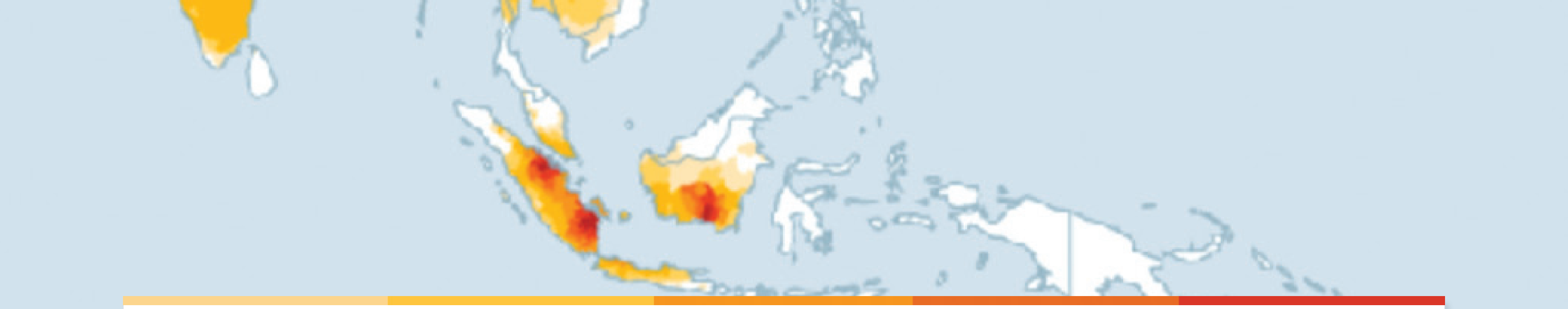
AQLI Air Quality Life Index®

AIR QUALITY LIFE INDEX® | UPDATE MARCH 2019

Indonesia's Worsening Air Quality and its Impact on Life Expectancy

By Michael Greenstone and Qing (Claire) Fan



SUMMARY

The average Indonesian can expect to lose 1.2 years of life expectancy at current pollution levels, according to the Air Quality Life Index (AQLI), because air quality fails to meet the World Health Organization (WHO) guideline for concentrations of fine particulate matter ($PM_{2.5}$). The pollution index, developed by Michael Greenstone and his colleagues at the Energy Policy Institute at the University of Chicago (EPIC), shows that the health effects are much larger in parts of the country with particularly high particulate pollution. Residents of Indonesia's capital, Jakarta, for example, can expect to lose 2.3 years of life expectancy if 2016 pollution levels are sustained over their lifetime. The loss of life expectancy in some regions is more than 4 years. Importantly, AQLI data show that air quality was not a pressing problem in Indonesia just two decades ago, but that air quality declined substantially in recent decades—with the steepest decline since 2013.

Indonesia does not currently have a national standard for air pollution levels. As the government begins to recognize the air quality problem, the AQLI demonstrates that Indonesia has the opportunity to accrue enormous health benefits by successfully cleaning up its air. Other countries in the Asia-Pacific region provide a useful benchmark. If, for example, Indonesia achieved sustained improvements in air quality comparable to what China has achieved in the last 5 years, the typical Indonesian could expect to live eight months longer. Those in the most polluted areas would capture even larger benefits, living up to 2.5 years longer on average.

