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# CLEAN AIR CATALYST

## Understanding Jakarta's Air

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Clean Air Catalyst

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Nine out of 10 people globally breathe air with levels of pollutants that exceed World Health Organization (WHO) air pollution guidelines, according to WHO data (WHO updated those guidelines in September 2021, and the statistics may change with those updates). Low- and middle-income nations bear the brunt of the burden, with the greatest toll on populations living in the WHO's Western Pacific and South-East Asia regions.

Jakarta, the capital city of Indonesia, has experienced rapid development. Its economy has doubled in size in the past decade and accounted for 16% of Indonesia's economy in 2020. In 2020, the city's population was estimated at 10 million with a population density of 14 people per km2 and a growth rate of approximately 0.92%, which has held steady in the past 10 years. Air pollution management is a major challenge faced by city authorities, with air pollution expected to worsen in the coming decades because of increasing economic activity and rapid urbanization.

The Clean Air Catalyst (Catalyst) is a five-year flagship program funded by USAID to accelerate clean air solutions in Jakarta. Our core strategies are building awareness of the sources of air pollution through collecting and analyzing air pollution data, identifying solutions that address the root causes of pollution, and building a strategic coalition to advance those solutions. The Catalyst takes an integrated approach with the goal of reducing air pollution while achieving health and climate benefits, as well as mitigating gender disparity due to the disproportionate impacts of pollution on women and vulnerable populations.

In this highlight note, the Catalyst wants to share what we know about air pollution in Jakarta, how it impacts health and the climate, and what we can do about it. Our goal is to reduce emissions while empowering women as Clean Air Catalysts. Will you join us?

## Sources of Air Pollution in Jakarta

Today, there are nine air quality reference monitoring stations in Jakarta, including five managed by the Environmental Agency of the Special Capital Region of (Daerah Khusus

Ibukota; DKI) Jakarta, monitoring CO, $O_3$, $SO_2$, $NO_2$, $PM_{10}$, and $PM_{2.5}$; two stations managed by the U.S. Embassy in Jakarta measure $PM_{2.5}$ and one managed by the Ministry of Environment and Forestry measures $PM_{2.5}$, $PM_{10}$, CO, $O_3$, $SO_2$ and $NO_2$. Lastly, one station owned by The Meteorology, Climatology, and Geophysical Agency (BMKG) monitors $PM_{2.5}$, $PM_{10}$, SPM, $O_3$, $SO_2$ and $NO_2$. In addition to the reference monitoring stations, several low-cost monitors have been deployed in the city to better understand air pollution and its main drivers.

The levels of air pollutants recorded over the past decade have exceeded Indonesia's air quality standards for nitrogen dioxide ($NO_2$) and ozone ($O_3$). Levels of $PM_{2.5}$, which have been monitored since 2019, have exceeded Indonesia's daily and annual limits on that pollutant. Further, Jakarta's air pollution levels have consistently exceeded WHO limits for $PM_{2.5}$, $O_3$, $NO_2$, and sulfur dioxide ($SO_2$) (DLH, 2020).

In general, air quality is worse during the dry season (June to November) compared with the rainy season (December to May), due to meteorological conditions such as high temperature, low humidity, and low wind speeds in the dry season. On the other hand, during rainfall season, wet deposition contributes to slightly lower concentrations of some air pollutants (Kusumaningtyas et al, 2018).

Although air quality monitoring infrastructure has been rapidly improving in the past two years, particularly for $PM_{2.5}$, there are some areas of opportunity for existing and new air quality monitoring resources, which are unevenly distributed within the city: the southern and central regions house more stations than the northern and eastern regions. Therefore, for a holistic understanding of the scope and extent of air quality pollutants in Jakarta, two key priorities emerge.

