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Air Quality, Smog, and Climate Interactions: Public Health Consequences in Major Pakistani Cities

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Abstract
Pakistan is a relatively small emitter of GHGs, but its citizens are at significant climate risk and some of the world's highest exposure to fine-particle air pollution. In the IQ Air World Air Quality Report of 2025, Pakistan secured first position with the annual mean PM2.5 concentration of 67.3 µg/m³. This was lower than the 73.7 in 2024 but still over 13 times higher than the World Health Organization's annual guideline of 5 µg/m³. The recurrent smog in Lahore, Faisalabad, Multan, Gujranwala, Islamabad-Rawalpindi, Karachi and Peshawar is an example of how transport, industry, brick kilns, crop-residue burning, waste burning and weather conditions all contribute to the formation of smog. In this relationship black carbon plays an important role as it affects human health and causes warming, and once deposited on snow and ice it can accelerate melting in the Hindu Kush–Karakoram–Himalaya region. The sources cited in this article are used to discuss recent air-quality patterns, major emission sources, interactions between climate and pollution and linked health impacts. It suggests that the impact is disproportionate and is even more pronounced in dense communities, in outdoor workers, in children, in older people, and in less well-resourced households that are less able to buffer themselves against the impact. The conclusion was that coordinated efforts on pollution and climate policies, along with reliable monitoring, public health protections, stronger enforcement, and continued regional cooperation are needed for effective responses.

Keywords: *Air quality, Smog, Black Carbon, Climate Interactions, Public health; Lahore; Punjab; Pakistan; Crop-Residue Burning; Climate Justice*

Introduction

The realities of air pollution and climate change are talked about as two separate environmental issues but in Pakistan they are becoming more common and are converging. The nation emits a small fraction of global GHGs, and its citizens are exposed to significant climate risks and frequent occurrences of air pollution hazards. In the Indo-Gangetic region, the smog is not an occasional occurrence anymore but a regular occurrence. Lahore is routinely ranked among the most polluted cities in the world, especially if the measurements are based on air quality index (AQI) (Punjab EPA, 2026; IQAir, 2025).

Lahore, Faisalabad, Multan, Gujranwala, Islamabad-Rawalpindi, Karachi and Peshawar are all cities with varying local conditions, but there are some common stresses. These include the presence of heavy road traffic, brick kiln activity, construction dust and their close proximity to agricultural fields where crop residues may be burned after harvest. These cities combine to house millions of people and to provide a significant part of the country's economic activity.

The argument goes that pollution from nearby sources can be more damaging when the weather conditions limit the dilution and movement of polluted air. Emissions of black carbon link the air-quality issue to broader impacts such as climate change, and temperature inversions, stagnant air and seasonal weather may extend exposure.

The health loss is not something that can be gauged by Pakistan's contribution to global emissions. This article is based on the data that has been referenced in various sources, including the data from the Pakistan Air Quality Initiative (PAQI), the World Health Organization (WHO), the Punjab Environmental Protection Agency and various other research sources. It sets out the context of Pakistan's emissions and air quality, discusses recent trends in major cities, looks at the key sources and interactions with the climate, and addresses the public-health impacts and potential policy responses. Although the figures are derived from several monitoring systems and secondary estimates, they should be interpreted with regard to the methods, coverage and timeliness of these monitoring systems.

National Emissions Context and Global Air-Quality Rankings

Emissions context at the national level and global levels of air quality. National estimates of emissions presented here show that Pakistan emits around 488 megatonnes of carbon-dioxide equivalent of GHGs in 2024 or an estimated 0.85% of global emissions. A per-capita emission of approximately 1.9 tonnes of CO■-equivalent per year is estimated. The reported emission mix is relatively CH4-heavy, with approximately 47% of the total being CH4, approximately 36% carbon dioxide, approximately 15% nitrous oxide, and less than 3% fluorinated gases. Pakistan's cumulative emissions since 1851 are also relatively low, ranging between 0.71% (Climate Change Tracker, 2026) and 0.72% (Global Carbon Project, 2025/2026).

