts and engine has made the vehicle obsolete (Schwela, et al., 2006). These vehicles are then used for a prolonged period in Bangladesh, without proper engine and motor maintenance, intensifying the level of emission into the atmosphere. Such old engines discharge significant volumes of black soot, sulfur, and other harmful substances and gases that contribute to the high levels of year-round ambient pollution (IQAir, 2022). The study under the DoE's project titled Clean Air and Sustainable Environment (CASE) revealed that around 10.4 per cent PM is emitted from vehicles in Dhaka city, whereas 7.7 per cent comes from road dust (DoE a& the World Bank, 2019). Diesel-run vehicles are the worst polluters compared to CNG, Octane or LPG-run vehicles (CNG = compressed natural gas; LPG = liquefied petroleum gas). Nitrogen oxides and black diesel smoke are emitted into the air, plummeting the air quality of the cities. Most of the diesel vehicles fail to comply with the Vehicles Emissions Standard of Bangladesh, thereby releasing higher levels of contaminants into the air.

3.2 Brick kilns

Besides vehicles, another significant source of emission is the brick kilns industry. Due to increased development projects taken by the Government of Bangladesh (GoB), the demand for construction materials has increased significantly in recent years. It is estimated that at least 15 billion brick kilns are produced annually in Bangladesh (ESDO, 2020). There were about 8000 brick kilns operating all over Bangladesh in 2018, producing around 15 billion bricks annually (DoE & the World Bank, 2019). Bangladesh's brick industry contributes about 1 per cent of the GDP and is a major energy consuming industry (DoE & the World Bank, 2019; ESDO, 2020). Hundreds of brick kiln clusters are located sparsely all over Bangladesh in various districts including Naryanganj, Gazipur, Dhaka, Rajshahi, and Khulna. These urban areas have higher proportion of construction activities and establishments of brick field; so, these districts are highly polluted compared to other districts of the country. In Bangladesh, bricks are manufactured in a primitive system using traditional methods (Darain, et al., 2013). These outdated models and technologies are inflicting serious damage on the environment by emitting large amounts of pollutants. They mainly release environmental pollutants like MP, and harmful gases such as CO, CO2, NOX, SO2, and NO (Darain, et al., 2013). Brick kilns primarily use biomass energy like agricultural residue and coal. Burning of coal emits huge volumes of dust, smoke, fumes and fly ash, causing huge environmental pollution. Suspended Particulate Matter (SPM) emission from brick fields has deleterious and long-term impact on health as well. The concentration of pollutant is extremely high in the areas where the brick fields are located and as we move away from the source, the concentration reduces gradually. This is one of the reasons why Dhaka city, along with Gazipur and Narayanganj, has poor air quality and high concentration of pollutants, in comparison to other cities of Bangladesh.

3.3 Construction activities

In Bangladesh, there are several ongoing construction activities in urban cities including construction of road, housing, and flyover (ESDO, 2020). Moreover, the government mega projects such as Metro Rail, Dhaka Elevated Expressway, Rooppur Nuclear Power Plant, Chittagong Cox's Bazar Rail Link, Padma Bridge Rail Link, Dhaka Airport Third Terminal, and Matarbari Coal Power Plant have been in construction for several years now. The construction of these projects contributes heavily to air pollution by emitting high levels of PM2.5 and PM10. Besides, SO2, NO2, CO, O3, methane and other pollutants are highly prevalent around construction site, especially during the dry seasons. Construction sites are often very dusty because there are no specific guidelines or rules on the storage and transportation of construction materials (ESDO, 2020). Majority of the construction sites do not follow rules like covering the construction material while transporting, storing or discarding. This increase gives rise to dust pollution in urban areas. In a study, it was found that, every day, 500 metric tons of dust settle on ground and 2000 metric tons of dust float in the sky in Dhaka city during winter. The economic boom of Bangladesh contributes to the development of roads, railways and infrastructure of the country, but at high opportunity cost of air quality.