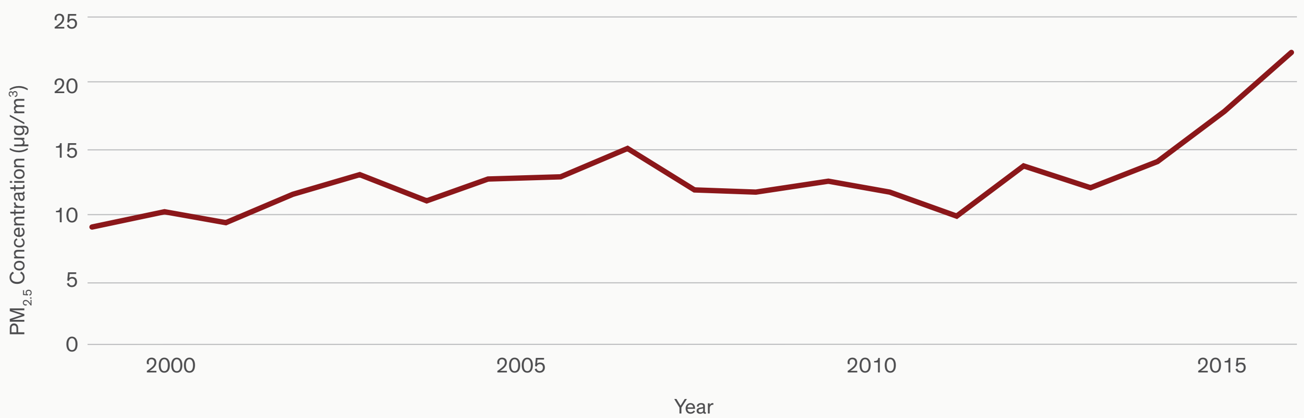
Indonesia's Pollution Challenge

Over the last two decades, Indonesia has seen dramatic changes in the quality of its air. From 1998 to 2016, the country went from being one of the cleaner countries in the world to one of the twenty most polluted, as particulate air pollution concentrations increased 171 percent. The greatest spike has happened over just the last few years. Pollution more than doubled from 2013 to 2016 alone, with at least some of the increase likely due to intense fires (See Figures 1 and 2). Regardless of the causes, 80 percent of Indonesia's 256 million people lived in areas where the annual average particulate pollution level exceeded the WHO guideline in 2016.

This high air pollution is now undermining Indonesians' health. In 1998, air pollution barely impacted the life expectancy of Indonesians. In fact, even in 2013, it shaved only a few months off of average life expectancy. If today's concentrations are sustained, it will cut the average life expectancy by 1.2 years, relative to what it would be if the WHO guideline of 10 µg/m³ for long-term fine particulate matter ($PM_{2.5}$) pollution was met.

Some areas of Indonesia fare much worse. In Indonesia's capital Jakarta, home to more than 10 million people, the average resident will live 2.3 years less if $PM_{2.5}$ levels remain at current levels, relative to if the WHO guideline was met. The analogous figure for residents on the islands of Sumatra and Kalimantan is about 4 years of life expectancy loss on average. In South Sumatra, city-dwellers in Palembang lose

Figure 1 · Indonesia's annual average $PM_{2.5}$ Concentration, 1998-2016 (µg/m³)



Note: The $PM_{2.5}$ concentrations shown in this figure are satellite-derived, and net of dust and sea salt to focus on human-caused pollution. Source: van Donkelaar et al. (2016)

METHODOLOGY

The life expectancy calculations made by the AQLI are based on a pair of peer-reviewed studies, Chen et al. (2013) and Ebenstein et al. (2017), co-authored by Michael Greenstone, that exploit a unique natural experiment in China. By comparing two subgroups of the population that experienced prolonged exposure to different levels of particulate air pollution, the studies were able to plausibly isolate the effect of particulates air pollution from other factors that affect health. The more recent of the two studies found that sustained exposure to an additional 10 µg/m³ of PM_{10} reduces life expectancy by 0.64 years. In terms of $PM_{2.5}$, this translates to the relationship that an additional 10 µg/m³ of $PM_{2.5}$ reduces life expectancy by 0.98 years. The AQLI applied this finding to Indonesia's $PM_{2.5}$ concentrations, taken from satellite-derived $PM_{2.5}$ measurements, to determine the current life expectancy impacts of air pollution in Indonesia and the potential impacts of air pollution reduction.

To learn more about the AQLI and its methodology, refer to the back of this report or visit:
aqli.epic.uchicago.edu/about/methodology

Figure 2 · Change in Indonesia's annual average $PM_{2.5}$ Concentration, 2013-2016