The picture is different with the air-pollution indicators. According to the 2025 World Air Quality Report by IQAir, Pakistan is the most polluted country in the world with PAQI of 86.2 micrograms per cubic metre (µg/m3) of air, an average of PM2.5 particles measured per cubic metre of air per annum. 67.3 µg/m³. This was an improvement over 2024 (73.7 µg/m³), but still much higher than the WHO annual guideline of 5 µg/m³. The same report has shown that as of 2025, only thirteen countries/territories fulfilled that guideline (IQAir, 2024, 2025; WHO, 2021).

These statistics clearly show that Pakistan's share of GHGs is negligible, while its citizens are facing significant air pollution and climate risks. This imbalance reinforces the need for climate policies to take into account differences in responsibilities and vulnerabilities. It also underscores the importance of international financial and technical cooperation, in addition to measures at the national level to combat pollution and safeguard public health. But a climate-justice approach does not have to mean that local sources of pollution can be forgotten; mitigation of pollution is still critical for the protection of people in Pakistan.

Table 1.Q National and selected city-level indicators

Indicator	Reported value	Period	Source cited
National greenhouse-gas emissions	Approx. 488 MtCO■e (0.85% of global total)	2024	**Climate Change Tracker / GCP**
Per-capita greenhouse-gas emissions	Approx. 1.9 tCO■e	2024	**Climate Change Tracker**
National annual mean PM2.5	67.3 µg/m³	2025	**IQAir (2025)**
National annual mean PM2.5	73.7 µg/m³	2024	**IQAir (2024)**

WHO annual PM2.5 guideline	5 µg/m³	Guideline	**WHO (2021)**
Lahore annual mean PM2.5	88.9 µg/m³ (reported down from 102.1)	2025	**IQAir (2025)**
Estimated annual premature deaths linked to air pollution	Approx. 128,000	Recent estimates	**PAQI-linked studies**
Estimated average life-expectancy loss	**Approx. 3.9 years nationally; up to 7 years in Lahore**	**Recent estimates**	**PAQI-linked studies**

Air-Quality Trends in Major Cities, 2024–October 2026

The longest duration episodes reported in the source is focused in the industrial and agricultural belt of Punjab. Further reading from the Punjab EPA was found to have increased significantly as smog started during the 2026 season in October (Punjab EPA, 2026; IQ Air, 2026). According to the city AQI on 22 October 2026, the air quality in Lahore was considered "Very Unhealthy" with a city-wide AQI of 314 on the US AQI scale. A few individual stations reported over 500 on the dashboard, which is the highest value they need to report and is categorized as "Hazardous."

The station-level readings provided for Lahore are a testament to the fact that exposure to a hazard can be very different within the same city. The concentration of PM10 around Multan Road was reported as 858 µg/m³ and for PM2.5 was reported as 418 µg/m³ while at GT Road the concentration of PM2.5 was reported close to 351 µg/m³. Previously in October, the city-level AQI values were reportedly from approximately 210 to 298 on peak days. Safari Park, Kahna Nau, Shahdara and areas adjacent to major roads have been identified as areas with the highest readings (Punjab EPA dashboard, October 2026). These differences are important as they can mask neighborhoods with much higher levels of short-term exposure.

Higher AQI levels were also reported in other cities of Punjab, such as Faisalabad, Multan, Gujranwala, Sheikhupura, Pakpattan and Kot Addu during the same time period. As the season started reading increased to around 130-180 in the area between Islamabad and Rawalpindi. In addition to challenges due to local topography and transit traffic, Peshawar has other challenges. Pollution in Karachi is more of a industrial and port related activity as the pollution peaks experienced during winters are not as high as in Lahore, however, the amount of pollution experienced annually is still higher than the WHO guidelines (PAQI, 2025; IQAir, 2025).