3.4 Transboundary sources

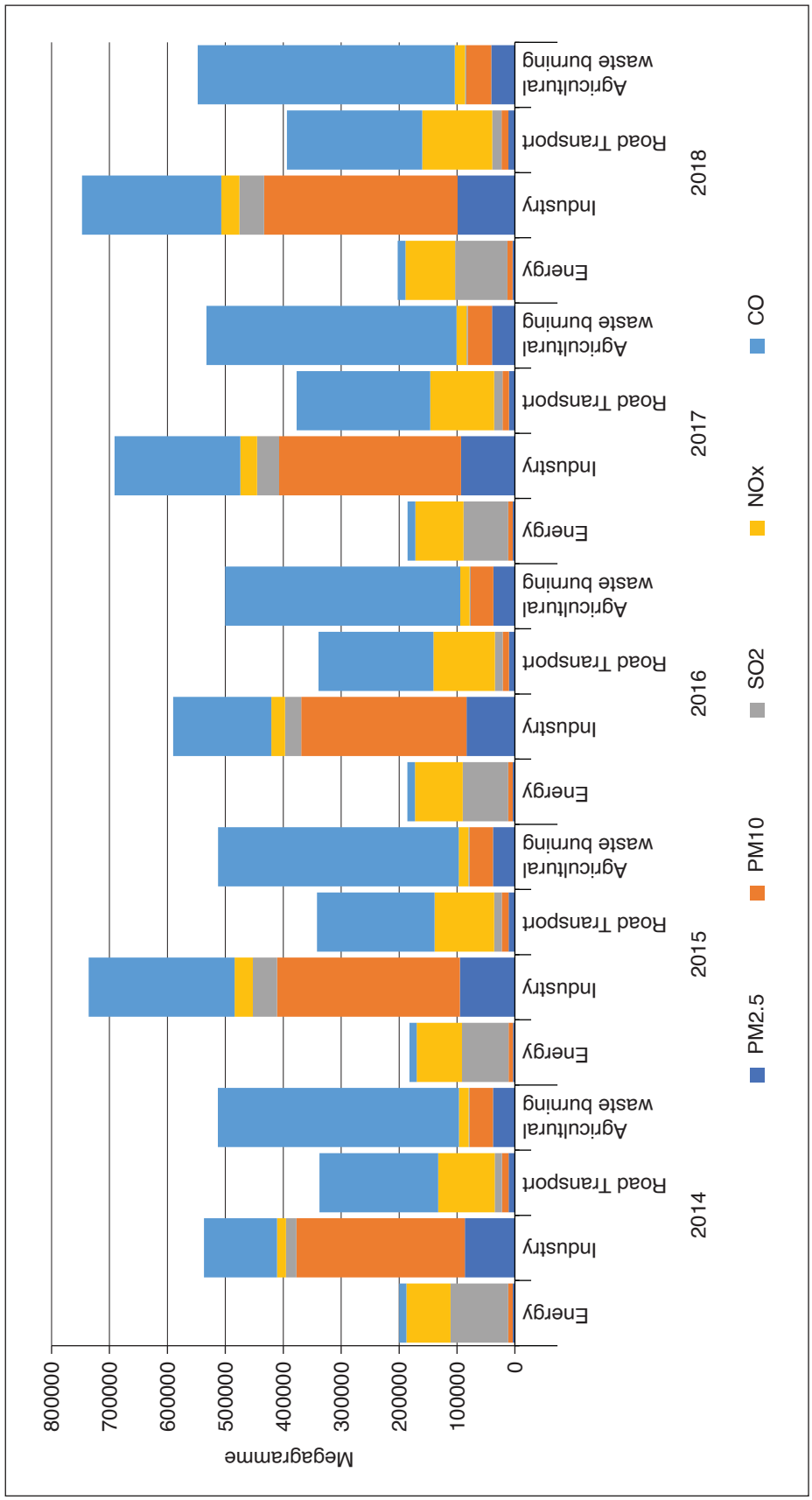
Transboundary air pollution is also a chief source of ambient air pollution in Bangladeshi cities. Transboundary air pollution occurs when emissions from fixed, mobile or other sources are transported from neighbouring countries and regions into our country by means of wind. Transboundary air pollution comes in the form of dust, sandstorm, acidification, which has many direct and indirect effects on health, economy, and the environment (Schwela, et al., 2006). Around 40 per cent of the pollution in Bangladesh comes from our neighbouring countries like India, Nepal, and Bhutan. During drier months, the air pollution in those countries is the highest, which also adds to the concentration of air pollution levels in Bangladesh. In Dinajpur city, it has been observed that a trail of polluted air comes from India each year during the winter months. India's particulate matter pollution increased from 53 µg/m3 in 2013 to 56 µg/m3 in 2020, which is roughly 11 times higher than the WHO guidelines (Greenstone, Hasenkopf & Lee, 2022). Pollutants in South Asia throughout winter are probably transported towards Dhaka city through different routes, much of the airborne pollutants that travel a long distance and cause air pollution. Pakistan, India, Myanmar, Bangladesh, and Nepal accounted for more than half of the world's air pollution in 2020, despite the ongoing lockdowns during COVID-19 pandemic (Greenstone, Hasenkopf & Lee, 2022). Depending upon the heights, air pollutants can travel from 200 km to 500 km in a specific area (Sakib, 2021). The problem of transboundary air pollution can be exacerbated by Dhaka's high population density, low levels of economic development, poor infrastructural condition, and lack of pollution management at the source.

3.5 Other key sources

Other drivers of pollution include construction activities, biomass burning, and waste burning. With rising economic growth, the energy consumption also rises in all sectors of the economy. The use of biomass, coal, oil and natural gases reflect economic growth and development of a country. However, due to the use of these natural resources without complying with the energy emission standards, high levels of pollutants are discharged into the air. This imposes various health and environmental cost on the economy.

Furthermore, burning of agricultural residue, biomass, and refuse (such as polyvinyl chloride or PVC, heavy metal, batteries, plastic waste, etc.) is also responsible for releasing potentially harmful pollutants into the air. Biomass burning in the agricultural sector emits large volume of carbon dioxide, and other harmful gas that add to the level of pollution. Manufacturing industries and factories including ceramic, cement, steel, parboiling rice mills, and glass plants emit significant amount of carbon monoxide, hydrocarbons, chemicals, and organic compounds into the air, resulting in severe ambient air pollution (ESDO, 2020). Open landfill incineration and plastic waste burning is also a contributing source of air pollution. Burning of municipal solid waste contains about 12 per cent plastic, which releases toxic gases into the atmosphere such as dioxins, furans, mercury, methane and polychlorinated biphenyls (ESDO, 2020). Airborne particulate emission (soot) and solid residue ash are byproducts of plastic combustion in Dhaka city. The contemporary landfill methods of waste disposal in Dhaka city insinuate an irreparable loss of essential raw materials and energy.

Figure 5: Annual Emission of Pollutants in Different Sectors of Bangladesh, 2014–18



Source: Authors' illustration based on data from EDGAR (EDGAR, 2022).

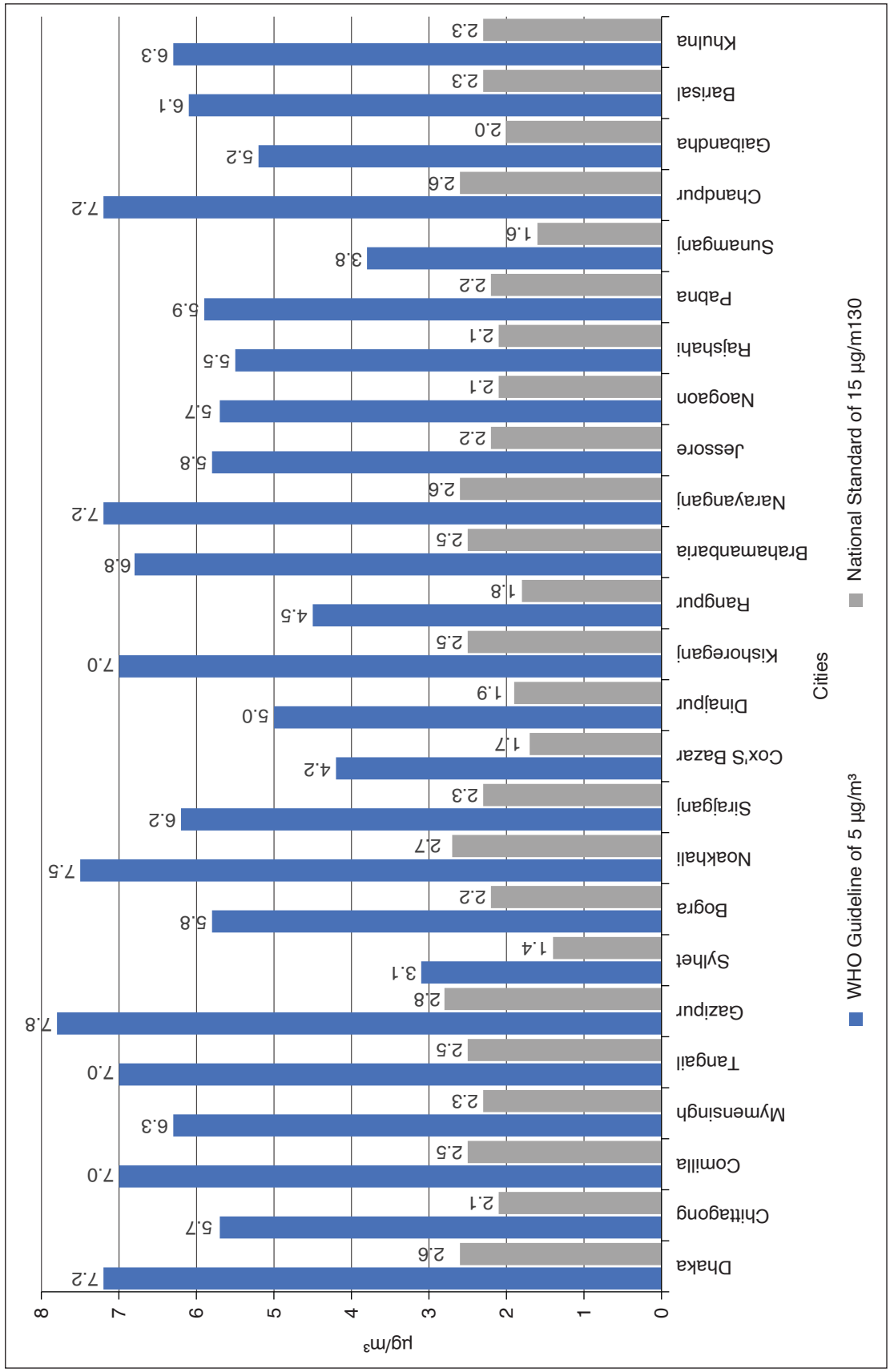
Different sectors account for different levels of pollutant emission into the atmosphere. Figure 5 illustrates the annual emission level of pollutants such as PM10, PM2.5, SO2, NOx, and CO for energy, industry, transportation, and agricultural waste burning sectors. Industries, such as manufacturing and power, release huge amount of harmful pollutants and chemical byproducts, which mixes with air and contaminates it. Among the four sectors, manufacturing and power industries have the highest emission contribution and have released increasingly greater amount of pollutants over the years, from 2014 till 2018. Agricultural waste burning and transport sectors also contribute heavily by releasing gases and pollutants into the atmosphere. The concentration of PM2.5 is the highest in transport and agricultural waste burning sectors, followed by PM10, NOX and SO2, which also accounts for high level of atmospheric air pollution (EDGAR, 2022).

