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Lahore Smog Crisis: Punjab Strategic Response through Policy & Public Engagement (2021–2024)

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Abstract

Lahore, capital of Punjab in Pakistan, is one of the most polluted cities in the world. Seasonal smog threatens public health, business activity, and the ecosystem. This paper analyzes policies regarding the smog crisis concerning multi-level governance from 2021 to 2024. It relies on policy documents and reports pertaining to health, international air quality datasets, and think-tank evaluations through a case-based governance lens to assess Lahore's move from responsive containment to proactive management. The analysis evaluates key actions including emission control enforcement for industries and vehicles, electrification of public transport, rural technology subsidies aimed at reducing stubble burning, and real-time monitoring system implementation like the Smog War Room. Other focal points include responding health systems for public communication campaigns such as **#DETOXLAHORE** as well as local governance roles towards implementation.The Lahore Development Authority (LDA) solved some issues through urban greening, regulating the construction dust control, zoning changes that align city planning with environmental goals. All of these efforts focus on cleaner air and reduce pollution. Results suggest actionable outcomes showing airborne particulate matter control technologies have been adopted by almost 96% of industrial facilities; some areas reporting an improvement of up to 38% in AQI. Public awareness also increased through consolidated outreach; tracking coordinated perception changes over time demonstrated these targeted efforts raised awareness around pollution issues within Lahore's vicinity. Despite these gains there are still persistent challenges like underfunding or poor coordination across government silos lack clear lines-of-accountability which has cascading effects on weak enforcement structures hinder action at multiple levels within a system plagued with unresolved pollution crossings coming from Indian Punjab region bound rationales. This paper adds to the body of work on subnational

environmental governance in South Asia by pointing towards a persistent need for investment, diplomacy, reforms, civic engagement, and multisectoral mobilization in the region's geopolitics.

Keywords

Lahore smog, environmental policy, air quality governance, transboundary pollution, electric mobility, Punjab EPA, stubble burning, South Asia, green public transport, sustainable urban planning

Introduction

Lahore is known as the cultural capital of Pakistan, but it is now associated with toxic air and dense layers of smog that blanket the city every winter and fall. The city used to be famous for its historical landmarks and beautiful gardens, but now, its shrines are graveyards for the lush greenery. It also ranks as one of the top three polluted cities in the world along with experiencing severely high AQI levels during winter months. "Coventry leans toward about 400 while Lahore regularly exceeds this mark and at times breaches 800". These numbers demonstrate a level considered dangerously unhealthy. WHO reported these in 2021 while Reuters published similar information in 2024.The grim reality poses a public health concern for citizens, while also triggering new issues regarding environment sustainable policies, governance, or urban public development.

The thick smog covering Lahore during the winter is a type of pollution caused by human activity and is primarily the result of fine particulate matter (PM2.5) suspended in the air. Based on its research conducted in 2021, World Health Organization describes PM2.5—particles smaller than 2.5 micrometers in diameter—as one of the most dangerous forms of pollution because they can get deep into one's lungs and blood stream. Research suggests that Lahore often has PM2.5 levels as high as more than thirty times the safe limit set by WHO (Khan, 2023). The health risks associated with long-term exposure include respiratory infections and asthma, heart problems, and even an early death due to such severe thinning of the body's systems over time. Children and elderly citizens tend to be most vulnerable in these situations to outdoor pollutants, which are flush during peak periods, allowing for easy intake but causing severe dilation within the body's structure (Government of Punjab, 2024).

This environmental catastrophe did not happen out of nowhere. Instead, it's caused by a lack of planning and ineffective governance as well as unchecked urban growth and development. Over the last twenty years, Lahore has experienced rapid population growth which led to an increase in private car ownership and construction activities. Cars that are several years old or poorly maintained make up the majority of Lahore's vehicle fleet, and they, along with other diesel-powered vehicles, greatly contribute to air pollution. Because there is no emission control technology for vehicles in Lahore, your low-quality fuels (often used in these vehicles), wreak

havoc in the form of sulfur dioxide, nitrogen oxides and particulate matter release (Ahmed & Rana 2022).Other than cars releasing smoke, factories that operate without any emission control devices alongside unregulated brick kiln operations directly add to smog levels in Lahore. Much like traditional kilns found all over Punjab that burn coal and rubber tires to inject black carbon into the atmosphere, many surrounding Lahore factories are just as bad by burning toxic gases and soot without restriction (Khan, 2023). In conjunction with construction dust, diesel generators, burning household rubbish waste add poison onto low-income neighborhoods suffering from a lack of proper waste disposal services.

Stubble burning is another important and often disputed agricultural practice that influences the smog problem both in Punjab and India. After harvesting rice and wheat, farmers need to burn crop residue so they can move quickly to the next planting season. Even with bans and awareness campaigns, this method remains common because there are very few affordable options like mechanical seeders. Satellite photos and drone footage provide evidence of thousands of crop-burning incidents each year, massively contributing smoke and carbon emissions to be transported into Lahore via prevailing winds (Ahmed & Rana, 2022).

The geographical and meteorological factors worsen the situation even more. In winter, the phenomenon known as atmospheric inversion will trap pollution below a certain altitude in layers of warm air making it impossible for those pollutants to escape. The bowl-like shape of the Lahore basin amplifies airborne toxins especially during gas exchange which further adds on to Lahore's existing problems- transforming it into a city-shape gas chamber where breathing becomes increasingly difficult (WHO, 2021). Furthermore, limited tree cover combined with low amounts of green spaces along with the urban heat island effect slows down natural purification processes resulting in stagnant air.To tackle this multi-faceted problem, the Government of Punjab has implemented multiple initiatives to tackle the root causes of smog and its effects. One notable effort is the implementation of EPA vehicle fitness tests. This program uses mobile testing units to monitor emissions testing and revoke permissions for vehicles that fail air quality tests. There has been progress with this system as "more than 10,000 smoke-emitting vehicles have been impounded" according to government data (Government of Punjab, 2024).

The Chief Minister's focus on sustainability by introducing electric and green buses marks another leap forward. The Punjab Mass Transit Authority has partnered with several organizations in an attempt to deploy 400 electric buses in Lahore by 2025. These electric buses will utilize solar powered charging systems on major routes to lessen traffic congestion from private vehicles (24 News HD, 2024). Moreover, the initiative aims at distributing 20,000 E-bikes further enhancing mobility solutions aimed at clean transport.The "**#DetoxLahore**" campaign is a complementing effort to tackle air pollution through public awareness, industrial monitoring, and city design. It is a multi-year and multi-sectoral initiative, which includes setting up a "Smog War Room," an interdisciplinary command center with real-time air pollution

monitoring systems, drones for detecting crop fires, and satellite predictive analytics (Reuters, 2024). Public institutions such as schools and hospitals have also been put under emergency protocols which require masking, remote work, and green lockdowns during the declared smog emergencies.The Lahore Development Authority LDA solved some issues through urban greening, regulating the construction dust control, zoning changes that align city planning with environmental goals. All of these efforts focus on cleaner air and reduce pollution.

These initiatives aim to take great strides toward better air quality; However, gaps still remain. Enforcement of protective environmental legislation remains plagued by politically motivated stagnation coupled with bureaucratic gridlock. Furthermore, while electric vehicles and emission control measures are introduced, their effectiveness will be restrained by available infrastructure, budgetary support, and sustained public cooperation over time. While praising some government policies, critics have countered that most proposals lack anticipatory governance embedded within an overarching environmental justice approach that tackles structural inequity alongside climate adaptation and resilience strategies (Ahmed & Rana 2022).This research paper looks into the reasons why Lahore has been facing a smog crisis. It also analyzes how the government is responding to it. The study focuses on whether the existing strategies address long-term resolutions or are merely superficial attempts at controlling damage through policy evaluation, exercising statistical review, interviewing relevant stakeholders, among others.

This research fulfills gaps in discussions about environment governance within Pakistan's cities and offers public policy suggestions concerning improving environmental health in Lahore during intensive pollution periods.

(Developed By Authors)

Drivers of Smog in Lahore

The issue of smog in Lahore has both natural and human-caused features. For example, there are certain weather conditions such as an atmospheric inversion (which is a form of warm front) that worsen the pollution in Lahore. However, it is the local and regional emissions that act as primary pollutants. The layered complexity of environmental issues reveals why understanding drivers of smog is essential.

Category	**Type**	**Source Examples**	**Pollutant Type**	**Contribution to Smog**
Natural Factors	Meteorological	Atmospheric inversion, low wind speed, low solar radiation (winter season)	Trapping of existing pollutants	Amplifies impact of anthropogenic emissions
Anthropogenic - Local	Primary Emissions	Diesel vehicles, aging buses/rickshaws, low-grade fuel, unregulated industries	PM2.5, NOx, CO, SO_2, VOCs	Major direct pollutant sources
		Brick kilns using traditional methods	PM10, black carbon	Significant localized pollution
		Construction dust from roadwork and development	PM10	Worsens air quality during dry seasons
Anthropogenic - Rural	Primary Emissions	Crop residue/stubble burning (Lahore outskirts, Sheikhupura, Kasur, etc.)	PM2.5, smoke, black carbon	Seasonal spike in emissions, especially Nov–Dec
Secondary Formation	Atmospheric Reactions	Reaction of NOx and VOCs with sunlight	Ground-level ozone (O_3), photochemical smog	Intensifies health risks and air toxicity
Transboundary Pollution	Regional External	Stubble burning in Indian Punjab (Amritsar, Firozpur) carried by wind	PM2.5, CO, VOCs	Adds pollutants during smog season (Nov–Jan)

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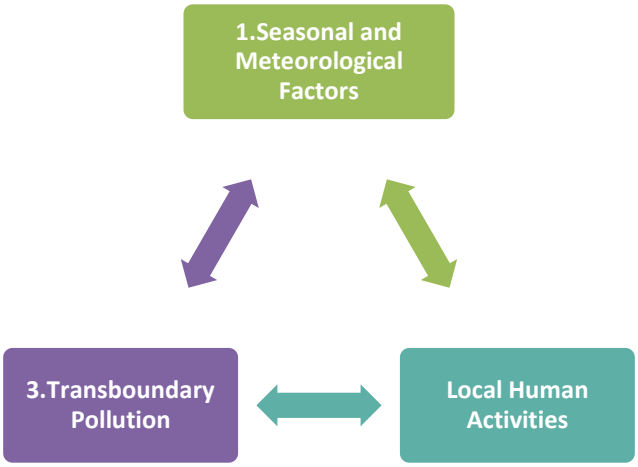
Table 1: Classification of Natural and Anthropogenic Drivers of Smog in Lahore (Adapted from EPA Punjab, Reuters, ICIMOD, NASA FIRMS, 2023–2024)



(Developed By Authors)

1. Seasonal and Meteorological Factors

An important factor contributing to smog in Lahore is directional temperature change or atmospheric inversion, which regularly occurs during winter seasons. The mix of air near the surface and warm air above does allow gases to rise and become less dense creating space for more dilute regions on top to exist freely. On occasions when an inversion happens, a warm layer traps cooler air below. Situations such as these can be found with great frequency in Lahore from early November through mid-January when nights cool down sharply (Reuters, 2024a).

Lahore is located in the Punjab region, which is a flat area without natural breezes because of low altitude and no coastal wind. Together with high amounts of moisture, low winds, and still air, an inversion layer creates pollution consisting of PM2.5, carbon monoxide, nitrogen dioxide, and sulfur dioxide (WHO 2021). This results in heavy fog making airflow even more difficult and visibility lessened as well as posing risks to people smothering public health while attacking the respiratory and cardiovascular systems.

2. Local Human Activities

Weather conditions may create the smog we see around this time of year but it's human emissions from inside the city and nearby areas that make it worse. One of these includes using low-grade fuels for vehicles as they are old and outdated. Lahore has a fleet composed mostly of older model motorbikes along with rickshaws and buses equipped with older combustion systems. These vehicles make up the majority Lahore's transport fleet where most do not have catalytic converters or modern emission control systems leading to massive amounts of PM2.5, Carbon Monoxide, Hydrocarbons being released into the atmosphere (Al Jazeera 2023).

The industrial activities located in the outskirts of Lahore further complicate the issue of pollution. Small to medium-sized manufacturing units that operate unofficially burn coal, rubber, and diesel without using emission filters. It has been reported by the Environmental Protection Department of Punjab that traditional brick kilns contribute significantly to emissions during the smog season. These fixed-chimney kilns are very common throughout rural Punjab, and they burn low-efficiency fuel while releasing a lot of black carbon and other pollutants (Khan, 2023).

Construction dust is another elementary cause of Air Pollution. At this moment there is quite a lot unregulated construction happening around Lahore’s urban areas which often produces a number of particles such as silica, cement and even very fine dust. When these materials enter suspension, they further increase Lahore PM10 and PM2.5 levels. Al Jazeera states there is no rules for stopping dust being created from construction work—using water or barriers are off limits—makes this problem worse (Al Jazeera, 2023).Also, farming activities like stubble burning in Punjab’s agricultural belt are major sources of airborne pollutants. Stubble burning is still common practice because there is a lack of access to mechanized harvesters or subsidized biodegradable alternatives to manual harvesting. The smoke produced from these fires travels over many districts and combines with smoke generated out of urban pollution, forming a toxic mix (Government of Punjab, 2024).

3. Transboundary Pollution

The problem of air pollution in Lahore has international dimensions as well as Transboundary pollution particularly from the Indian side’s Punjab and Haryana regions contributes significantly to deteriorating Lahore air quality especially during “smog” season. With Indian farmers practicing massive crop residue burning, resulting smoke gets transported to the western side by seasonal winds for October through November. Both Pakistan Meteorological Department and private research institutes have provided meteorological data and satellite images showing the existence of smoke plumes crossing the border into Lahore’s airshed (Reuters, 2024b).

On various occasions, the Punjab Government has officially cited cross-border emissions as one of the primary factors for the region's smog problem. They also believe there needs to be more

collaboration between both states because the Indian and Pakistani sides of Punjab have similar geographic and climatic zones, agricultural cycles, and farming practices (Reuters, 2024c). Still, progress on environmental diplomacy remains scant due largely to longstanding geopolitical relations between the two countries. The lack of a bilateral agreement on joint environmental action enables trans-boundary pollution to continue being what Ahmed & Rana (2022) describe as “shared but unaddressed” burdens.While paying attention to local accountability is imperative, external sources like cross border pollution are far too impactful to be ignored. Certain atmospheric models indicate that during peak stubble burning seasons in India, anywhere from 35–45% of Lahore's PM2.5 levels may use external resources (Khan, 2023). These figures bolster the case not just for emission cuts at the source but also for increased international political cooperation to tackle smog as a collective environmental issue.

Government & EPA Interventions

A. Regulatory & Enforcement Measures

The Government of Punjab has taken action regarding the smog crisis in Lahore by allocating resources to special programs enforced by the Environmental Protection Agency (EPA) along with the provincial government. These changes have been made to lessen pollution’s greatest contributors, while also helping to develop future management strategies for holistic air quality control. Now, rather than solely monitoring pollution caused by emissions from vehicles, industries, and construction activities, as well as real-time assessments of air quality, the government is taking more enforcement action as observed in this intervention case.

1. Vehicle Fitness Inspections

Inadequate emission control systems make older vehicles a prime contributor to air pollution in Lahore due to vehicular emissions. In order to tackle this issue head on, the EPA launched a comprehensive vehicle fitness inspection initiative in 2023. Under this program, mobile inspection units are sent visioning around Lahore conducting random roadside inspections and measuring exhaust as well as opacity levels emissions using analyzers metes devices.Vehicles that fail emissions tests for black smoke or surpass set emission thresholds are seized or fined.

As reported, more than 10,000 smoke-emitting vehicles have been impounded alongside the revocation of thousands of routes, permits for public and freight transport operators due to non-compliance with fitness regulations (Government of Punjab, 2024). Under this program, it also entails mandatory testing for diesel public transport buses and inter-city logistics vehicles (known for their significant contribution) to the PM2.5 pollution levels. Meanwhile, fuel adulteration is being checked in collaboration with OGRA to assure cleaner diesel.

2. Restrictions on Heavy-Duty Vehicles

To combat increasing emissions from vehicles, the Punjab government has restricted the movement of heavy-duty vehicles during peak smog seasons. Most importantly, large trucks and trailers are now barred from entering Lahore on weekends spanning Fridays through Sundays when congestion and pollution reach their peak level. The rules predominantly affect vehicles not transporting perishables or emergency supplies (Punjab Government, 2024).

This attempt focuses on curbing emissions during low-dispersion weather periods when temperature inversions trap pollutants close to the surface. Enforcement is carried out through traffic police checks along with city surveillancesystem fines are applicable for permit and emissions violation as well as suspension of vehicle permits.

3. Construction and Industrial Controls

As part of the government's anti-smog campaign, a specific focus has been placed on regulating construction activities alongside emissions from industries. During the smog season of 2023-2024, the Punjab government banned all non-essential construction in Lahore and adjacent districts. Remote construction sites without dust suppression systems on worked were sealed, and offenders were prosecuted under the Punjab Environmental Protection Act (Thenews.com.pk, 2024).At the same time, EPA has further narrowed its scope of monitoring within industries that provoke pollution. brick kilns that have traditionally burnt coal, rubber and plastic are in line to be shut down or converted to new fuel sources. More than ninety percent of kilns in Lahore had either implemented Zig-Zag technology—a cleaner design—or ceased operations by the end of 2024 (Nation.com.pk, 2024). This greatly reduced black carbon emissions within this sector.Additionally, around 96% of the region's industries had installed and emission control equipment like scrubbers, baghouse filters, and electrostatic precipitators. Compliance is monitored through the EPA and independent environmental auditors. Factories checked to be in noncompliance were boarded up or given notice of violation. There are also public informational campaigns directing industries toward low-emission production and natural gas (Punjab Government, 2024).

4. Air Quality Monitoring and Surveillance

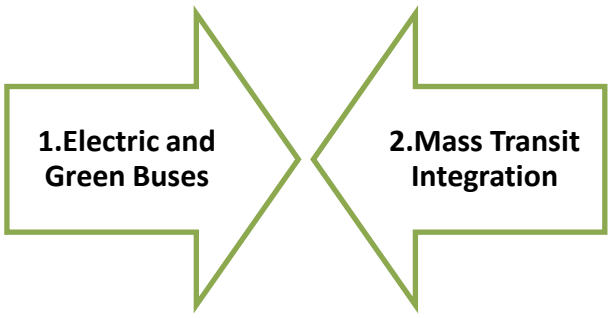
Data collection in real time serves as the cornerstone of the smog management plan. Over twenty-five fixed AQI monitoring stations have been set up in Lahore alongside other major urban centers in Punjab. These monitors have state-of-the-art equipment that can capture PM2.5, PM10, CO, NO_2, O_3 emissions. Data integration to the EPA's online portal allows real-time access for citizens through mobile apps as well as city-wide digital displays (24 News HD, 2024).Moreover, the Lahore Safe City Authority has combined its surveillance system of more than eight thousand cameras with the EPA for monitoring cases of industrial espionage and illegal waste incineration. Drone technology has also been utilized to monitor burning residues

on crops in rural areas as well as inspecting smoke stacks of factories live (DGPR Punjab, 2024). These drones have thermal imaging cameras and sensor devices that detect smoke particles enabling them to easily identify and geo-tag areas with heavy pollution.

The EPA was also working with international bodies towards designing an integrated satellite early warning system for issuing alarm messages relating to Smog. The alerts are sent to government departments, schools, and health institutions which enables proactive measures like shutting down schools, issuing public service announcements, or deploying healthcare staff immediately (Nation.com.pk, 2024).

B. Public Transport Revolution

The use of private and public fossil fuel transportation in Lahore continues to ruin the air quality in the city. To improve the transport-related emissions, the Government of Punjab has started a new revolution to improve public electric vehicles (EVs), better integrate mass transit systems, and promote green mobility.



(Developed By Authors)

1. Electric and Green Buses

One of the main goals for pollution control is deploying electric buses in Lahore metropolitan areas. The project funded by Punjab Mass Transit Authority, has already approved 400-installment program with 27 operational as of early-2025 (Chief Minister's Office, 2024). As part of an initiative sponsored by the Chief Minister of Punjab, these lithium-ion battery-powered buses will move on high-traffic corridors aimed at reducing diesel reliance among public buses.Complementing these efforts, the Punjab Transport Department's green mobility policy aimed at students and low-income commuters is launching 20,000 electric bikes (Punjab Transport Department, 2024). Additionally, 30 EV buses were deployed for a preliminary engagement and efficiency evaluation. Charging stations are being set up at major transit hubs alongside these vehicles which will be partially powered by solar energy.

2. Mass Transit Integration

In keeping with the Chief Minister's vision, the province is moving towards an integrated mass transit system that includes connections between Lahore Metrobus, Orange Line Metro Train, and EV bus lines (DGPR Punjab, 2024). Through this multimodal system, movement requires less private vehicle use through a singular fare payment system along with synchronized timetables. This initiative has the potential to greatly reduce emissions during peak traffic hours when heavy congestion causes heavily polluted air.

C. Agricultural & Rural Strategies

Lahore takes the blame as the urban center of pollution in Punjab, agricultural activities from outside of cities add significantly to seasonal smog. In response to this aspect of the crisis, the Punjab government is applying a mix of subsidized technological adoption and enforcement of stricter environmental protections.

1. Super Seeder Scheme

Following the directives of the minister's office, the Punjab Agriculture Department allocated 1,000 super seeders under 60% financing to aid in alleviating stubble burning. (Ministry of Agriculture Punjab, 2024). These machines are very advanced as they do wheat sowing directly onto the previous crop's remnants without requiring burning.Alongside distribution, training and awareness campaigns were held in rural districts.This policy has been particularly useful in addressing agronomic challenges as well and is proving to be beneficial to the environment as well (Dawn, 2024a).

2. Crop Burning Bans with Enforcement Technology

To further support the implementation of super seeder initiative schemes, a complete prohibition on crop residue burning was introduced by the Punjab EPA along with technology enforcement monitoring. (Environmental Protection Agency Punjab, 2024). The use of drones and satellites alongside thermal sensors provide real time tracking for burn events. Legal penalties such as fines or FIRs are attributed to offenders which make breaking this law unbeneficial.

As noted by the Environment Minister of Punjab, there was a marked reduction in rural fires during enforcement of laws in 2024, which indicates drone-integrated governance was working (Ministry of Environment Punjab, 2024).

3. Urban Planning and Structural Measures: The Role of Lahore Development Authority (LDA)

The fight against smog in Punjab transport and regulatory interventions have taken center stage, it is now apparent that urban planning including the initiatives from Lahore Development Authority (LDA) needs to be integrated into long-term environmental governance. The LDA, as the controlling authority of land planning, infrastructure development, and building regulation enforcement within Lahore, directly influences traffic congestion and construction dust pollution through green space, vehicle congestion management, and construction policies—much of which comprises astounding levels of smog.Recently, the LDA has taken up different projects with the Chief Minister's office and the Punjab Environment Protection Department aimed at improving environmental sustainability. One of these projects is Urban Foresting where they have established Miyawaki forests on Canal Road, Ring Road and other major roads in Lahore which increases forestation by thousands of trees (LDA, 2023). This helps in fortifying dust and PM2.5 concentrations in heavily populated areas. LDA has also made it compulsory for new housing societies to have green buildings and to have a minimum percentage of tree coverage while also having green belts and parks as open spaces. New policies from LDA state that all new residential developments must include tree planting per kanal along with rainwater harvesting systems, construction using solar energy, and be architecturally solar compatible (Punjab Urban Unit, 2023). Another key intervention anti-encroachment operations along with road widening are meant to ease traffic congestion which minimizes emission-causing vehicle standing time. Alongside TEPA, LDA has reworked bottleneck junctions and implemented signal free corridors easing congestion around Ferozepur Road and Main Boulevard which suffer from High population density traffic.

The LDA has put in place construction dust control regulations such as dust screens, water spraying, and enclosed material transport for large projects like the Shahkam Chowk Flyover and Central Business District (CBD) construction sites. Compliance with these measures is becoming more common along with drone surveillance in coordination with EPA compliance teams (Dawn, 2023). Although these policies seem to reflect growing effort towards blending environmental concerns into urban planning, there are still many unaddressed problems. The enforcement of these policies continues to be uneven, especially in outlying areas where unchecked construction expansion thrives. Moreover, limited collaboration amongst LDA, local municipal divisions, and EPA stifles collective action like enforcing tree cutting bans and dust regulation enforcement. In any case—shaped by supportive legal frameworks for inter-agency alignment and citizen engagement—structurally supported interventions by LDA could provide a blueprint for other Pakistani urban centers afflicted by smog.

Communication and Governance Structures

The creation of centralized governance systems along with public information campaigns is a critical component, although sometimes unnoticed, in the anti-smog strategy for Lahore. The

Punjab Government has undertaken efforts to improve cross departmental streams of coordination controlled through strategic communication frameworks because fragmented institutional responses failed to holistically address the complicated environmental crises.

1. The Smog War Room

In order to provide for complete and real-time responsive coordination from all sectors involved, the provincial government set up a central decision-making and monitoring hub in Lahore called the Smog War Room. This command center is jointly controlled by PDMA, EPA and other relevant departments and it integrates real time satellite imagery with AQI feeds from 25 fixed and mobile monitoring stations as well as weather forecasting models to evaluate smog levels on a daily basis (Reuters, 2024a).

The War Room issues daily data-driven advisories to the public, schools, hospitals, and industrial centers. These advisories recommend actions for certain sensitive populations which include children, seniors, as well as people with pre-existing respiratory diseases. Furthermore, these often lead to school closures, remote work notifications, cessation of construction activities, and other temporary policy shifts. The facility also checks compliance with anti-smog regulation. Such as vehicle emission testing, bans on stubble burning, and limits on industrial emissions (Reuters 2024b).

Equally important, the War room allows implementation of interdepartmental transport coordination involving agriculture, health departments, local government bodies and law enforcement which ensures unified action on anti-smog enforcement from all levels. With this system in place, provincial officials can quickly identify active pollution hotspots to dispatch inspection teams and coordinate high-risk zone medical aid emergencies autonomously. Officials of EPA and PDMA claimed that the Smog War Room has changed Punjab's environmental governance approach from fragmented reactive initiatives towards proactive integrated climate governance (Government of Punjab 2024).

2. The #DETOXLAHORE Campaign

The existing government measures, the Punjab authorities have started a comprehensive public information and mobilization initiative with the title **#DETOXLAHORE**, which represents a ten-year plan for development aiming at making Lahore a sustainable and livable city. It is led by Chief Minister of Punjab and Senior Minister Environment, Urban Planning concerning synergies in various sectors such as transport, energy, industry, construction and agriculture (Chief Minister's Office 2024).

The campaign includes sector-wise emission targets alongside renewable energy adoption plans and structural reforms in waste management and urban planning. The campaign has been

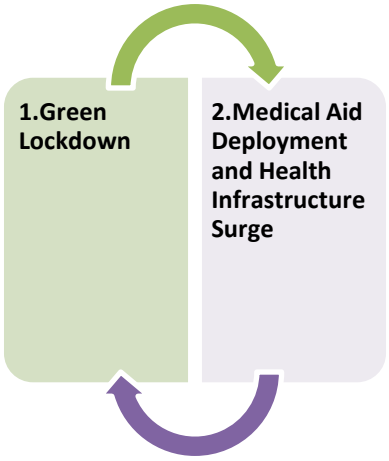
designed to foster greater public involvement through social media, schools, community centers to raise awareness about their role in air pollution and motivate them to change their habits. Under the outreach pillar of the campaign public service messages have been sent out alongside air quality alerts as well as “green citizen” recognition schemes designed to reward socially responsible actions.

A prominent element of **#DETOXLAHORE** is its youth engagement scheme which enlists student ambassadors from colleges and universities to spearhead awareness drives, plantation drives, and pollution audits in their respective localities. This initiative not only enhances the government’s communication efforts but also fosters long-lasting environmental stewardship among the young people. As per official government briefings, the **#DETOXLAHORE** strategy incorporates annual review frameworks which give the government real-time policy-change capabilities considering air quality metrics and stakeholder assessments (DGPR Punjab, 2024).

The Smog War Room together with the #DETOXLAHORE campaign shows how far the Punjab government is willing to go in trying to integrate rigid enforcement with integrated strategic communication civic action for foundational climate awareness and resilience.

Health and Emergency Actions

The long-term approaches such as vehicle electrification and agricultural reforms may curb the root causes of smog in Lahore, however, the persistent health emergencies stemming from pollution necessitates responsive immediate measures. The administrative short-term responses which span healthcare systems, education, and local government within a defined framework aim at mitigating the risk to public health whilst managing exposure during the healthcare system surge, especially during the season when smog is dominant (BBC, 2023).



(Developed By Authors)

1. Green Lockdown

The very high readings of air quality index that reach above 400 to hazardous levels. The Government of Punjab has used 'Green Lockdowns' over and over again. These are temporary but intensive containment policies applied usually between mid-November to December of every year (The Government of Punjab).Corporate offices and non-essential government departments implemented work-from-home policies during the lockdowns. This implementation helped reduce pollution from commuting, even if just a little bit. Urban face covering rules often accompanied these lockdowns, particularly for school-aged kids, traffic police, and construction workers who tend to breathe in harmful dust (Reuters, 2024a).

Public health authorities have stood by these measures claiming they're essential for avoiding widespread outbreaks of respiratory illness. Authorities believe that the reduction in emissions resulting from these sacrifices will prevent hospitals from experiencing capacity challenges and improve attendance at workplaces and schools during seasons of high smog.

2. Medical Aid Deployment and Health Infrastructure Surge

In response to the increase in healthcare demand during the smog season, the Punjab Health Department mobilized healthcare staff and resources more aggressively than in previous years. Within this framework, they set up over 200 mobile health clinics that provided basic respiratory care like pulse oximetry monitoring, nebulization therapy, as well as medicines for allergies and minor ophthalmic irritations (Punjab Health Department, 2024).

These mobile clinics were based in the vulnerable and low-income eastern and southern parts of Lahore city, which tend to be underserved in terms of access to hospitals and pharmacies. Each unit offered on-site treatment as well as health education focused on smog protection and served roughly 300-500 patients each day.In addition to the mobile services, all hospitals in Lahore were also asked to increase their admitted volume for respiratory cases, especially children and elderly patients. During the 2023–2024 smog wave, more than two million patients were managed in emergency departments and outpatient centers for chronic conditions like asthma, bronchitis, sinusitis, allergic rhinitis, and even some forms of cardiovascular distress (Thenews.com.pk, 2024). There was also increasing trends noted in the ER admissions of several high smog period prevalent illnesses at The Punjab Institute of Cardiology, Mayo Hospital and Jinnah Hospital.

To accommodate this increase in demand coming from other hospitals during peak periods of having multiple patients from outside physicians who work for these facilities due to high volumes being present there in combination with teaching facilities as well district health

authorities set up relief units for providing free medications along with these outpatient services that needed extra hours added due to extended operation times being approved for their open rehabilitation clinics. Alongside these activities a campaign dealing with public health was initiated aimed at guiding people through recognizing early signs resulting from exposure towards air pollution so they can seek medical assistance within appropriate timelines after its onset. Online doctor appointments helped people access healthcare without stepping into congested hospitals filled with overcrowding and heavy pollution. The combination of online resources alongside traditional healthcare systems created a protective shield for people during the smog crisis.

Assessment & Early Outcomes

The Anti-Smog Action Plan officially launched by the Punjab Government, including regulatory compliance measures, public health actions, transport policy changes, and public healing programs has produced some initial encouraging results. Despite ongoing enforcement and habitual challenges, growing systematic air pollution management efforts demonstrate initiatives undertaken in air quality monitoring and evaluation as well as compliance supervision detail positive trends.

1. Emission Control Uptake and Enforcement Metrics

As highlighted by the field audits commissioned by the Punjab Environmental Protection Department (EPD) and conducted alongside regional assessments, from a total of 751 industries which were reported as registered to operate in Lahore and its adjacent districts close to 96% have installed government emission control systems scrubbers, baghouse filters, and gas capture systems mandated for their operation regions (DGPR Punjab; Government of Punjab, EPD & CCA 2024). This is a marked positive turnaround compared to more recent years where aging unregulated industries contributed copious amounts of airborne particulates.

For transportation, the EPA has stepped up enforcement actions using roadside emission monitoring units. PIDE reported that 144 vehicles of public and private organizations had their permits suspended due to non-compliance with emissions regulations during the smog season of 2023-2024. This was part of an EPA intervention which, alongside other regions, examined more than 40,000 vehicles in major traffic bottlenecks regions (PIDE, 2024).

This shift demonstrates the improvement in the state's environmental governance capacity planning as a result of institutional changes such as drone imagery for real-time surveillance, log digitization of inspections, and collaboration across government departments.

2. Smog Reduction: Clear Evidence

Perhaps even more interesting is that both official data pertaining to air quality & European Space Agency's Copernicus Atmospheric Monitoring Service (CAMS) satellite observations have confirmed approximately 38% decrease in PM2.5 concentration in Lahore relative to previous smog seasons (ESA, 2024). Although AQI levels are still volatile and remain above WHO recommendations, this decline is a sign of progress from clean fuel policies with electric public transport systems, industrial retrofits and a slowdown or pause in stubble burning. This was backed by the 2024 policy brief from the Sustainable Development Policy Institute (SDPI, 2024) which mentions Lahore's air quality improvement as a result of "sector-specific compliance backed by public pressure, high-frequency monitoring, and executive accountability" (SDPI, 2024). Moreover, the brief states that while some reduction may occur, it could be structural reforms along with enforcement that would sustain such changes.

3. Additional Environmental Actions and Structural Adjustments

Aside from responding to emergencies like smog, the Punjab government is trying to integrate sustainability into urban planning. Some of these initiatives are:

• Under urban greening and afforestation campaigns over 1.5 million trees were planted in Lahore during 2023-2024. Together with IUCN, there are ongoing efforts towards improving biodiversity and fostering carbon-sequestering ecosystems under the Urban Forest project.

• The subsidization of solar panels through PEECP is aimed at encouraging urban domestic and small industrial use resulting in lower fossil fuel reliance as well as reduced emissions on a more localized scale (PEECP, 2024).

• National Electric Vehicle Policy (NEVP) supports electric vehicle promotion for both consumers and manufacturers through tax exemptions, waived registration fees and reduced tariffs on imported EV components provided by Pakistan's Ministry of Climate Change (MoCC,2024).

The first trial using vertical air purifiers or smog towers was conducted in heavily populated areas. While the scientific community is still debating whether these "smog towers" work (Gupta et al., 2023), preliminary research from The Energy and Resources Institute in India indicates that there may be some improvement to AQI levels within a 500-meter radius (TERI, 2023).

As a whole, these other efforts represent progress beyond reactive measures towards proactive, comprehensive planning that integrates environmental sustainability into policy frameworks.

Challenges & Future Outlook

The Punjab government's multi-pronged anti-smog policy strategies showcase an effort to build political trust and institutional investment. As much as these policies are a step towards action,

they are still facing some significant gaps including structural issues, funding allocation, and even geopolitics which impact the extent to which we can implement any reform that is holistic in nature. Improving the air quality around Lahore will require commitment from local authorities, overcoming existing limits on implementation capacity, improving governance efficiency, investing in those commitments, enhancing regional diplomacy regarding cross-border pollution governance, and dealing with cross-border air pollution.

1. **Funding Gaps and Capacity Constraints**

Among all of these factors that come into play in mitigating smog in Lahore, lack of funding seems to be the most prominent one. This issue lies not just with the provincial governments but also poses a challenge for the roll out of electric vehicles especially when considering industrial emission controls. Investment in infrastructure alongside sufficient rural electrification coupled with expansion in air monitoring constitute a fully-fledged approach towards implementing **#DetoxLahore** regardless of how much money it takes. Punjab has seen noticed absent environmental expenditures because they remain under 1% of public expenditure allocation akin to other provinces. Spending less than a single percent is counterintuitive when you consider sustainable development goals globally (ADB). Donor aid often falls short as it targets immediate relief giving first priority to quick-solve programs devoid of long-term planning which results in fragmented funding streams targeted towards superficial structural shifts lacking real change.Public-Private Partnerships (PPPs) have been recognized as one of the key solutions for financing green transportation, renewable energy systems, and urban forestry projects. Nonetheless, in Pakistan's environmental sector, successful PPPs remain scarce due to underwriter risk concerns, ambiguous legal frameworks, and lack of definitive institutional guarantees (World Bank 2023).

Another persistent challenge is the need to improve the technical training skills for environmental health officers at the EPA and local governments. Many compliance inspectors from Environmental Protection Authorities do not have adequate staff resources with respect to equipment, skills, or legal authority needed to ensure compliance within Lahore's densely industrialized and politically active regions (UNESCAP 2022). Policy enforcement is still trailing far behind regulated standards because there has not been sufficient funding towards people management and digital technologies.

2. **Governance and Implementation Gaps.**

The policy gaps are getting more sophisticated with the establishment of new institutions such as a Smog War Room, vehicle testing protocols, and emissions targets per industry as evident by policy documents which still present major implementation shortfalls on record level policies. In some cases, policies are litigated but fall victim enforcement due to bureaucratic stagnation,

cross-silo gridlock or political capture.Take the stubble burning ban as an example. It has been enforced and technologically monitored several times, yet enforcement remains sporadic in politically sensitive rural areas. Furthermore, while green buses have been delivered, there is still a lack of EV charging infrastructure and route planning (PIDE, 2024).

The overlap of municipal and provincial boundaries makes environmental governance even more difficult. The metropolitan governance system of Lahore is split among many different agencies which leads to coordination breakdowns and slack accountability. Environmental governance gaps that are created by a lack adequate legal regulations to strengthen centralized environmental powers and concrete evaluation criteria for performance results will undermine progress in the future.

3. External Dependencies and Regional Cooperation

Cross-border air pollution impact is one of the most intricate challenges—especially the emissions coming from Indian Punjab to Lahore. The region has garnered attention due to rampant crop residue burning between October-November annually, leading to suffocating air quality (BBC, 2023). ICIMOD and NASA FIRMS have both reported that considerable portions of smogparticulates originating from eastern Punjab are transboundary in nature with India's influence which dramatically worsens Lahore's smog problem regardless of local efforts (ICIMOD, 2022).

At the moment there is no official agreement on the issue of air pollution between India and Pakistan. This is in spite of both countries being part of more broad frameworks like the UN at ESCAP's Asia-Pacific Clean Air Partnership. This lack of diplomacy hinders the regional governance of common atmospheric systems while creating an unjust burden on local authorities in Punjab to manage a partially outside problem.Some experts have suggested setting up a cross-border clean air task force which would include members from civil society, climate experts, and policy makers below the national level from both sides. These groups could act as neutral platforms for sharing information, providing seasonal forecasts, and coordinated agricultural reform similar to Indo-Bangladesh cooperation on flood management (Brookings 2023).

In any case diplomatic efforts like these need to be made first, otherwise Palermo will remain exposed to beyond provincial or even national issues. Such conditions stall long term planning but require great flexibility, adaptability, and determination from policymakers.

Conclusion and Recommendations

The smog problem in Lahore is no longer just a seasonal issue. It has developed into a long-term environmental and healthcare threat. In reaction, the Punjab province's governance structure—which includes regulatory enforcement, urban planning, green mobility shifts, comprehensive

reforms, and rural-urban program infusions—shifts markedly from past neglectful policies. Rather, it integrates responsive approaches and real-time data-driven systems to address one of South Asia's acute urban sustainability concerns.These changes are transformative as they include real-time monitoring systems like the Smog War Room, vigorous vehicle inspection drives, introduction of electric buses and bikes to public transport, and technological subsidies such as super seeders in agriculture. These changes support from health sector mobilization and institutional coordination along with multi-sectoral campaigns such as **#DETOXLAHORE** marking growing political concern for air pollution on long-term policy initiatives.

First evaluations yield positive results with improvements to AQI levels, enhanced industrial compliance, increased public participation measures, alongside raised awareness on the health impacts of air pollution. