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Air Pollution and Management: A Brief Introduction

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Air Pollution and Management: A Brief Introduction

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Summary

The deteriorating quality of air, transboundary haze pollution and global climate change are the major problems affecting the atmospheric ecosystem. Air quality has deteriorated as a result of increasing traffic congestion, rapid industrialisation and increased energy consumption. Tackling air pollution in the Asia and Pacific region is of utmost urgency, and every aspect mitigating air pollution should be assessed and policy options should be taken with the purpose of preventing future harms.

Air quality monitoring is the first tranche to which countries should place adequate emphasis on. The monitoring of certain pollutants, such as Ozone (O_3), Nitrogen Oxides (NO_x), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Particulate Matter (PM), and others are imperative to fully understanding how and where to enact air pollution mitigation policies. The study and differentiation of long-lived and short-lived climate pollutants would also aid in this endeavour.

Urban air pollution should be another area of emphasis for countries, as they consume 78 per cent of the world's energy and produce more than 60 per cent of greenhouse gas emissions (GHGs) while only accounting for less than 2 per cent of the earth's surface. Reducing vehicle emissions is imperative, and sustainable urban development in every sector, especially in waste management, should be rigorously pursued.

Household air pollution should be strongly addressed, as 3.8 million annual premature deaths are a direct cause of indoor pollutants. The continued reliance on biomass burning for daily meal preparation, lighting, cooling/heating, along with traditional agricultural practices contributes to the direct and indirect harms on populations, especially the most vulnerable such as women and children. The impacts of air pollution constitutes a wide range, not simply health, but also exacerbates inequalities, climate change, negative economic impacts, and affects food production.

As air pollution is a transboundary issue, it is critical that higher levels of cooperation also happen in a transboundary nature. In order to effectively mitigate the impacts and causes of air pollution, collaboration and cooperation is paramount. Through an organized shared purpose can meaningful influence be exerted which can have significant impact on policy and implementations.

Regional partnerships should be pursued at all levels, in all facets such air pollution research, air quality monitoring, air quality assessment, allowing for technical knowledge sharing. Countries should enter regional frameworks for air quality management, and existing countries should be fully supported.

In order for air pollution mitigation actions to be effective, this policy brief recommends these

priorities:

- Science-based measures should be incorporated into all facets of government (regional, national, provincial and city levels). The urgency and cross-cutting nature of air pollution and it's impacts constitutes a comprehensive paradigm, one that needs to be rooted in robust air quality data and material implementation actions.

- Municipal governments should take a front-line approach to air pollution reduction strategies. Local municipalities are uniquely situated within the air pollution mitigation nexus, they are the most impacted by the harmful effects of air pollution and are also most able to enact effective air pollution mitigation policies. Their engagement is crucial at all steps of the air pollution mitigation process.

- Countries should firmly place residential household emissions reduction strategies as a core tent of their air pollution mitigation strategies. Shifting the behaviours and incentives of the residential sector to more environmentally friendly alternatives, such as liquefied natural gas (LPG) and electrified options, and away from biomass burning is integral to any air pollution policy framework.

- Using the full regulatory and legislative power of governments to transition to cleaner energy production alternatives. The governmental instruments of investment, policies, legal structures, regulations, and assessments are some in the toolkit that can be employed to make a clean transition.

- Transition to sustainable agricultural management practices. Harmful agricultural practices such as unwanted rice straw burning, accounts for a sizable amount of air pollution, especially from a seasonal perspective. Providing alternatives and policies that shift those harmful practices help mitigate air pollution and aid in supporting the socio-economic floor of farmers in their respective countries.

- In order for air quality measures to be successful, a collaborative approach with the greater public is needed. Public buy-in and engagement is central to full adoption and execution of air pollution mitigation policies, especially certain public behaviours such as high public transportation usage, household cooking and heating options, and others.

Acknowledgement

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Abbreviations

ACG	Air Quality Guideline
BC	Black Carbon
CO	Carbon Monoxide
CHEST	Clean Household Energy Solutions Toolkit
CCAC	Climate and Clean Air Coalition
GDP	Global Gross Domestic Product
GHG	Greenhouse Gases
HFC	Hydrofluorocarbons
LPG	Liquefied Petroleum Gas
CH_4	Methane
NEACAP	North-East Asian Clean Air Partnership
NOx	Nitrogen Oxides
O_3	Ozone
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter 2.5
PM_{10}	Particulate Matter 10
$PM_{0.1}$	Particulate Matter 0.1
PAHs	Polycyclic Aromatic Hydrocarbons
SLCPs	Short-Lived Climate Pollutants
SO_2	Sulphur Dioxide
SDG	Sustainable Development Goals
UNEP	United Nations Environment Programme
UM	Urban Metabolism
VOC	Volatile Organic Compounds
WHO	World Health Organization's