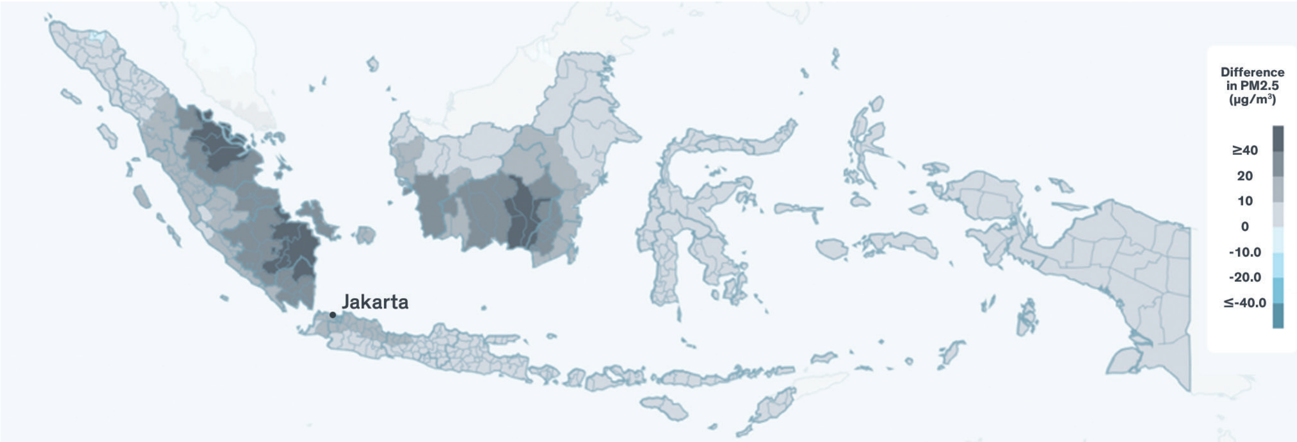


Figure 3 · Life Expectancy Gain in Indonesia from Reducing $PM_{2.5}$ from 2016 Concentrations to WHO Guideline

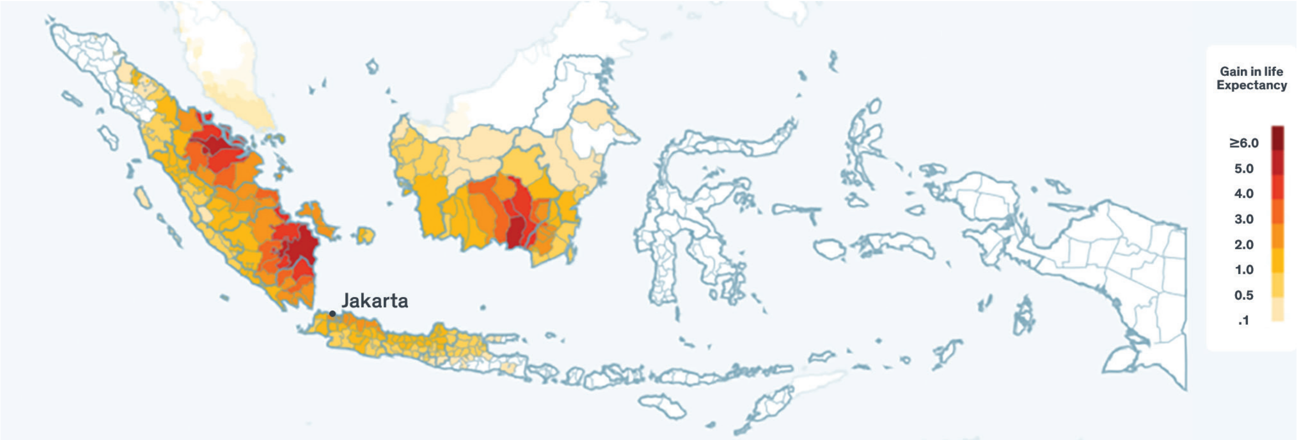
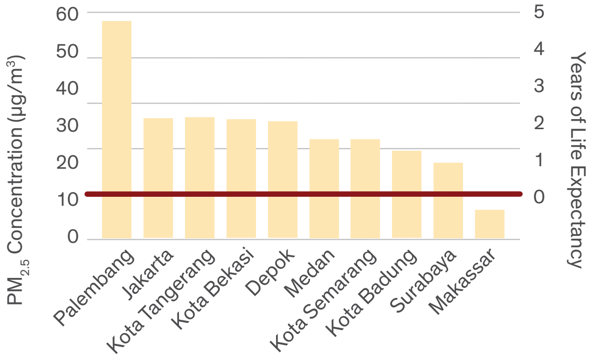


Figure 4 · $PM_{2.5}$ Concentration and Life Expectancy Gain by Meeting WHO Guideline in 10 Largest Cities, 2016



Note: This figure includes the 10 largest cities in Indonesia according to the 2010 Census, ordered by 2016 annual average $PM_{2.5}$ concentration, with the five administrative cities of Jakarta aggregated together using population weights. The red line depicts the WHO guideline of 10 ug/m³ for annual average $PM_{2.5}$.