Several emission inventories have been developed for the city, with varying methodologies and activity data. From these emission inventories, the transport sector was identified as the greatest source of $NO_x$, CO, and $PM_{2.5}$. Energy generation and the manufacturing sectors have both been identified as the greatest emitters of $SO_2$ and $NO_x$, and the second most important sources of secondary $PM_{2.5}$ (Lestari et al., 2020). However, this result might not represent the entire picture of the major sources of air pollutants in the city because other critical emission sources, such as residential and agricultural areas, were not included in the inventories. Though the current emissions inventories offer a great starting point, their quality and accuracy could be enhanced by filling three notable gaps: the lack of a consistent methodology, limited local activity data, and localized emission factors.

Previous source apportionment studies suggest that the major sources of air pollution in Jakarta include vehicular emissions, and power generation from coal-fired power plants operating in areas surrounding Jakarta (power plants in Jakarta use only combined gas and heavy oil fuel) (Santoso et al., 2020a, 2020b; Vital Strategies and ITB, 2020a; and Myllyvirta et al., 2020). From the emissions inventories developed using data from 2015, transport and industrial combustion were found to contribute 46% and 43% of $PM_{2.5}$ emissions, respectively (Lestari et al., 2020). Industries also contributed more than two-thirds of $SO_2$ emissions; vehicular emissions contributed more than 90% and 57% of the CO and $NO_x$ emissions, respectively. Although these studies paint a good picture of Jakarta's emissions sources, more comprehensive studies that account for emissions from secondary processes are required to strengthen air quality managers' goals and outcomes.

Several air pollution models developed by research organizations corroborate the monitoring data that point to transportation and energy generation as the most important sources of air pollutants. However, these modeling exercises are short-lived and are not available to policymakers for use as tools in developing emissions mitigation actions. In addition, these exercises tend to focus mostly on pollution from transportation and rarely focus on the sources of air pollution that can alter emissions and significantly contribute to worsening air quality.

In the area of air quality policies, the Governor's Policy on Air Pollution Control Strategy (SPPU), which was made public last September, is currently in draft form as *Rencana Keputusan Gubernur*. This SPPU includes three strategies: enhancing governance for the control of air pollution; lowering emissions from mobile and lowering emissions from stationary sources. Several programs are used to improve air pollution control governance: improved air quality monitoring systems, the quantity and quality of emission inventories, and analysis of the effects of air pollution on society, the economy, and health. The establishment of cross-sector working teams, the creation of regulations and policies, and law enforcement all complement this governance.

To reduce emissions from mobile sources, transportation programs in SPPU include rejuvenating public transportation and developing environmentally friendly transportation; emissions testing; the development of low emission zones; the reduction of community mobility; the improvement of connecting infrastructure to public transport facilities; the development of traffic engineering management; and increasing community participation. As for the strategy to reduce emissions from stationary sources, there are three programs: increasing green open spaces; upgrading rooftop solar panel installations; and controlling air pollution from industrial activities.

This SPPU consists of a total of 16 programs, each of which has their own action plan. As a result, there is a total of 70 action plans. The goal of lowering pollutant concentrations is hoped to be accomplished by 2030 with the implementation of all of these programs.

## Using science and innovation to raise awareness of local sources of air pollution

The Clean Air Catalyst consists of a team of scientists working to make pollution more visible and raise awareness of the sources of air pollution. The Catalyst is partnering with public, private, and community leaders to improve knowledge of main sources and impacted communities. The Catalyst then evaluates the root causes of poor air quality and builds public support for effective clean air action. The Catalyst also has been working with our partners to develop a mobile monitoring study. This aims to enhance the knowledge about transboundary air pollution affecting air quality in Jakarta, as well as to compare air pollution exposure in high- and low poverty neighborhoods.

The Catalyst has identified two priority sources of air pollution and three most impacted communities in Jakarta through a *Source Narrowing* process. The two priority sources are land transportation including Heavy Duty Vehicles (HDVs), particularly buses and trucks, and large industries, particularly coal-powered manufacturing processes, such as the cooking oil industry. The three most impacted communities are women (particularly pregnant women) and children (0-5 years old), elderly people (59 years and older), and motorcycle drivers (commuters and online taxis). In addition, the Catalyst has identified three areas in Jakarta that may include members of those communities that are near emission hotspots, namely Pulo Gadung (East Jakarta), Marunda, and Pluit (North Jakarta). Understanding the two sources and three most impacted communities will help identify and develop possible interventions and control strategies to reduce emissions while achieving benefits for health, the climate, and gender equity.