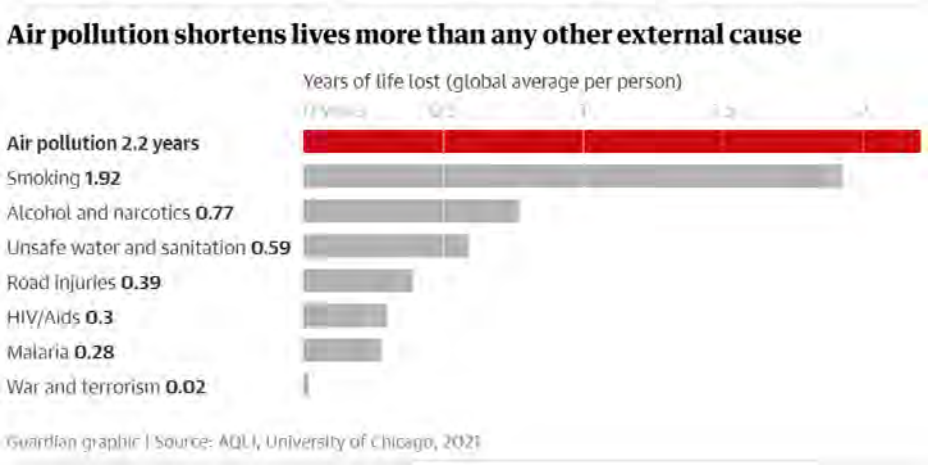
I. Introduction

Air pollution is now considered the most significant environmental risk to human health, with seven million premature deaths annually attributed to unhealthy air quality[1]. Seventy per cent of these deaths occur in Asia and the Pacific, where over 4 billion people (92 per cent of the population) are exposed to air that exceeds the World Health Organization's (WHO) air quality guideline (ACG) levels[2].

This takes as much as five years off people's lives in some heavily polluted areas, significantly higher than the aforementioned global average of 2.2 years[3]. The impact of air pollutants on human health justifies demand for immediate action to improve air quality. However, health impacts are not the only worrying aspect. Air pollution also undermines economic growth due to medical expenses caused by pollution exposure, labour loss due to illness and loss of crop yields, along with other costs, including those associated with increased global warming.

It is estimated that the average person is losing 2.2 years of their life expectancy to a myriad of health complications from the air they breathe. This is greater than the effects of infectious diseases including tuberculosis and HIV/AIDS or behavioural killers such as cigarette smoking and war (Figure 1).

FIGURE 1: AIR POLLUTION SHORTENS LIVES MORE THAN ANY OTHER EXTERNAL CAUSE



Source: (Lee & Greenstone, 2021)[3]

In the Asia Pacific region, most $PM_{2.5}$ results primarily from the burning of fossil fuels (i.e., oil, gas, coal), biofuels (e.g., wood, charcoal, ethanol, biodiesel) and biomass (e.g., wood, straw), during combustion processes aimed at producing transportation energy (e.g., diesel vehicles) or electricity production (e.g., coal power plants), for land preparation and waste (e.g., crop burning).

Air pollution and climate change are closely linked. Therefore, mitigating air pollution has the co-benefit of slowing the adverse effects of climate change. Rising temperatures from global warming cause wildfires to become more frequent and powerful, a cyclical issue, as open fire (natural or human-made) creates more air pollution.

The financial price tag to move away from fossil fuels, sustainably manage crops and put the infrastructure in place to mitigate air pollution is often beyond the capacity of developing nations to bear alone. This, and the fact that air pollution can travel thousands of kilometres away from its source, impacting countries outside of its original jurisdiction, requires that countries strengthen cooperation and work with multilateral organisations to develop solutions to this transboundary emergency.

This policy brief will review the urgent need to tackle air pollution in Asia and the Pacific and its environmental, social and economic impacts on the region, taking into account the World Health Organization (WHO) updated guidelines in 2021 for recommended levels of air pollutant concentrations, defining the line between what is referred to as clean or dirty air[4].

It is to be noted however that air pollution does not affect the whole Asia-Pacific region in the same manner, with the Pacific for example not being much affected by $PM_{2.5}$ [5] but heavily impacted by ocean acidification and rising sea levels. Hence this policy brief will mostly focus on Asia.

Ahmad Hidayat/Unsplash

II. Types of Pollution

Air pollution is a complex mix of solid particles, liquid droplets and gaseous chemicals emitted in the atmosphere. Each comes with its own unique set of challenges and impacts. While some aerosols occur naturally (i.e., aerosolization of sea salt, ashes from volcanoes, wildfires), most pollutants are from anthropogenic sources (Table 1).

Understanding the chemical fingerprint of air pollution for any given area is the key to identifying its source and ultimately pinpointing how to best reduce emissions, concentrations and exposure. To do so requires extensive measuring and monitoring of a large panel of air quality parameters.

It is also important to note that air pollution in the region follows a seasonal pattern driven by environmental conditions such as temperature, wind and rainfall. In the parts of Asia experiencing monsoon, this is characterised by relatively low air pollution levels during the summer monsoon season, as winds and heavy rainfall help to disperse and remove pollutants.

TABLE 1: COMMON TYPES OF POLLUTANTS

Pollutant	Description
Particulate Matter (PM)	Suspended microscopic solids or liquid droplets, directly emitted into the air from fossil fuel combustion, open burning, dust, etc. (primary PM), and from complex reactions of chemicals such as sulfur oxide and nitrogen oxides (secondary PM)
Ozone (O_3)	Formed by reacting with sunlight (photochemical reaction) and pollutants such as nitrogen oxides (mainly vehicle emissions) and volatile organic compounds (VOC)
Nitrogen Oxides (NO_x)	Predominantly originated from combustion of fossil fuels at high temperature (heating, power generation, engines in vehicles and ships)
Sulphur Dioxide (SO_2)	Originated from the combustion of sulphur-containing fossil fuels for domestic heating, power generation and motor vehicles

TABLE 1 (CON'T): COMMON TYPES OF POLLUTANTS

Pollutant	Description
Carbon Monoxide (CO)	Odourless but poisonous gas, produced by the incomplete combustion of carbonaceous fuels such as wood, petrol, coal, natural gas and kerosene
Methane (CH_4)	Main component of natural gas, produced from the agriculture sector (i.e., rice production, livestock, manure management), solid waste landfills and fossil fuel production
Volatile Organic Compounds (VOCs)	Vaporise from solids and liquids such as paints, coatings, gasoline, other solvents and ozone-depleting hydrofluorocarbons