Figure 5 · Global Distribution of Life Expectancy Lost to Particulate Pollution

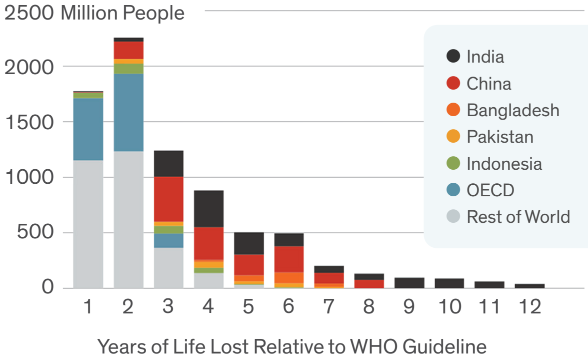
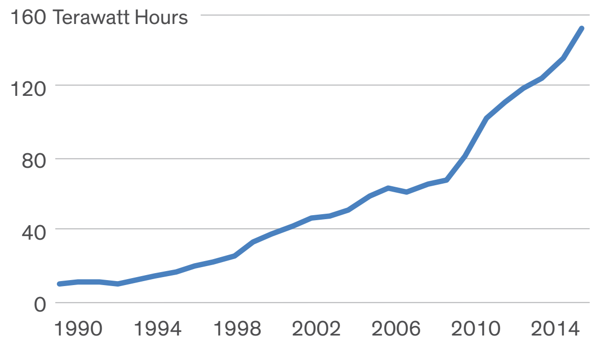
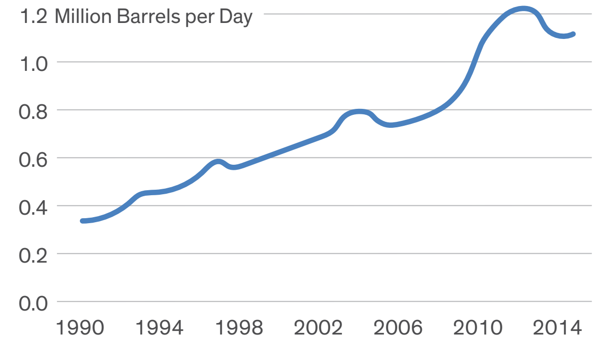


Figure 6 · Indonesia: Electricity Generation from Coal



Source: BP, plc. Statistical Review of World Energy, 2018.

Figure 7 · Indonesia: Gasoline and Diesel Demand



Source: International Energy Agency, Oil Information, 2018.

4.8 years of life expectancy on average, and residents of the regency of Ogan Komering Ilir lose 5.6 years of life expectancy (see Figures 3 and 4 and the Appendix Table for more cities and regencies). In total, the current Indonesia population will lose about 309 million life-years to particulate pollution if 2016 concentrations are sustained, which is one of the highest burdens in the world, behind only India, China, Bangladesh and Pakistan (see Figure 5).

A variety of sources contribute to particulate air pollution in Indonesia. In Jakarta, motor vehicles accounted for 31.5 percent of the city's $PM_{2.5}$ in 2008-2009, and, by the government's estimate, 70 percent of the city's PM_{10}—the larger form of particulate matter with diameter less than 10 micrometers.[1] Since 2010, there have been sharp increases in electricity generation from coal-fired power plants and gasoline and diesel consumption, both contributors to $PM_{2.5}$ air pollution (see Figures 6 and 7).