4. IMPACTS OF AIR POLLUTION IN BANGLADESHI CITIES

Air pollution is a serious global health risk factor. Poor air quality has several health, environmental, and economic implications for a country. Increase in economic development has its cost on the environment, as well as on human health. In 2019, air pollution has been ranked as the fourth most leading risk factor for death, compared to tobacco, dietary risks, and high systolic blood pressure, contributing to 6.67 million deaths worldwide in 2019 (HEI, 2020). Even the prevalence of diseases is quite high when one is exposed to polluted air (World Health Organization, 2023). In a World Bank study, it was found that the loss of welfare due to air pollution accounts approximately for 6.14 per cent of the total GDP of Bangladesh in 2013 (IHME & World Bank, 2016). Five out of ten causes of deaths are attributed to air pollution in Bangladesh (Hossain, et al., 2021). According to an AQLI study, it is estimated that citizens of Dhaka city are losing more than 8 years of life expectancy on average (AQLI, 2022). On the other hand, residents of Chittagong, Comilla, Gazipur, and Narayanganj cities are losing more than 6.6 years, 8 years, 8.8 years, and 8.2 years of life expectancy, respectively (AQLI, 2022).

The WHO guideline and NAAQS of the average concentration of PM2.5 are oftentimes exceeded by many cities of Bangladesh including Dhaka, Chittagong, Khulna, Gazipur, Narayanganj and Chandpur. Prolonged exposure to PM2.5 has adverse health impacts and is susceptible to reduced life expectancy (AQLI, 2022). Figure 6 shows the years of life lost in various cities of Bangladesh, for exceeding the guidelines and standards set for the emission of PM pollution. In comparison to the WHO guideline, cities that lost the highest member of years in terms of life expectancy, include Gazipur, Narayanganj, Noakhali and Chandpur, with more than 7 years of life lost as they are more susceptible to diseases due to prolonged exposure to air pollution. On the other hand, Sylhet has lost only 3 years of life expectancy, which is the lowest among the other cities in the country (AQLI, 2022).

Figure 6: Years of Life Expectancy Lost in Bangladeshi Cities due to Exposure to PM2.5 Concentration, Compared to WHO Guideline and National Standards in 2020