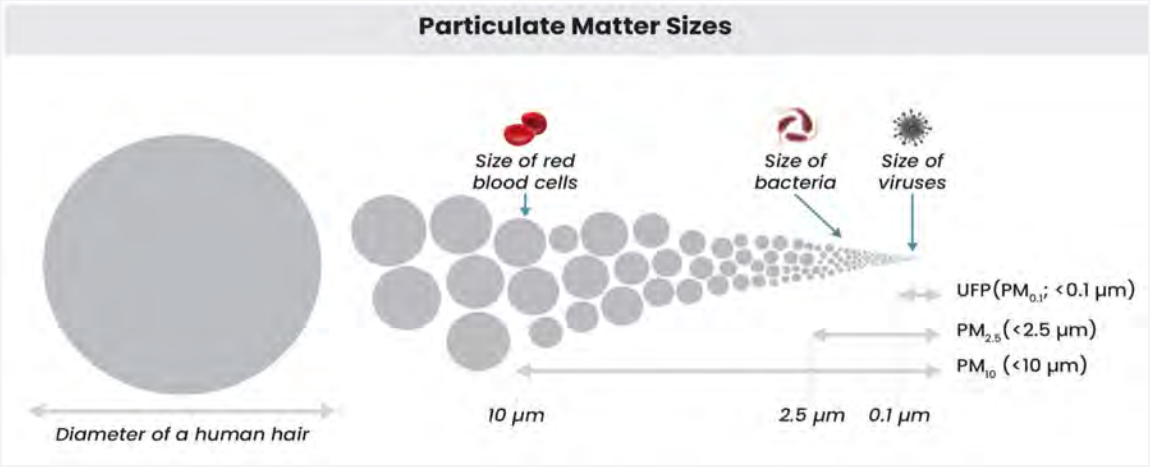
A. PARTICULATE MATTER

Particulate Matter (PM) has become a major global concern over the last three decades and, although it often makes headline news, many still do not understand the complexity and threat of this type of air pollution[6]. It is usually highest in the urban areas of low and middle-income countries, including the expanding cities of Asia-Pacific. South-East Asia sees the highest population-weighted concentrations of this pollution. PM is composed of a wide range of particulate aerosols of different natures (e.g., sulphur dioxide, nitrogen oxides, ammonia, black carbon, mineral dust, volatile organic compounds, sea salts).

PM spans a wide range of sizes from coarse (PM_{10}; <10 µm in diameter), down to fine ($PM_{2.5}$; <2.5 µm in diameter) and ultrafine particles (UFP) ($PM_{0.1}$; <0.1 µm in diameter) (Figure 2)[7]. This classification helps quantify impacts, as health is impacted by PM of all sizes but can be particularly severe for smaller particles sizes. PM emitted during combustion processes (e.g., internal combustion in motor engines and power plants, as well as open burning of agricultural and domestic waste and biofuels) makes up most anthropogenic emissions.

This is because smaller particles can more easily penetrate body tissues such as the lungs and move through the bloodstream. Also, despite their tiny size, the particulates can still absorb and transport substantial amounts of toxic compounds[8]. The smaller the particles, the lighter they are, and therefore stay in the air longer and travel farther. As a result, the atmospheric lifetime of a PM can vary from days to a few weeks, and they can travel up to tens of thousands of kilometres away from their source. One of the challenges in understanding the impacts of PM, is that its effects are dependent on the unique chemical make-up of each particle, which can change how it interacts with the environment and inside the human body[9].

FIGURE 2: PARTICULATE MATTER SIZE



Source: French National Research Institute for Sustainable Development (IRD)

B. LONG LIVED AND SHORT LIVED CLIMATE POLLUTANTS

The atmospheric lifetime of a pollutant is the duration of time the pollutant remains in the atmosphere before it disappears, either through decomposition in the atmosphere or by joining terrestrial or oceanic ecosystems. Carbon dioxide (CO_2), the most significant contributor to climate change, has a long-lived impact on the climate with an atmospheric lifetime of anywhere from 300 to 1,000 years.

While CO_2 is the main driver of climate change, an estimated 30 per cent to 45 per cent of current global climate change is from short-lived climate pollutants (SLCPs). These have relatively short lifespans but can still cause environmental damage and increase health risks.

The four identified SLCPs (and their atmospheric lifetime) are:

- Black Carbon (BC) - days to weeks
- Ozone (O_3) - hours to weeks
- Methane (CH_4) - around 12 years
- Hydrofluorocarbons (HFC) - 15-29 years

Cutting all CO_2 emissions would slow global warming by 0.1°C by 2050 and 1.1°C by 2100. Significant gains can be made in parallel by cutting SLCPs, where by 2050 it would be possible to avoid 0.6°C of warming and 1.5°C of warming by 2100[10].

This is because certain SLCPs have a far more significant impact on warming, such as black carbon, which is considered 460-1,500 times stronger than CO_2 but has a very short atmospheric lifetime. Long-Lived and most Short-Lived Climate Pollutants also directly linked to poor air quality.

Therefore, managing CO_2 and SLCPs are levers to address climate change and slow global warming. Aggressive actions to reduce CO_2 and SLCPs will generate public health benefits while keeping nations aligned with the Paris Agreement and Sustainable Development Goals (SDGs).