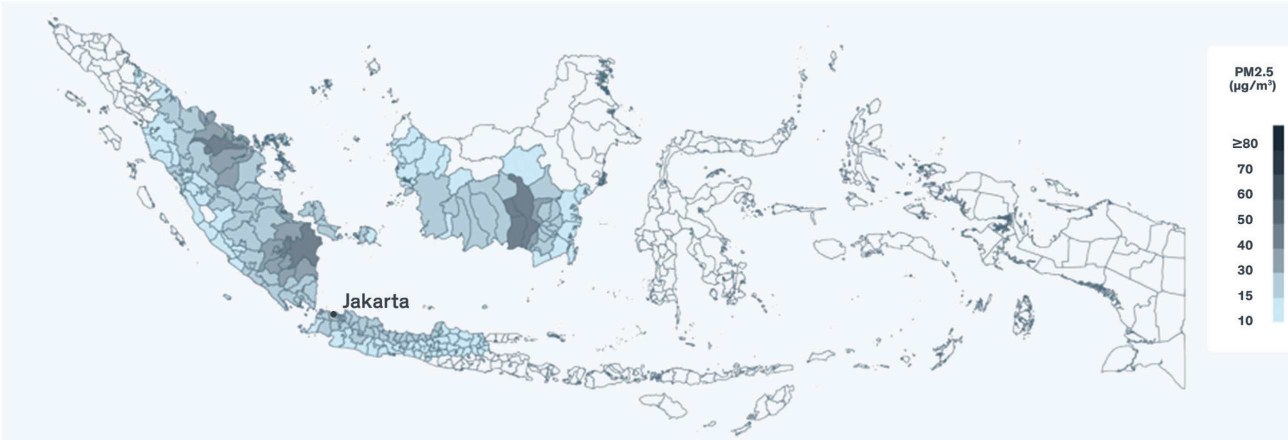
In more agricultural areas, particularly in Sumatra and Kalimantan, forest and peatland fires—often associated with illegal deforestation, oil palm plantations, or slash-and-burn agriculture—are significant contributors to particulate pollution. Much of Indonesia's forests lie atop peatlands, which are swampy areas of decomposed carbon-rich plant matter. After forest land is logged for commercial purposes, the peatlands are drained to accommodate agriculture, making the land highly combustible. In the event of a fire, peat releases not only CO_2 but also black carbon, a form of particulate matter. This biomass burning affects air quality not only in local population centers, but thanks to the wind, also further away—making up about 31 percent of Jakarta's $PM_{2.5}$, by one estimate.[2] In the El Nino drought years of 1997 and 2015, these fires were so intense that they not only emitted more CO_2 per day than the European Union, but created a haze of air pollution across Southeast Asia, affecting health and air travel in Indonesia, Singapore, Malaysia, and beyond.

Government Efforts to Confront Air Pollution

Although Indonesia does not currently have a $PM_{2.5}$ standard that all regions are expected to meet, the government has begun to take initial steps to confront the growing particulate pollution problem. To date, much of the focus has been concentrated on the transportation sector, a significant contributor to air pollution in urban areas such as Jakarta. In 2017, the government required that all gasoline-fueled vehicles adopt Euro-4 fuel standards by September 2018. An internationally-recognized fuel standard initially adopted in the European Union and now popular throughout the world, Euro-4 demands the use of high-quality, cleaner fuels with a sulfur content no higher than 50 parts per million (ppm)—ten times more stringent than the sulfur limit in the Euro-2 fuel that Indonesia previously used.

2 Supra, and Reddington, C.L. et al. (2014). Contribution of vegetation and peat fires to particulate air pollution in Southeast Asia. *Environmental Research Letters*, 9(9).

Figure 8 · Change from Reducing $PM_{2.5}$ from 2016 Concentrations by 32%



The government has also stepped up its efforts to combat air pollution from peat and forest fires. After the 2015 Southeast Asian Haze caused international health and economic damages, Indonesian President Joko Widodo enacted a moratorium on new peatland development and established the Peatland Restoration Agency (BRG). The BRG's efforts to rewet degraded peatlands have been cited as one possible reason why Indonesia has since experienced fewer fires. In 2018, the land area that experienced fires was 7 percent of the size of 2015's fires. However, as some of the areas that did catch fire in 2018 are part of lands supposedly prioritized for peat restoration or protected from drainage, it remains unclear whether the decrease in fires are due to the government's efforts or simply milder weather conditions than in 2015.