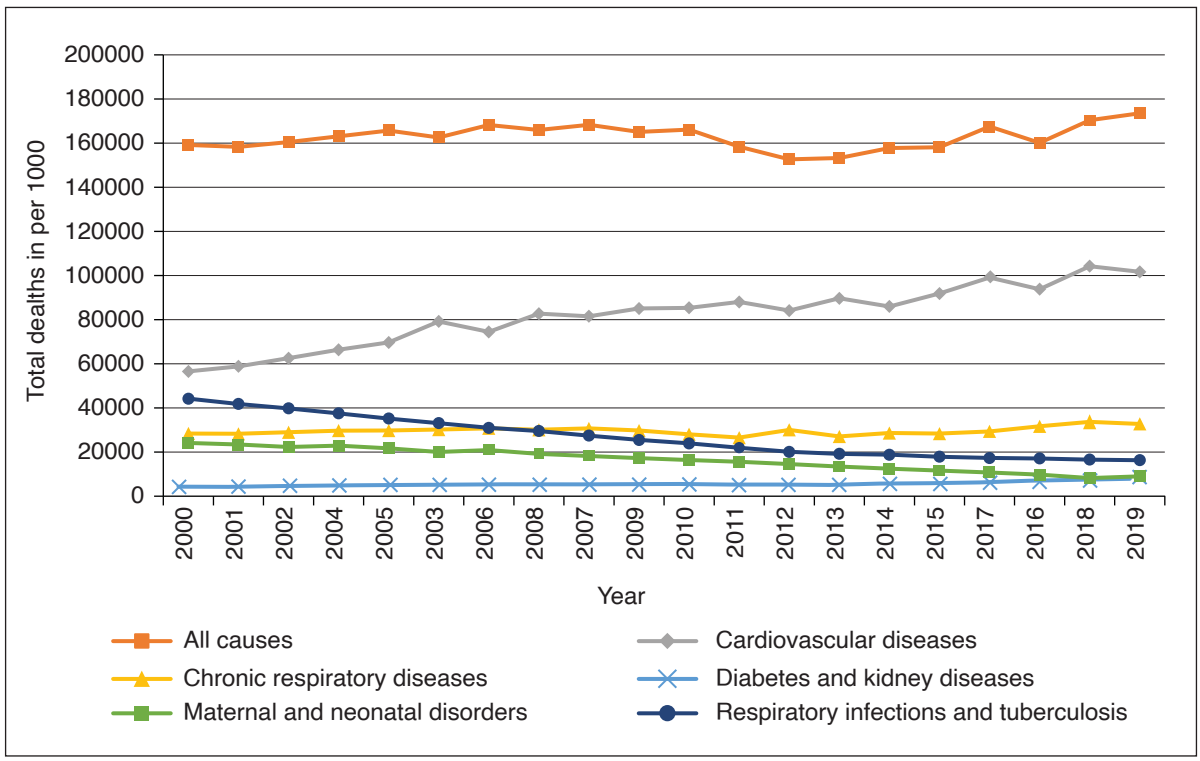
Source: Authors' illustration based on data from AQLI (AQLI, 2022).

4.1 Impact on health

Exposure to poor and contaminated air triggers adverse health risks, creating various symptoms and diseases. Both long-term and short-term exposure to poor air have detrimental health risks and may even cause deaths from diseases, for example type 2 diabetes, lower respiratory infection, pulmonary diseases, ischemic, cardiovascular diseases, and chronic obstructive pulmonary diseases (Boogaard, Walker, & Cohen, 2019). On top of that, the toxicity of the air pollutants may gradually reduce the functionality of our lungs, and may increase susceptibility to lung cancer and chronic heart diseases. (Hossain, et al., 2021). Though blood flow, small micro level particles like particulate matter can travel to other parts of the body, including our heart, intensifying the existing diseases and damaging the organs. Air pollution may also cause eye and nasal irritation, skin diseases, bronchitis, chest tightness, and may trigger asthma symptoms (HEI, 2020; Hossain, et al., 2021). Particulate matter pollution may even influence the birth outcomes and the neurological condition of new-born babies. New-born babies and children are highly affected by poor air quality. Children between age 1 to 4 and the elderly between the age 60 to more than 95, are the most vulnerable groups, as their mortality increases when exposed to ozone, particulate matter, and dust pollution. The report of Global Burden of Diseases (GBD) estimated that, 476,00 new-borns died worldwide due to the mother's exposure to air pollution during pregnancy in 2019 (HEI, 2020).

Deaths from numerous diseases associated with air pollution in Bangladesh has risen by 9 per cent over the last 20 years (IHME & GBD, 2019) (Figure 7). The highest causes of death are cardiovascular diseases, followed by chronic respiratory diseases. The Number of deaths from respiratory infections and tuberculosis has fallen over the years. The development of Bangladesh may reduce the burden of disease and deaths from air pollution over time, since socioeconomic development of a country can be tied to both air pollution and the availability of healthcare in the country,

Figure 7: Number of Deaths from Diseases Associated with Air Pollution Irrespective of Gender and Age in Bangladesh



Source: Authors' illustration based on data from Institute of Health Metrics and Evaluation (IHME) and Global Burden of Diseases (GBD) (IHME & GBD, 2019).