Niilo Isotalo/Unsplash

III. Regional Air Pollution

Asia's economic growth, industrialisation, urbanisation and growing energy consumption have been accompanied by a significant degradation of air quality, placing the region's sustainable development at risk. Air pollutants, however, do not stay in one place. Some can travel vast distances, impacting millions, regardless of the source of the pollution.

These populations may be outside the jurisdictional reach or national boundaries, hindering those affected by that pollution from being involved in the process to make needed interventions. Thus, success for the region in combating air pollution will largely depend upon creating partnerships for cooperation among countries, regions and sectors, including on improved and/or harmonised air quality standards, and enhanced cooperation towards global goals, such as the Paris Agreement and the Sustainable Development Goals[11].

Sharing of data and information on air quality is also important, as is the adoption of best practices in the air quality policies and proven technologies, such as advanced monitoring networks. Efficient methods to manage agricultural waste and infrastructure that favours cleaner modes of transportation are opportunities that can be deployed across the region. These efforts must be supported by capacity building to ensure that clean air measures are effectively implemented and monitored.

Box 1: Air Pollution from the Agricultural Sector

The Agricultural Sector is an area of concern for the region.

Some of the main contributing factors from this sector, are:

- Slash-and-burn methods for land and field clearing
- Open burning agricultural waste (e.g., straw)
- Mismanaged livestock manure
- Inefficient transportation logistics

Managing these problems will take regional cooperation between nations, as many of these activities are ubiquitous across the region and practices happening in one country can deeply impact neighbouring countries.

IV. Urban Air Pollution

Cities consume 78 per cent of the world's energy and produce more than 60 per cent of greenhouse gas emissions (GHGs) while only accounting for less than 2 per cent of the earth's surface. As urban areas continue to expand, it is expected that their emissions will continue to increase.

Many Asian cities such as Chiang Mai, Bangkok, Hanoi or Delhi, regularly experience severe air pollution episodes due to various factors such as energy production, transport, industrial and residential activities. However, many of the most polluted cities in the region are also impacted by sources of air pollution well outside city limits, including agriculture and crop burning in rural peripheries, influenced by climate and weather conditions (wind, rain, stagnant atmospheric conditions).

Emissions from vehicle represents a large portion of the sources of air pollution in cities, about 25 per cent of overall fine particulate pollution[12] adversely affecting urban dwellers. Reducing traffic congestion through improved public transport and urban traffic management systems are essential. Fuel quality and vehicle emission standards and enforcement require coordination between local authorities and national transport ministries, particularly for heavy-duty diesel vehicles.

Another primary cause of urban air pollution comes from inefficient municipal waste systems. Recent studies have shown that nearly 2 billion tonnes of waste are generated worldwide annually, and 33 per cent of that is openly burned[13]. In open dumps, fires can self-ignite or are set intentionally, resulting in significant air pollution in urban centres where human exposure is greatest.

Therefore, comprehensive municipal solid waste management is critical for cities to ensure that clean disposal and recycling are feasible alternatives to burning. Modern refuse-to-fuel systems provide opportunities for cities to adopt waste management practices that also have air quality co-benefits.

V. Household Air Pollution

Of the 7 million annual premature deaths attributed to air pollution globally, 3.8 million are a direct cause of indoor pollutants. Residential combustion in developing countries is the leading cause of indoor air pollution.

In Southeast Asia, many rural areas still rely on biomass fuels and biomass-derived fuels for daily meal preparation, lighting, cooling and heating. For example, about 94 per cent and 80 per cent of the population in rural Cambodia and Lao PDR, respectively, use fuelwood and charcoal for meal preparation[14]. Other sources of indoor air pollution include the use of crop residue, rice husk, bagasse, sawdust, dung cakes, peat coal, coal cake, honeycomb coal briquettes, gaseous fuels and kerosene.

Household air pollution has a heavier impact on women and children in the region, as domestic responsibilities, including cooking, are usually done by women with their children in the household, exposing them directly and for long periods to these pollutants. 45 per cent of deaths due to pneumonia in children under five years of age are from household air pollution[15].

Policy-makers and decision-makers should recognise the impact of household air pollution on women. These considerations should also be extended to the broader community, ensuring a sense of collaboration between community members and decision-makers. This allows decision-makers to determine whom a regulation will impact and what support mechanisms will be needed during transitional phases.

Additionally, household air pollution does not just stay indoors. It leaks into the environment, contributing to overall ambient air pollution. This is a considerable concern for densely populated and impoverished urban areas. Tackling household air pollution will require awareness raising and providing clean energy alternatives for cooking and other household needs.