Table 2. Selected AQI and PM2.5 readings reported for October 2026

Location / station	Approx. date	Reported AQI	Category / PM2.5 context
Lahore city average	22 Oct 2026	314	**Very Unhealthy; elevated particulate matter**
Multan Road, Lahore	22 Oct 2026	500	**Hazardous; PM2.5 approx. 418 µg/m³**
GT Road, Lahore	22 Oct 2026	500	**Hazardous; PM2.5 approx. 351 µg/m³**
Safari Park, Lahore	19 Oct 2026	500	**Hazardous; high particulate readings reported**
Lahore peak readings	Mid-Oct 2026	210–298	**Very Unhealthy; readings varied by location**
Selected Punjab cities	Oct 2026	150–280+	**Unhealthy to higher; variable**
Islamabad–Rawalpindi	**Oct 2026**	**130–176**	**Unhealthy for sensitive groups to higher**

The intensity of smog tends to increase around mid-October, peak from November to January, and be reduced by about mid-February. In some recent years the onset has occurred earlier. In the upcoming season of 2024-25, Lahore has seen very high AQI levels on several days, leading to school closures, restrictions on outdoor activities and public-health alerts. Long spells of dangerous air quality (IQAir ranking; reported in Dawn, The Express Tribune and other media, 2024–2026) were recorded during the 2025–26 season as well.

Provincial monitoring AQI values and international AQI values can be slightly different. The reported index could be affected by the location, calibration, averaging time, and pollutant coverage and conversion methods. Nevertheless, frequent readings of Unhealthy and Very Unhealthy and Hazardous indicate a long-term public health issue. Therefore, all AQI values are not always directly comparable and the use of comparisons should be avoided unless the platform and measurement period are specified.

Sources of Pollution and Climate Pollution Interactions

Major emission sources

The contribution from pollution sources varies and differs from one urban air shed to another. PAQI data and other studies indicate that the main sources of PM2.5 emission in Lahore include transport (35%), industry (28%) and brick kilns (17%). It is estimated that approximately 53% of total transportation cost is being spent on transportation in the Islamabad-Rawalpindi region. The industrial pollution profile in Karachi is said to be around 49% of which could be due to transit-trade traffic and brick kilns (18–19%) in Peshawar (PAQI, 2025). These numbers are estimates, not statistics and can change depending on the study area, inventory assumptions, and the way the inventory is calculated.

The other important source is the burning of crop residues particularly after rice harvest in Punjab. Other sources include open burning of municipal and agricultural waste, emissions from poorly-maintained vehicles, and construction dust and emissions from biomass fuels in the household sector. The post-monsoon months have seen a large number of fires in the Indo-Gangetic Plain recorded by satellite fire-detection systems, like MODIS and VIIRS. However, the source of pollution is not always unique in a shared air shed for smoke can be transboundary.

Burning crops residues produces fine particles and black carbon, and carbon monoxide and gases that contribute to the formation of secondary pollutants. During times of widespread fire, these emissions may play a large role in regional PM2.5 levels. It is essential that successful alternatives are both feasible for farmers and cost effective and easily accessible when residues must be removed. Until there is a longterm solution, which will likely be provided by enforcement, there is no equipment, incentives, or easy solutions to deal with residue.

Black carbon and short-lived climate pollutants

Black carbon is formed when fuels such as diesel and biomass burn in an incomplete way. It forms part of fine particulate pollution, causing harm to human health, but it also absorbs sunlight and is a contributor to warming of the atmosphere as well. The impact of its climate depends on the location of its emission, its residence time in the atmosphere and on the type of deposition on snow or ice. However, research has indicated that the warming effect of black carbon can be more significant on shorter time scales, depending upon the method and time scale used (IPCC, 2013; Bond et al., 2013).

Examples of potential sources in Pakistan are household combustion, transportation, industry, brick kilns, and agricultural burning. The emissions estimates cited in the source material are based on inventory studies at the national level and range between 180 and 200 kilotonnes (kt) of emissions per year. These estimates are subject to review with the original inventory before using as national 'definitive' estimates. However, the broader message is straightforward: Actions that decrease the

amount of incomplete combustion can provide local health benefits and can also help to limit near-term warming.

Weather conditions, climate change, and feedbacks

Emissions are highly dependent on weather in terms of dispersion or ground-level buildup. A temperature inversion is when the air near the ground is colder than the air above, and acts like a lid, which inhibits vertical mixing. When the atmosphere is stable and the wind is light, pollutants will accumulate over a couple of days. These conditions are particularly significant during the cooler season of the year when many cities in Pakistan have a high prevalence of smog.