4.2 Impact on environment

High level of emission from factories and industries not only causes adverse health implications, but the impacts to the environment are felt quite heavily as well. The urban air has been infused with toxic fumes and polluted particles. During January, the meteorological condition is the worst in Bangladesh. Some heavy metals like lead and mercury are commonly found in road dust and other pollutant sample. When this dust falls into flowers, it disturbs their pollinating process. Therefore, lack of pollination reduces the growth of flowers, and their food reproduction and hampers the growth of trees or their ability to produce good quality fruits. Air pollution also effects the photosynthesis, growth, and reproduction in plants, (Gurjat, Molina, & Ojha, 2010). Besides, ground-level ozone is a highly reactive pollutant that hinders the growth of agricultural crops and decline the yield of many crop species such as wheat, rice, soybean, and cotton. During the months of January to March, the ground-level ozone concentration increases, and therefore the production of crops and winter vegetables is adversely affected in Bangladesh (Gurjat, Molina, & Ojha, 2010). In addition to that, acid rain becomes increasingly prevalent in areas with extremely high air pollution. The atmospheric oxidation of NO2 and SO2 produces sulfuric acid and, nitric acid which fall as acid rain and affect the plants, trees, vegetation and aquatic life in water bodies. This may cause a lack of oxygen in the water, which is required for fish and shellfish to survive, and it may also cause severe reductions in water quality (Gurjat, Molina, & Ojha, 2010).

4.3 Impact on economy

Urban air pollution imposes high economic cost to the society. The economic cost of air pollution is often attributed to the cost of healthcare. A large portion of people's income is spent on healthcare in Bangladesh. Bangladesh's average annual out-of-pocket expenditure has drastically risen over the years. Each person had to spend BDT 8,334 per year on healthcare from their own pocket in 2019 (The World Bank, 2022). The healthcare expenses have become a huge burden on the poor and marginalised people of the country. The poor are more vulnerable and the most exposed to pollutant emission in urban areas. Exposure to high concentration of air pollutants often exacerbates various diseases, and therefore incurs high healthcare cost (Schwela, et al., 2006).

Moreover, if people suffer from health problems due to air pollution, their costs and health expenditure would likely rise, which in turn puts a strain on their work productivity. They will spend more time and money on their health, which will reduce their physical working capacity and productive working hour. People will miss their work more often, leading to a fall in productive output. As the labour force is vital for economic growth, an increase in healthcare expenses often cause labour productivity to fall, and therefore incurs a huge economic loss (Mujtaba & Shahzad, 2021). Due to pollution and environmental degradation in urban areas, the annual loss of productivity was estimated to be USD 1.44 billion for Dhaka city and approximately USD 6.52 billion, or 3.4 per cent of its GDP for Bangladesh in 2015 (The World Bank, 2018). Therefore, an improved healthcare system is a significant aspect to improve the productivity of the labour force. An increase in labour productivity will cause an increase in income, which will eventually lead to a rise in the GDP and economic development of the country.

Over the years, Bangladesh's budget allocation on healthcare has fallen from 6.18 per cent in FY2009-10 to 5.42 per cent in FY 2021-22 (Ministry of Finance, 2023). As a Least Developed Country (LDC), a low health-GDP ratio means that there is low public spending on healthcare, eventually putting an increased burden on private healthcare expenditure. It has been found in a study that increased healthcare expenditure for LDC or a developing country leads to an overall fall in the GDP of the country (Mujtaba & Shahzad, 2021).

5. MEASURES TAKEN BY OTHER ASIAN CITIES

Many Asian and South Asian cities have been suffering from the adverse impacts of air pollution for years. However, these cities have taken effective measures to abate the level of pollutants in the air and achieve a cleaner ambient air quality and sustainable environment. Most of these cities have adopted ambient air quality standards. For instance, China has been a leading example for reducing air pollution, despite the on-growing industrialisation, increased energy consumption, and rapid growth of the population in the country. China's strict public policies and regulation made significant improvements to its air quality after 2013, when its National Air Quality Action Plan had been introduced.

China even declared “war against pollution” in 2014 by setting some key economic targets for pollution reduction and environmental protection. Coal-fired power plants and other polluting industries in Beijing, Shanghai and Guangzhou were mandated to follow strict emission guidelines, use renewable energy sources instead of fossil fuels, and were relocated or shut down. China’s pollution levels fell by 39.6 per cent from 2013 to 2020, whereas Beijing experienced a significant decline in its particulate matter emission levels from 85 µg/m3 in 2013 to 38 µg/m3, or a 55 per cent decline in 2020 (Greenstone, Hasenkopf, & Lee, Air Quality Life Index Annual Report 2022, 2022). China’s command and control policy to reduce pollution has worked wonders for its country. Bangladesh can also use China’s example to shape its policy measures to control the air pollution levels of the country.