One source of particulate pollution where stricter regulation may be possible is the combustion of coal. Coal combustion emits black carbon, a form of particulate matter, and sulfur dioxide (SO_2) and nitrogen oxides (NO_x), which in turn react with other substances in the atmosphere to become particulate matter. Although electricity generation from coal has more than doubled since 2010 to meet rising energy demand, regulations on coal plant emissions remain significantly less stringent than those of other countries in Asia. For example, limits on the concentrations of PM, SO_2, and NO_x in Indonesian coal plant emissions are three to 7.5 times higher than the limits that China has in place, and two to four times higher than India's limits for plants installed between 2003 and 2016.[3] Though the government has attempted to strengthen these limits, which have been in place since 2008, conflicting criticisms of the proposed revisions have hindered the efforts.[4] If enacted, the proposed new limits would have been less stringent than China's and India's.[5]

The above measures show that the government has begun to address some of Indonesia's multiple sources of air pollution. Moving forward, it is apparent that air pollution reductions will require new regulations and/or stricter enforcement.

Demonstrated Success from Air Pollution Policies

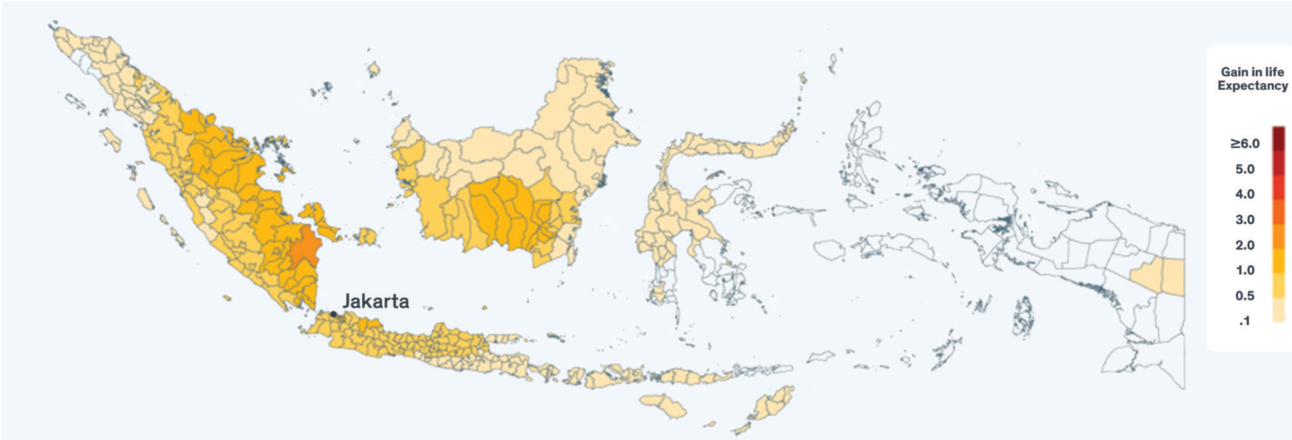
The dual challenges of economic growth and environmental quality faced by Indonesia today are no different from those once confronted by London, England, Los Angeles, California, or Osaka, Japan—once respectively known as "the big smoke," "the smog capital of the world," and the "smoke capital"—during their periods of industrialization. That legacy of environmental improvement is evidence that Indonesia's pollution challenges are solvable.

3 Zhang, X. (July 2016). *Emission standards and control* of $PM_{2.5}$ from coal-fired power plants. Retrieved from https://www.iea-coal.org/emission-standards-and-control-of-pm2-5-from-coal-fired-power-plant-ccc-267/

4 Indonesian Center for Environmental Law. (2018, February 15). Govt takes more time over stricter emissions rule. Retrieved from https://icel.or.id/en/govt-takes-more-time-over-stricter-emissions-rule/

5 Proposed revision of coal plant emissions limits from https://www.thejakartapost.com/news/2018/02/12/ngo-planned-new-coal-emission-standards-not-strict-enough.html

Figure 9 · Life Expectancy Gain from Reducing $PM_{2.5}$ from 2016 Concentrations by 32%



In fact, China has seen tremendous progress in improving air quality in the last few years. In 2014, the government declared a "war against pollution" and instituted a nationwide plan to confront it. According to measurements from ground-level monitors, particulate pollution in China's cities has been reduced by 32 percent on average since the "war against pollution" was announced. Though these reductions are generally larger than the reductions found with the satellite-derived pollution data used in the AQLI, if they are confirmed and sustained over time, life expectancy would improve by 2.3 years.[6] India, having declared its own war against pollution in January 2019, would be on a similar path if it succeeds in meeting its stated pollution reduction target of 20-30 percent.