The Catalyst aims to support Jakarta's air quality managers by undertaking additional monitoring in the city with the aim of increasing source awareness. This will entail an in-depth understanding of transboundary contributions to local air pollution, major local emissions sources, and the background contribution to local air pollution, including setting a baseline for black carbon. The Catalyst will use several methods to set the baseline: continue to collect information and data, and undertake measurements and analysis. Two phases of monitoring are planned, namely no-regret/fixed monitoring and mobile monitoring. The monitoring focuses primarily on the use of reference-grade instrumentation to generate air pollution measurement data. The locations have been identified for: 1) three new sites that will be added to the existing fixed monitoring sites, and 2) eight polygons and four transects for mobile monitoring. These priority sites were identified by taking into consideration existing studies and factors such as population density, income levels with a focus on low-income households, proximity to major emission sources, proximity to public facilities such as schools and hospitals, existing air quality monitoring, and meteorological information. Catalyst monitoring activities will focus on black carbon, which contributes to climate change, and $PM_{2.5}$, which is the primary source of air pollution-related health impacts. Other upcoming studies on air pollution in Jakarta include emission estimation, source attribution modeling, and source apportionment.

Clean Air Catalyst's science-driven approach is part of what makes it unique. From the outset we are committed to raising awareness about the sources of air pollution, so that this "source awareness" process is the foundation for meaningful action.

## Highlighting health impacts to women and vulnerable communities

In general, women and men are exposed to different levels of air pollution and occupational risks and suffer different consequences. Available evidence suggests that globally, women from low- and middle-income countries experience greater exposure to indoor air pollution from solid fuel use, increased harm from poor sanitation and waste burning, and higher exposure to toxic chemicals in certain occupations such as the textile industry (OECD 2021). Compounded by biological differences and social circumstances like poverty, gender inequality, and discriminatory gendered cultural norms, studies link air pollution to irregular menstruation, infertility, gestational diabetes, dementia, metabolic syndrome, and polycystic ovary syndrome. Other impacts include higher risks of osteoporosis, cancer, cardiovascular disease, chronic obstructive pulmonary disease, and a higher propensity to strokes. In addition to women, especially pregnant women, global studies have also consistently shown that air pollution is most damaging to the health of children, the elderly, and low-income communities (WHO 2022).

Air pollution can also have broader impacts on women through other channels, including their household responsibilities for caring – which may reduce their employment opportunities. Research documents a link between air pollution and psychological factors affecting mental and physical health, cognitive performance, and even violent behavior, of which women are the main victims (OECD 2021). More generally, women are especially exposed to urban living risks in parts of cities that lack safe public spaces (under-lit and under-policed), are poorly connected to safe public transport, and where crime rates can be high (UN Women).

Given gender-differentiated patterns of how people move and live in the city, identified sources of air pollution in Jakarta likely have differential impacts. However, there is a lack of local Jakarta-specific and nuanced research on the health impacts of air pollution and gendered intersectionalities, with the exception of exposure to indoor air pollution. Amalia et al 2013 found that in general, low-income families living in houses with bamboo walls and dirt floors and with smaller front or back yards likely have poor indoor air quality and as a result, tend to have more restricted activity days because of health issues and that children are the most vulnerable group to particulate matter pollution. Traffic and commute-based exposure experienced by Jakarta residents are among the highest in the world and represent a health concern for school children and adults based on the relatively high concentrations and the amounts of time spent in and near vehicles (Both et al 2013). Motorcycle taxi drivers also have unsafe exposure to PM10 and O3 because of the duration and frequency of exposure (Simatupang et al 2022). Another study has found that children raised in low-income households are also at risk of higher acute respiratory tract infections from household solid waste burning, especially boys and younger children in general (Irianti and Puguh 2019).