On the other hand, Delhi is one of the most polluted megacities in the world. Delhi was in top five most polluted cities in the world beside Dhaka, in 2020. The average annual PM2.5 level of Delhi is 107 µg/m3 and it exceeds the WHO guideline more than 21 times (Greenstone, Hasenkopf, & Lee, Air Quality Life Index Annual Report 2022, 2022). The government of India also declared “war on pollution” and approved its National Clean Air Programme (NCAP) in 2019, with the aim of cutting down particulate matter pollution by 20 to 30 per cent by 2024. India has also introduced fuel emission standards that are in line with the European Standards (HEI, 2020). India also developed a national database for pollutant emission inventories and has conducted a cost-benefit analysis of air pollution control options for Delhi (Sharma, 2018). Besides, Nepal has adopted the Air Quality Management Action Plan for Kathmandu valley and has taken various policy measures for emission control for vehicles and industries. In addition, emission standards for new private motor vehicles, light-duty vehicles, two-wheelers and three-wheelers were adopted in 2000. On the other hand, Pakistan also has a high concentration of air pollution, for which the government of Pakistan has shut down polluting industries during the winter season and has also coordinated the national action plan on air pollution (HEI, 2020).

Hong Kong set Air Pollution Control Ordinance (APCO) in 1983, with the objective of controlling vehicular emissions, construction dust and other key stationary sources. In July 2000, Hong Kong became the first city in Asia to introduce ultra-low sulfur diesel motor vehicles which have reduced SO2 emissions significantly. With regard to emission standards, Hong Kong has adopted Euro III emission standards since January 2001 for all newly registered vehicles. Moreover, the Government of Hong Kong has implemented a policy to eliminate smoky motor vehicles and diesel-run vehicles and promoted the use of mass transit systems that are pollution free (Schwela, et al., 2006). Bangladesh can learn a great deal from these cities, especially China and Hong Kong. China’s policy measures can act as a road map to implement the policy efficiently. Effective measures and policies can be developed to tackle the rising issue of air pollution. As Bangladesh is graduating from the LDC status in 2026, Bangladesh will need a comprehensive strategy regarding air and environmental pollution, so that the country’s development doesn’t hamper the lives and livelihood of its citizens.

6. EXISTING POLICIES IN BANGLADESH

Over the years, the Government of Bangladesh (GoB) has taken several measures to improve the air quality of Bangladeshi cities. In July 1999, the GoB removed lead from gasoline to reduce the harmful emission of the pollutant into the air. The thick blanket of black smoke, PM, and hydrocarbons emitted from 2-stroke wheeled baby taxis covered the skies of Dhaka city and other major cities of the country in the early 2000s. At the beginning of 2003, the government of Bangladesh helped improve the air quality by eliminating 41 per cent of PM2.5 concentration by banning and completely phasing out 2-stroke baby taxis from Dhaka city (DoE and the World Bank, 2019). The government also promoted the use of cleaner Compressed Natural Gas (CNG) as a fuel for vehicles so that emission from burning of petroleum can be greatly reduced, and lower greenhouse gas emissions can be observed. Moreover, the GoB banned the use of buses and trucks older than 20 years and 25 years respectively. The vehicle emission standard of Bangladesh was revised in 2005, and the new standards incorporated EURO-II for new and light vehicles and EURO-I for on-road and heavy vehicles (Hossain, et al., 2021).

In addition, the government also issued a High Court order to shut down existing illegal brick kilns and the establishment of brick kilns in commercial, residential, and environmentally sensitive areas around Dhaka city in 2019. This intervention by the government has reduced substantial level of pollution concentration around Dhaka city and improved the air quality. Additionally, the government decided to use concrete blocks instead of bricks in all future government projects by 2025, so that brick production can be minimised as brick kilns are a major source of air pollution in this country. In recent years, more environmentally friendly technologies for brick production are being considered so that the emission from brickfields can be diminished (Hossain, et al., 2021).

Furthermore, in 2009 the Department of Environment (DoE) undertook an extensive project titled "Clean Air and Sustainable Environment" to address the problems of air pollution from vehicular emission and brick kilns. Under this program, the air quality index (AQI) was established for different cities of Bangladesh to get a clear idea about the daily air quality. The government is also encouraging the use of green technologies and solar panels by incentivising them with tax exemptions and reduced import duties (Hossain, et al., 2021). Besides, the government released draft of the Clean Air Act in 2019 to manage the national ambient air quality of Bangladesh. The draft was submitted; however, the act has not yet been implemented. Policymakers and economists are concerned about the social cost of air pollution, but they should act on it more stringently so that we can achieve cleaner air for our cities.