Indonesia has the opportunity to experience similar progress. If Indonesia were to achieve the same 32 percent pollution reduction experienced in China and to sustain it, its residents would live another 8 months on average. This would take the country 55 percent of the way toward having all of its population breathe air that is in compliance with the WHO guideline. Those in the most polluted areas of Indonesia would live a year and half to two years longer (See Figures 8 and 9 and the Appendix Table for the impacts on the 50 most populous regencies).

Conclusion

In the last two decades, Indonesia has experienced a dramatic increase in $PM_{2.5}$ concentrations from 8 μg/m³ to 22 μg/m³. According to the AQLI, as 80 percent of Indonesia's population of over 250 million is exposed to annual average pollution concentrations above the WHO guideline, the country has the fifth highest loss of life-years due to particulate pollution in the world. The typical Indonesian would gain 1.2 years of life if particulate pollution were permanently reduced to the WHO guideline. Residents of Jakarta would gain 2.3 years, and residents in the city of Palembang in fire-prone South Sumatra would gain almost 5 years.

In the last several decades other countries, including Japan, the United States, and the United Kingdom, have enacted and successfully enforced policies to reduce air pollution, underscoring that today's air pollution need not be tomorrow's fate. And more recently, China has greatly reduced $PM_{2.5}$ concentrations after declaring a "war against pollution." These policies have imposed costs on polluters and the broader economy, but the AQLI makes concrete that their benefits can be measured in perhaps the most important metric—longer and healthier lives.

6 The monitor data generally show higher $PM_{2.5}$ concentrations, and larger percent reductions, than the satellite-derived pollution data used in the AQLI. For more information about our analysis of Chinese monitor data, see "Is China Winning its War on Pollution" at https://aqli.epic.uchicago.edu/reports

Appendix Table | Current and Potential $PM_{2.5}$ Concentration and Life Expectancy Impact in 50 Most Populous Regencies

Province	Regency	Population (Millions)[6]	$PM_{2.5}$ Concentration (μg/m³)		Life Expectancy (Years) Gained from Reducing $PM_{2.5}$ from 2016 Concentration	
			2016	After 32% Reduction[7]	To WHO Guideline of 10 μg/m³	By 32%
West Java	Bandung	5.3	23	16	1.3	0.7
Banten	Tangerang	4.1	31	21	2.0	1.0
West Java	Bogor	4.0	29	20	1.9	0.9
Special Capital Region of Jakarta	East Jakarta	3.2	33	22	2.2	1.0
North Sumatra	Medan	3.0	27	18	1.7	0.9
East Java	Surabaya	3.0	21	14	1.1	0.7
West Java	Sukabumi	2.7	18	12	0.8	0.6
West Java	Garut	2.7	20	14	1.0	0.6
East Java	Malang	2.6	10	7	0.1	0.3
West Java	Cirebon	2.5	31	21	2.1	1.0
West Java	Cianjur	2.5	19	13	0.9	0.6
Banten	Serang	2.5	26	18	1.6	0.8
West Java	Kota Bandung	2.4	24	16	1.3	0.7
West Java	Karawang	2.4	31	21	2.0	1.0
West Java	Bekasi	2.3	32	21	2.1	1.0
Special Capital Region of Jakarta	West Jakarta	2.3	34	23	2.3	1.1
East Java	Jember	2.2	11	7	0.1	0.3
Special Capital Region of Jakarta	South Jakarta	2.2	33	22	2.2	1.0
West Java	Indramayu	2.1	35	24	2.4	1.1
West Java	Tasikmalaya	2.0	18	12	0.8	0.6
West Java	Kota Bekasi	2.0	32	22	2.2	1.0
Banten	Kota Tangerang	2.0	33	22	2.3	1.0
West Java	Ciamis	1.9	19	13	0.9	0.6
North Sumatra	Deli Serdang	1.9	21	14	1.1	0.7
Central Java	Brebes	1.9	28	19	1.8	0.9