VI. Impacts

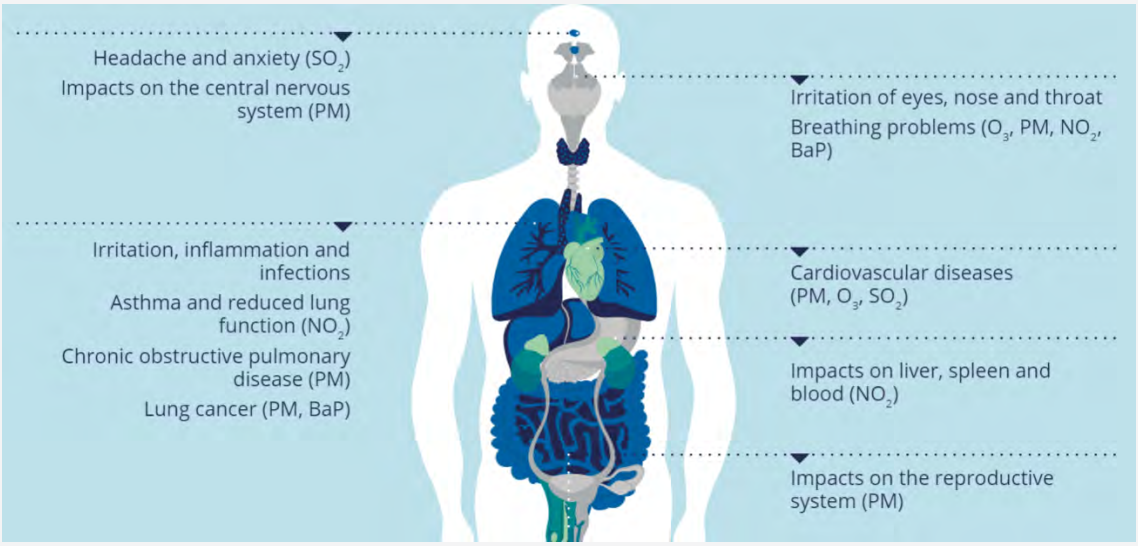
A. HEALTH

$PM_{2.5}$ is the primary driver of health impacts from air pollution. Other significant contributors are ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO).

Since 1987, WHO has periodically issued health-based air quality guidelines to assist governments and civil society in reducing human exposure to air pollution. The last update came after a 15-year hiatus and was released in September 2021[16].

Much has changed since then, both in understanding the severity of this crisis and the human health impacts. For instance, there is now proof that even small amounts and short-term exposure can have severe implications.

FIGURE 3: EXPOSURE TO AIR POLLUTION HEIGHTENS THE RISK OF DISEASE



Source: (European Environment Agency, 2023)[17]

For example, every five micrograms per cubic meter increase in exposure to $PM_{2.5}$ during pregnancy is associated with a 4 per cent increased likelihood of low birth weight. For adults, exposure to five micrograms per cubic meter per year is associated with a 13 per cent increased likelihood of heart attacks and cardiovascular-related deaths[18]; a 4 per cent increased chance of lung cancer[19] and doubles the likelihood of Alzheimer's[20]. For students, an increase of 10 μg/m^3 of PM_{10} on the day of the examination decreases scores by around 6 points (8 per cent)[21].

In this regard WHO undertook a review of their air quality guideline (AQG) levels (Table 2). In the case of $PM_{2.5}$ exposure, WHO cut recommended levels in half, lowering the average maximum exposure from 10 micrograms per cubic meter per year to 5. They also tightened the limits for gaseous air pollutants like nitrogen dioxide, cutting it down by one-quarter from the previous level, at 40 to 10 μg/m^3.

Currently, most countries in the region exceed the old maximum recommended amounts regularly - they will have to work twice as hard to meet the new limits. To rise to this new challenge, swift action is required in Asia and the Pacific to protect human health.

TABLE 2: COMMON TYPES OF POLLUTANTS

Pollutant	Averaging time	Interim target				AQC level
		1	2	3	4	
$PM_{2.5}$, μg/m^3	Annual	35	25	15	10	5
	24-hour[a]	75	50	37.5	25	15
PM_{10}, μg/m^3	Annual	70	50	30	20	15
	24-hour[a]	150	100	75	50	45
O_3, μg/m^3	Peak season[b]	100	70	-	-	60
	8-hour[a]	160	120	-	-	100
NO_2, μg/m^3	Annual	40	30	20	-	10
	24-hour[a]	120	50	-	-	25
SO_2, μg/m^3	24-hour[a]	125	50	-	-	40
CO, μg/m^3	24-hour[a]	7	-	-	-	4

Source: (WHO, 2021d)[4]

Notes:
a = 99th percentile (i.e. 3-4 exceedance days per year).
b = Average of daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running-average O_3 concentration.

B. INEQUALITIES

Air pollution is pervasive and can cause harm to any individual exposed. Still, its impacts are felt heaviest by at-risk groups, including children and women, the elderly, those with pre-existing medical conditions and the poor, as they often have little choice over where they live and work. Many spatial, or geographic factors, make air pollution particularly harmful for those in certain areas due to proximity to sources and varying densities of pollutants.

For example, data suggests that particulate pollution from vegetation and forest fires disproportionately impacts poorer populations across Southeast Asia. These fires contribute to over a third of their total $PM_{2.5}$ exposure[22]. Furthermore, while it is well-studied that indoor air pollution typically has more drastic impacts on women and children, the gendered effects of ambient air pollution are among the least studied aspects of global environmental issues.

Some key facts are well understood including the link between $PM_{2.5}$ and an increased risk of mortality from breast cancer for women[23] as well as indications of gender-differentiated duties for childcare when unhealthy air can adversely impact women and threaten their health. However, understanding the more nuanced connections between gender and air pollution can help shape policy that has impactful benefits for women and girls in the region.

BOX 2: THE HUMAN RIGHT TO A SAFE, CLEAN, HEALTHY, AND SUSTAINABLE ENVIRONMENT

In October 2021, the United Nations Human Rights (UNHR) Council recognised that having a clean, healthy and sustainable environment is a human right, recalling the States' commitments to meet 2030 Agenda for Sustainable Development Goals and reminding States' that a safe, clean, healthy and sustainable environment is vital for the enjoyment of human rights.

The report recognised that the consequences of pollution are felt most acutely by those segments of the population that are already in vulnerable situations, including women and girls, indigenous peoples, older persons, and persons with disabilities[24].

This resolution empowers governments to act against all factors of environmental degradation that harms human societies. Given the devastating impacts of poor air quality on people's lives, health and human rights, priority needs to be placed on managing air pollution, focusing on ameliorating conditions for the most vulnerable.