7. CONCLUSION AND RECOMMENDATIONS

Air pollution in the cities of Bangladesh is worsening with the passing minute. It is likely to double in the next 10 years if strong political intervention and effective policies are not taken immediately. Achieving a greener environment with cleaner air has become a necessity for the citizens of the country. The rising health, economic and environmental concern should be addressed and effective policies should be taken by the government to fight against air pollution. Unmanaged source activities such as brick kilns, traffic, open burning of waste, dust sources such as construction, city corporation fields, SME and industries are key sources of pollutant emission. If these sources of air pollution are addressed and managed using right policy measures and law enforcement, then there will be a huge improvement in the air quality of our country. The co-benefits and associated benefit from air pollution reduction outweighs the cost of implementing policies in the long run.

Some possible solutions and policy measures that can be taken are as follows:

- Hybrid cars should be made more affordable by lowering the import duty. As hybrid cars are more environmentally friendly, encouraging the use of hybrid cars may help reduce vehicular emissions. Moreover, electric vehicles can also be introduced on the streets as electric vehicles have more long-run benefits. However, primary investment in electric vehicles is quite high, and there should be a renewable source of energy to generate power to run the electric vehicles.
- Fitness testing on vehicles should be done on a regularly basis. Scrapping and phasing out old vehicles which do not comply with the fitness standards is also a key step which should be taken by the government to reduce vehicular emission. The government can also encourage the wide use of computerised emission testing in cars, buses, and trucks to meet the vehicular emission standards.
- Carbon tax can be imposed by the government. This will help reduce carbon footprint. A systematic tax collection and minimum tax return system should be maintained to enjoy the maximum benefits of imposing such taxation. Hence, the government need to conduct a systematic study to identify the feasibility and potential gains from imposition of carbon tax.
- The technology used to manufacture bricks in the brick kilns are quite primitive. As brick kilns are a major source of air pollution, efficient brick production technologies which emit lesser pollutants can be established. For example, the existing models and technologies can be replaced by Hoofman Kilns and Vertical Shaft Brick Kiln.
- Construction sites should also be regulated to ensure proper storage, covering, and transportation of construction materials. In addition, a regulatory framework and dust control measures should be devised by the government

to regulate the emission from the construction activities.

- Watering roads and areas around the construction site may also be a solution to reducing air pollution. It is also important to water the trees to protect the biodiversity and the ecosystem from the effects of air pollution.
- In Bangladesh, the temporal and spatial variation is very high. Therefore, policies should be taken according to the temporal and spatial variations of the country. The government needs to ensure a strong political commitment among politicians, researchers, scientists, and physicians to reduce the negative impacts of temporal and spatial variation.
- The government of Bangladesh can discuss with the central government of our neighbouring countries about possible solutions to reduce transboundary air pollution.
- More data collection points across the cities of Bangladesh are recovered for air pollution.
- Emission calculation and emission database should be updated regularly. Strict monitoring and enforcement of controlling emission levels are a must. Emissions of key pollutants should be monitored for 24 hours every day. Sensor based monitoring and drone monitoring can be used as well.
- We need to create mass public awareness and inform the people of our country about the harmful effects of polluted air on human health. The government can increase investment in healthcare in cities with higher AQI to minimise the burden of out-of-pocket health expenditure of individuals.
- Lastly, we need to shift from coal and move towards renewable energy. Investment in renewable energies and green technology will lead to a reduction in air pollution, mitigate climate change issues, and promote economic growth.

Bangladesh should have a broader policy space and identify practical, implementable policies to achieve cleaner cities and eventually minimise the adverse impacts of air pollution. Whenever some technology is implemented in the top, we need to have some basic studies considering Bangladesh economic system, we need to go deeper each sector, and we need to do some ground level analysis. Government should conduct a comprehensive study on air pollution in Bangladesh to identify the main sectors which contributes to pollution. The study should include the drivers and impacts of air pollution in various cities of the country so that the government can plan a comprehensive regulatory framework and policy measures accordingly. A timeline of goals and targets should also be set by the government to achieve in the next few years. Climate change, air pollution and political health are inter-linked. We can look into this in a more integrated way and push for reforms and policy change. Ensuring strong commitment among politicians, researchers, scientists, and physicians is paramount for an effected approach towards emission reduction. Coordination between ministries need to be more efficient to have proper enforcement of laws and regulation to reduce air pollution. Strong enforcement by the Department of Environment and other public and private stakeholders can help Bangladeshi cities achieve cleaner air and a greener environment. Environmental experts and policy makers should work closely to merge economic and environmental policy to get health and economic benefits.

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