The amount of time for agricultural burning and the capture and/or dispersion of air pollutants also depends on seasonal rainfall and monsoon timing. These conditions could be changing with climate change, but the direction and magnitude of local impacts is different depending on region and weather pattern. It is thus not correct to say that climate change causes every inversion or smog event, but rather, that it can enhance the occurrence of certain pollution episodes. Black carbon also connects the dots between urban and regional air pollution and High Mountains. Any particles deposited on snow and ice will darken the surface and lower its reflectivity, or albedo. The darker surface absorbs more solar energy, and may lead to increased melting in the Hindu Kush–Karakoram–Himalaya region. Impact on Indus Basin (ICIMOD and related assessments) seasonal river flow is significant for agriculture, hydropower and water security.

Combined, all emissions, weather and climate feedback can escalate local pollution into a regional issue, impacting tens of millions of people. Since the Indo-Gangetic Plain is an air shed which is common to both countries, cooperation at regional level is also required. Meanwhile, cross-border contributions should not divert from actions needed to reduce transport, industry, kiln, waste and agricultural emissions at home.

Public-Health Consequences

In epidemiological studies the effects of chronic exposure to PM2.5 and other pollutants such as nitrogen dioxide (NO2), sulphur dioxide (SO2), carbon monoxide (CO), ozone-forming compounds (OFCs) are confirmed. Fine particles can penetrate deep into the lungs and enter the bloodstream and cause inflammation and oxidative stress. The processes are related to respiratory and cardiovascular effects (WHO, 2021; relevant systematic reviews).

Severe smog events can cause asthma and COPD sufferers to have more severe symptoms and can cause additional patients to present to the hospital with breathing difficulties and cardiovascular complaints. Irritation of the eyes, nose and throat also occur. Exposure over longer periods of time can lead to poor lung development in children, risk of ischaemic heart disease and stroke, poor pregnancy outcomes and increased mortality risk. During the smog seasons of 2024-2026 news reports from Lahore and other cities reported rises in respiratory complaints and emergency presentations, though the extent of impact could not be determined from news reports.

According to the estimates mentioned in this article, about 128,000 lives are lost every year in Pakistan due to air pollution. According to other estimates, the average life expectancy was reduced by around 3.9 years across the country, and up to seven years in Lahore. These are based on assumptions and models of health and exposure information; they are estimates and should not be counted as exact numbers. Despite this qualification, the extent of the burden reported means air pollution is a serious environmental-health issue.

There is a lack of equal risk sharing. Children have lungs that are not fully developed, and breathe a higher volume of air than adults, which means they are highly susceptible. Older adults and individuals with underlying medical conditions such as heart or lung diseases or immunocompromised may be more susceptible to developing severe illness. Exposures have been linked to low birth weight and premature birth. Outdoor workers, such as traffic policemen,

construction workers, agricultural laborers, street vendors and others frequently work for long periods in polluted environments and without control over their working environment.

Financial and/or housing circumstances also contribute to exposure. Higher cost of living communities might have more exposure to industrial facilities or to roads, and they might not have access to adequate filtration, well-closed indoor areas, health care or flexible working patterns. While this advice to stay at home is easy for most, it is not so easy for everyone especially those who work outdoors on a regular basis. Thus, public-health interventions should include personal protection advice as well as steps taken to mitigate pollution at its source.

Economics costs also go beyond health-care expenses. Sickness can lead to lost productivity, lost household income and school closures can hinder learning and add further pressure on families. Long-term health consequences can also impact educational outcomes and access to the labour market. Though the exact costs are not known and should be backed by a clearly defined study when mentioned, some estimates have placed air pollution as taking a toll of several percentage points of GDP from the economies of the world annually, including Pakistan.

Policy Implications and Practical Pathways

The evidence is in favour of a coordinated policy on air quality and climate change. Black carbon and other climate-warming pollutants are also emitted with many activities that produce PM2.5. Mitigation of the emissions of these sources can thus deliver immediate health benefits and help mitigate climate. Focusing on the contribution of Pakistan which is relatively small in the global context makes the case for international assistance, while continued domestic action is essential.