To help address the gap in disparity data, the Clean Air Catalyst will prioritize research on characterizing exposures and impacts of vulnerable populations to air pollution from land transportation, especially heavy-duty trucks. This will include exposure to women (particularly pregnant women) and children, and elderly people which experience cumulative impacts from transportation. The focus will also include workers and commuters who are impacted by transportation emissions, especially ridesharing app drivers and commuters who use either public transport, cars, or motorcycles.

## How air pollution impacts the climate

Air quality and climate change are strongly linked by the chemistry of pollutants, common emission sources, and their impacts on human health. Firstly, ground-level ozone, its precursor methane, and darker particulate matter like black and brown carbon are all short-lived climate pollutants (SLCPs) that accelerate warming and glacial melting (Institute for Governance and Sustainable Development, 2013); (USAID, 2022). Secondly, many major sources of air pollution such as vehicular fossil fuel exhaust emissions, waste burning, thermal power plants and industrial fuel combustion processes contribute to particulate matter emissions as well as the emission of short-lived climate pollutants such as black carbon and methane, and long-lived climate pollutants such as carbon dioxide. Similar to air pollutants, short-lived and long-lived climate pollutants lead to the onset of pulmonary, respiratory, and other chronic conditions and diseases impacting the heart and other critical organs (IPCC, 2018). These interlinked impacts demonstrate that actions taken to address air quality will also contribute to the reduction of climate pollutants and protect public health (Zusman et al., 2021).

With 19% of all greenhouse gas emissions in Jakarta being attributable to the transportation sector, DKI Jakarta's provisional long-term strategy for Low-Carbon Development, that is in line with Indonesia's Long-term Strategy for Low Carbon and Climate Resilience by 2050, seeks to achieve net-zero emission in 2060 or sooner through interventions in this sector. The Greater Jakarta Transportation Masterplan 2018-19, approved by Presidential Decree 55/2018, authorized a roadmap for 100% electrification of TransJakarta operated buses by the year 2027. In addition, the commercial freight sector, whose demand is likely to increase in 2050 by 12.7 times the recorded demand in 2010, is also likely to emit four times the recorded CO2 volumes by 2050 in comparison with 2010 estimations (Nugroho et al, 2020). Therefore, multi-modal decarbonization solutions within the transportation sector are required to not only enable low carbon development in Jakarta but also help improve its air quality, given the sector's contribution to air pollutants per existing source apportionment studies and emission estimates ((Santoso et al., 2020a, 2020b; Vital Strategies and ITB, 2020a; Myllyvirta et al., 2020; and Lestari et al., 2020).

The Catalyst is committed to co-developing clean air solutions that reduce short-lived climate pollutant emissions. To this end, it is monitoring black carbon emissions to trace their sources within the city boundaries. In addition, to better understand the contribution of waste burning and transportation to $CO_2$ and $CH_4$, the Catalyst will estimate source contributions as part of an integrated, air and climate pollutant inventory informed by secondary data. Insights from these estimations, combined with the estimation of emissions reductions from the project's proposed clean air solutions, will help the Catalyst build a case for integrated clean air and climate action planning in Jakarta.

## Building a coalition to drive solutions

Clean Air Catalyst wants to invite you to be part of our coalition to drive solutions for clean air in Jakarta. We would like to connect with you and are more than happy to work together with any stakeholders, including government officials, research institutes, universities, private sector and civil society organizations.

We have strong local scientific partners with expertise in atmospheric measurements, emissions inventories, air quality modeling, and source apportionment to work alongside a team of global partners. Our expertise also covers air pollution related to health, gender, and climate sectors. Therefore, we are working on air quality and its analysis related to health, gender, and climate as well. Data gaps exist, but the skill set of the Catalyst's consortium is able to fill those gaps with local monitoring and modeling efforts and then to use the resulting information to identify priority sources and interventions for cleaner air, climate change mitigation, healthier environment, involving social inclusion and lower exposure.

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