6 Source: LandScan (2015)

7 As China achieved from 2013-2017. For more information, see "Is China Winning its War on Pollution?" at https://aqli.epic.uchicago.edu/reports

Appendix Table | Current and Potential $PM_{2.5}$ Concentration and Life Expectancy Impact in 50 Most Populous Regencies

Province	Regency	Population (Millions) [1]	$PM_{2.5}$ Concentration (μg/m³)		Life Expectancy (Years) Gained from Reducing $PM_{2.5}$ from 2016 Concentration	
			2016	After 32% Reduction	To WHO Guideline of 10 μg/m³	By 32%[2]
East Java	Sidoarjo	1.9	18	12	0.8	0.6
Central Java	Cilacap	1.8	19	13	0.9	0.6
Special Capital Region of Jakarta	North Jakarta	1.8	33	23	2.3	1.0
West Java	Subang	1.7	32	22	2.2	1.0
East Java	Banyuwangi	1.7	9	6	0.0	0.3
Lampung	Central Lampung	1.7	43	29	3.3	1.4
East Java	Kediri	1.6	15	10	0.4	0.5
East Java	Pasuruan	1.6	13	9	0.3	0.4
Central Java	Tegal	1.6	29	20	1.9	0.9
Lampung	South Lampung	1.6	33	22	2.2	1.0
West Java	Depok	1.6	32	21	2.1	1.0
Central Java	Kota Semarang	1.5	27	18	1.6	0.8
West Java	Majalengka	1.5	30	21	2.0	0.9
Central Java	Grobogan	1.4	21	14	1.1	0.7
Banten	Pandeglang	1.4	19	13	0.9	0.6
Central Java	Pemalang	1.4	28	19	1.8	0.9
East Java	Lamongan	1.4	17	11	0.6	0.5
East Java	Bojonegoro	1.4	18	12	0.8	0.6
South Sulawesi	Makassar	1.3	8	6	0.0	0.3
South Sumatra	Palembang	1.3	59	40	4.8	1.8
Central Java	Magelang	1.3	19	13	0.9	0.6
Central Java	Kebumen	1.3	18	12	0.8	0.6
Lampung	Tulang Bawang	1.3	57	39	4.7	1.8
Central Java	Banyumas	1.3	20	14	1.0	0.6
East Java	Jombang	1.3	17	11	0.7	0.5

ABOUT THE AIR QUALITY LIFE INDEX®

The AQLI is a pollution index that translates particulate air pollution into perhaps the most important metric that exists: its impact on life expectancy. Developed by the University of Chicago's Milton Friedman Professor in Economics Michael Greenstone and his team at the Energy Policy Institute at the University of Chicago (EPIC), the AQLI is rooted in recent research that quantifies the causal relationship between long-term human exposure to air pollution and life expectancy. The Index then combines this research with hyper-localized, global particulate measurements, yielding unprecedented insight into the true cost of particulate pollution in communities around the world. The Index also illustrates how air pollution policies can increase life expectancy when they meet the World Health Organization's guideline for what is considered a safe level of exposure, existing national air quality standards, or user-defined air quality levels. This information can help to inform local communities and policymakers about the importance of air pollution policies in concrete terms.

aqli.epic.uchicago.edu @UChiEnergy #AQLI

ABOUT EPIC

The Energy Policy Institute at the University of Chicago (EPIC) is confronting the global energy challenge by working to ensure that energy markets provide access to reliable, affordable energy, while limiting environmental and social damages. We do this using a unique interdisciplinary approach that translates robust, data-driven research into real-world impacts through strategic outreach and training for the next generation of global energy leaders.

epic.uchicago.edu @UChiEnergy /UChicagoEnergy

FURTHER READING

Introducing the Air Quality Life Index: Twelve Facts about Particulate Air Pollution, Human Health, and Global Policy

Is China Winning its War on Pollution?

India's 'War Against Pollution': An Opportunity for Longer Lives

Pakistan's Air Pollution Challenge & Potential for Longer Lives

aqli.epic.uchicago.edu/reports

EPIC | ENERGY POLICY INSTITUTE AT THE UNIVERSITY OF CHICAGO

THE UNIVERSITY OF CHICAGO