Before that, car emission regulations must be toughened, and enforced. The pollution in busy urban corridors could be reduced through inspection and maintenance programmes, cleaner fuels, and the phased replacement of high emitting diesel vehicles, as well as through improvements in public transport. Electric mobility can be a component to the answer, especially when electricity production and charging infrastructure enable true emission reductions.

Second, brick kilns need better regulation, and the transition to cleaner technologies and a sound management plan for the end of highly polluting practices. Compliance tests should be regular and transparent not just during the worst weeks of smog. Third, to minimize use of burning, alternative methods to burning should be considered, including: mechanized alternatives to burning, collection and reuse of crop residues, economic measures and technical support to farmers. There needs to be coordination between the agriculture and environmental authorities and regional dialogue should be developed to resolve smoke pollution that transgresses the common airshed.

Fourth, open burning of waste should be tackled in conjunction with the improvements of municipal collection, separation, recycling and disposal. If households and businesses don't receive reliable waste services, bans will have only limited effect. Fifth, monitoring networks need to be expanded and continued and the data at the monitoring stations need to be publicly available, along with an explanation of how the AQI values are calculated. Public health messages should include the meaning of the readings and practical recommendations such as wearing an N95 or KN95 respirator during periods of high exposure and when they are available, decreasing strenuous outdoor activities and improve indoor air quality. Especially schools, health centres, and those working outdoors should be given special consideration.

Sixth, urban planning has the potential to alleviate congestion and construction dust and promote public transport, safer walking routes, and green spaces. Emission control is not reduced by the presence of green cover, but the creation of green cover can be complementary to the broader emission control measures if planned appropriately. Seventh, air quality targets should be included in Pakistan's national climate pledges and adaptation plans; climate finance from the international community to initiatives that have evidence of public health and climate impacts. Last but not least,

there should be more data exchange and cooperation on seasonal responses between countries and provinces within the Indo-Gangetic airshed.

In 2025–2026, the Punjab EPA reported the following actions in Punjab: Non-compliant industrial units and kilns were identified and enforcement was carried out, Open waste burning was restricted, and monitoring and anti-smog activities were expanded. However, the extreme readings taken in October 2026 indicate that the levels of exposure are still not being reduced to safe levels. This will take time and require a sufficient budget, consistent enforcement, inter-agency cooperation, publicly disseminated information, and a testing of what works in preventing pollution. Seasonal crackdowns can convey urgency but it cannot be a substitute for long-term, systemic reform.

Conclusion

The air quality issue in Pakistan's major cities is a consequence of the interplay between emissions and weather conditions which can cause air pollution to accumulate close to the ground. However, the seasonal smog is particularly intense in the cities of Punjab, including Lahore, and there are also areas of transport, industrial, geographic and seasonal contribution in Karachi, Peshawar, Islamabad and Rawalpindi. Pakistan's emissions are small compared to the overall global emissions, while the pollution and climate risks in the country are high. There are consequences to the health that are serious and unevenly distributed. Fine-particle pollution causes respiratory and cardiovascular disease, early death and loss of life expectancy. Children and elderly, those with underlying health issues, outdoor workers and lower income groups may have fewer options to avoid exposure. This difference in effects renders air quality an environmental concern, as well as a concern for public health and social justice. Pollution has to be tackled at the source, and monitoring, protection of public health, urban planning and cooperation at regional level need to be enhanced in order to achieve a lasting response. Improvements in PM2.5 and black carbon can enhance the quality of life and can also help to achieve climate objectives. Domestic policies will be more successful if supported by sufficient resources, clear data and international cooperation that takes into account the different distribution of climate responsibility and climate harm. Future research needs include updating of source-apportionment studies using recent activity data, health impact estimates for each emission source, and evaluation of the efficacy of new policies recently instituted. The modelling of other mitigation pathways may also help to better understand which interventions have the largest benefits in terms of health, climate and the economy. Better national decisions and an informed international discussion on communities that contribute relatively little to the global climate problem but face large consequences would benefit with stronger evidence.

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