In 2019 the UNHR helped to provide a framework around air management by providing seven key recommendations[25]:

- Monitoring air quality and health effects
- Public reporting on air quality
- Establishing air quality legislation, regulations, and standards
- Preparing air quality action plans
- Implementing and enforcing air quality rules
- Evaluating and revising air quality standards and plans
- And protecting environmental human rights defenders

C. CLIMATE CHANGE

The most significant cause of anthropogenic climate change is fossil fuels, with carbon dioxide alone accounting for 65 per cent of GHG emissions. Fossil fuels are also responsible for the most significant portion of air pollution such as nitrogen oxides, sulphur oxides, carbon monoxide and particulate matter.

For example, approximately 60 per cent of urban ambient $PM_{2.5}$ comes from this source. Also, methane, emitted predominantly by the agriculture and energy sectors, is the second powerful GHG contributing to climate change and is largely responsible for rising tropospheric Ozone levels as a major precursor.

Another recognised factor impacting climate change is the relationship between PM emission and residential energy consumption. A study in Singapore found that residential electricity demand grows by 1.1 per cent when $PM_{2.5}$ rises by 10 $\mu g/m^3$ [26]. This occurs as people tend to stay indoors to protect their health, resulting in more energy use to cool their homes and power electronics (including air purifiers). This increases energy use directly affects air pollution.

Thus, many policies and regulations for cutting GHG emissions can create co-benefits of reducing air pollutants, and vice versa. Air pollution policies aimed at inducing structural changes, for example closure of polluting coal power plants or improving fuel efficiency of automobiles have potential positive spill-over effects for climate mitigation.

Policies to improve energy efficiency and expand renewable energy as components of broader climate policies tend to have benefits for air quality improvement. In Asia, the benefit of air pollution reduction through GHG mitigation measures were estimated to reduce premature mortality by 0.79 million[27].

D. ECONOMIC IMPACTS

Globally, the costs related to mortality and morbidity caused by exposure to $PM_{2.5}$ in 2019 were US $8.1 trillion, equivalent to 6.1 per cent of global gross domestic product (GDP)[28]. In the ESCAP region specifically, the cost ranged from an equivalent of 9.3 per cent of GDP in East Asia and Pacific to 10.3 per cent in South Asia. Air pollution from fossil fuels is estimated to directly cost the global economy US $2.9 trillion annually or 3.3 per cent of global GDP, far exceeding the likely costs of reducing fossil fuel use.

These costs undermine a country's economic growth potential in many ways, such as a decrease in people's work hours (sick leave from air pollution is estimated to cost the world $100 billion annually[29], cost of disease and loss of human life (see list of estimated costs below) and loss of agricultural productivity[30].

Global health costs of air pollution:

- Disability from chronic diseases: US $200 billion
- Asthma: $17 billion
- Preterm births: $90 billion
- Child deaths: $50 billion
- Adult deaths: $2,400 billion

These costs are associated with the high direct costs of air pollution (health, loss of labour and agriculture). However, there are many types of indirect economic loss as well, including loss of tourism revenue, a key driver of economic growth in the Asia Pacific Region. Without action these costs will only increase as any negative impact on capital accumulation has a permanent effect on economic growth rates[31].

E. FOOD PRODUCTION

The relationship between food production and air pollution is clear: unsustainable agricultural practices are a contributor to air pollution and poor air quality impacts the quantity and quality of food that can be produced.

Therefore, air pollution is threatening the region's food supply, contributing to increasing levels of food insecurity. With nearly one in three people globally suffering from food shortages today and a constantly growing population, any threat to production is a cause for concern[32].

The agriculture sector contributes to air pollution through emissions of ammonia, nitrogen compounds and methane. The sector also impacts air pollution through open burning methods used to cheaply clear land, resulting in the emission of large amounts of PM.

Conversely, there is increasing evidence that food production is also threatened by air pollution. SLCPs, like Ozone and Black Carbon, are highly oxidising and penetrate plant structures and impair their development ability[33]. They are blamed for impeding photosynthesis, reducing the ability to sequester carbon, damaging plant cells and reducing food quality and nutritional value[34].

Ozone alone was estimated to cause relative global crop losses of 6 per cent to 16 per cent for soy, 7 per cent to 12 per cent for wheat, and 3 per cent to 5 per cent for maise. Some crops are more sensitive than others to ozone exposure, with wheat and soybean being most susceptible and potato, rice and maise being moderately sensitive.

Of concern is the fact that these most sensitive crops are all staple foods for most of the world's population[35] and key crops in the region, hence the need for a sustainable approach that balances food production/ safety, livelihoods and environmental impacts of agriculture.

VII. Strengthening Regional Cooperation

Countries in Asia and the Pacific have adopted National Ambient Air Quality Standards for the key air pollutants including particulate matter, sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide, heavy metals like mercury, lead and cadmium and various polycyclic aromatic hydrocarbons. However, the values of standards often differ from country to country, as do the number of substances and averaging times utilized for monitoring.

Harmonized or common standards across the region would provide a basis for coherent approaches to measuring and monitoring of pollutants. As air pollution comes from various sources, the first step needs to be identification and source apportionment. Innovative data sources and deployment of emerging technologies to identify air pollution hotspots are necessary to develop informed and efficient policies.

To gain an exhaustive overview of air quality and decipher its sources, multiple data-collection approaches should be used, as different monitoring technology comes with unique advantages and disadvantages and can yield different spatio-temporal resolutions. This monitoring must be planned for the long-term to ensure measures' effectiveness and continually seek to improve air quality through innovation. Comprehensive air quality management planning must include air quality monitoring, emission inventory development, source attribution and modelling, health impact assessment, other data (i.e., weather, traffic, land-use) and decision-support analysis (e.g., cost-benefit or cost-effectiveness analysis) that examines multiple angles of emission reductions.

Robust data can be utilised with innovative tools, like machine learning algorithms, to model different scenarios based on different measures. This allows policy-makers to select the most efficient approach to fix their unique air pollution issue. Across the region, best practices and solutions to the challenges of air pollution are being deployed but not at the scale or the pace that are needed to tackle the increasing levels of air pollution, while effective solutions to limit transboundary air pollution are limited.

Subregional initiatives and platforms in North-East Asia, South Asia and South-East Asia, as well as region-wide partnerships have been established to share and scale-up the adoption of science-based solutions within and across sub-regions. The North-East Asian Clean Air Partnership (NEACAP), the Malé Declaration, the ASEAN Agreement on Transboundary Haze Pollution and the Low Emission Analysis Platform in South Asia are key models for the exchange of best practices and solutions. Technological best practices and clean air measures have been developed and recommended for various sectors, such as agriculture, industry, transport, waste collection and treatment, clean cooking and decarbonization of domestic heating, mining and energy efficiency.

Twenty-five science-based solutions for these sectors have been identified by the United Nations Environment Programme and the Climate and Clean Air Coalition in the report: "Air Pollution in Asia and the Pacific: Science-based solutions" [36]. The means exist to reduce or mitigate air pollution (i.e., cleaner energy production and agricultural management options, cleaner modes of public transportation, enhanced monitoring networks).

However, much of Asia and the Pacific have not deployed, enforced or trained on measures or technologies at the scale necessary to reach clean air goals[37]. This is because many governments in low- and middle-income countries, like most in the region, lack the capacity to manage air pollution properly, and barriers exist to initiate or sustain effective clean air actions. Actions against air pollution must be designed and deployed at the regional, national and local levels, written hand-in-hand with the academic, civil and private sectors to generate mutually agreeable solutions.

If organisations within and beyond governments work together to develop action plans, mitigation efforts have a more substantial chance of success in the real world. Political will, government leadership, intersectoral approaches and partnerships are essential to address the issue of air pollution. Unfortunately, in Asia and the Pacific, cooperation to improve air quality is fragmented. A lack of consistent data, standards and regulations across the region have hindered their success in mitigating air pollution. This disorganisation has created a void of information and guidance.

Coordinated regional action that prioritises improvement of air quality management, facilitation of air quality monitoring and sharing of open data, exchange of best practices and outreach, facilitation of capacity-building and technical support for national action and mobilization of commitment to multilateral cooperation needs to be put in place through enhanced regional cooperation to build and deploy action plans. While sharing data between countries is a crucial first step, other ways regional nations can support each other and build trust are by sharing best practices, assisting in creating action plans and coming to mutual agreements and goals.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VIII. Conclusion and Recommendations

Air pollution is a persistent problem and many of its devastating impacts are globally recognised. Unfortunately, for the Asia-Pacific region, this crisis is only worsening, and projections show no sign of slowing. To avoid being plagued by this menace, the region must urgently align itself with global goals and invest more resources to find and enact solutions.

If the region's countries can bring down their levels of air pollution to meet the standards deemed healthy by the World Health Organization (WHO), they will not just protect the well-being of their citizens but will also enjoy the co-benefits of protecting livelihoods and the health of the economy, reducing global-warming gas emissions, preserving global food supplies and levelling the playing field on some barriers to equality.

However, none of this is possible if the region does not take immediate action. Improving air quality may appear overwhelming. But, with regional cooperation and capacity management, it is possible to implement and finance effective measuring and monitoring tools so that the right science-based measures can be applied to combat air pollution.

A focus on the following priorities is essential if the region is to see meaningful improvements in air quality:

A. SCIENCE-BASED MEASURES

Science-based measures can be built into action plans at all levels of government (regional, national, provincial and city levels). These plans should focus on gradual progress, marked by the achievement of interim targets with a hierarchy of goals that reduce emissions, concentrations and exposure. The report, "Air Pollution in Asia and the Pacific: Science-based solutions", outlines such measures in industry, transport, agriculture, residential sectors, etc., that can bring direct health and socioeconomic benefits.

This 'menu' of measures gives an overview of the central measures that need to be implemented. However, as sources of pollution vary, and given the geographic and socio-economic diversity of the region, plans must be tailor-made for each specific area. Therefore, in the following sections, this Policy Brief will take a closer look at some solutions for cities, household air pollution and the private and civil sectors.

B. CITIES

Municipal governments must play a larger role in addressing air pollution, particularly when it comes to reducing emissions and shifting to sustainable power systems. This will include designing a new urban framework of consumption and production that considers the total sum of the technical and socio-economic processes that occur in cities to manage energy, movement and waste, otherwise known as urban metabolism (UM)[38].

Even improving urban wastewater management systems can help improve air quality, as municipal and industrial wastewaters that are not properly managed can emit volatile organic compounds (VOCs) and other inorganic pollutants (heavy metals)[39].

Examples of actions include developing a sustainable urban metabolism (UM), improving wastewater management systems and other measures cities can use to improve air quality. For a city to identify the right solutions for its problems, and implement appropriate solutions, it must develop effective local clean air action plans that tie to national, regional and global goals.

The following mechanisms should be carefully considered:

- Focus first on clean air jurisdiction within their boundaries. This includes investing in efficient and clean public transit infrastructure.
- Bring together local ministries or government agencies that often do not work together to find shared resources that help improve air quality. This can include shifting bus fleets to clean energy sources.
- Bring together local stakeholders from the private and civil sectors to advance voluntary actions. This includes launching effective public awareness campaigns and encouraging the best use of corporate social responsibility spending.
- Coordinate technical expertise from local academic institutions and scientists to implement effective monitoring networks and determine the right solutions for their city.
- Align to and shape regional and national action plans. Using multiple strategies and having city, national and regional governments play complementary roles will enhance the effectiveness of any measure[38].
- Urban development planning must prioritise air pollution control measures, and funds for the enforcement of such measures must be allocated at the local level.
- Leverage city networks such as Clean Air Asia and ICLEI–Local Governments for Sustainability to transfer knowledge between countries and cities.

C. RESIDENTIAL

Policy and cooperation among sectors can also play a huge role in reducing residential air pollution by providing citizens incentives to switch to a more energy-efficient way to cook, heat and cool their homes. Many homes still cook with biomass fuels in the region even though cleaner options like liquefied petroleum gas (LPG) and electricity are available.

This happens because the cost of the transition can be a barrier for some people, however with interventions, the burden of cost for consumers can be alleviated. One example of this is the "pay-as-you-go" smart meter technology for households that switch to LPG, so they do not have to pay the total upfront cost of an LPG cylinder[41].

Other solutions to residential air pollution can be found in the WHO's Clean Household Energy Solutions Toolkit (CHEST). This toolkit provides mechanisms that can be used to develop policy action plans for expanding clean household energy access and use. CHEST is intended to help professionals and policy-makers implement recommendations found in the WHO Guidelines on indoor air quality: household fuel combustion.

D. ENERGY

The energy sector is of primary concern for the region. Currently, for example, in Southeast Asia coal-fired power plants under construction or planned to be built could cause $PM_{2.5}$, SO_2 and NO_x emissions to increase 2.5 - 3 fold by 2030. Transboundary pollution control conventions and rules, accompanied by emission reductions and the use of the best available emission control technologies could support a transition to cleaner power systems.

Useful instruments to reduce air pollution in the energy sector include:

- Investment in the research and development of alternative energy sources (i.e., solar, wind, hydro) to shift away from fossil fuels and increase the use of renewable energy in the energy mixes of countries.
- Policies on the efficient and sustainable management of natural resources, including conserving high-priority natural land and combatting conservation crimes
- Policies and legal structures to promote cleaner production (e.g., subsidy reform)
- Regulatory changes to encourage power plants to install flue gas desulphurization and other emission control technologies
- Use of environmental impact assessments to regulate industries

Furthermore, an ever-increasing number of global businesses are seeing the opportunity in the zero-carbon economy and are making various low-carbon commitments on their own through coalitions and partnerships, such as the We Mean Business Coalition, Ceres (Coalition for Environmental Responsible Economies), The Ambition Loop, the World Business Council for Sustainable Development and the Carbon Pricing Leadership Coalition. These types of partnerships and efforts needed to be encouraged and promoted throughout the region.

E. AGRICULTURE

Unsustainable practices in the agricultural sector are often driven by socio-economic factors, as many farmers lack the resources to switch to green energy practices. However, by addressing these pollution-creating issues, not only will the air become cleaner, but there is also the possibility for payback in the form of cost-saving practices and can improve equality in the industry.

This can be improved by more sustainable management of straw and manure, egalitarian land rights, alternative cash crops, agroforestry practices that have roots in local knowledge and organically produced fertilizers. The burning of straw is a growing problem, particularly in multiple cropping areas of the region[42]. It is estimated that only 20 per cent of the rice straw in the region is used sustainably, most of the rice straw is burnt after harvest. 48 per cent of the rice straw in Thailand, 62 per cent in Indonesia, 42 per cent to 58 per cent in the Philippines and 54 per cent in Vietnam all go up in smoke.

The high-efficient utilisation of crop straw in the region is constrained by a lack of appropriate methods and machines, shortage of rural labour and weak environmental awareness. Farmers mostly burn this unwanted crop straw after harvesting or before planting. However, if these biomass fires could be prevented, 59,000 premature deaths would be avoided every year in the region.

If appropriately managed, straw can be a precious resource that saves or makes farms money by providing:

- Fertiliser
- Fodder
- Biogas production (ethanol)
- Paper products

Training, financing and access to markets for these products needs to be ensured so that farmers can adopt these practices, and consideration must be given to the terrain and current agricultural practices to examine which solutions can realistically be implemented.

An example of how improvements can be made in the agricultural sector to mitigate methane is using anaerobic digesters on livestock waste to generate biogas. Biogas can be collected from manure and burned to meet on-farm energy needs such as electricity, heating and cooling. Surplus electricity or biogas can be sold to neighbouring operations or the utility grid.

F. PUBLIC ENGAGEMENT

Funding better air quality management requires the government to take steps that impact citizens, such

as taxation, shifting subsidies, expending funds on improved air monitoring, regulating emissions and mandating clean fuel. And, for measures that rely on behavioural change to be effective, including switching to public transit and changing how they cook and heat at home, the public must actively participate.

Therefore, most air quality measures success depends on the public buy-in to the importance of clean air and the understanding that the shifts are absolutely needed and will improve quality of life today and for future generations.

How to encourage behavioural changes:

- Open air quality data, along with awareness-raising campaigns to inform and engage
- Strengthen and enforce vehicle emissions and fuel quality standards which should be aided by the rapid expansion of public transport and accessibility of electric vehicles
- Provide subsidies for households and businesses that switch to clean energy options

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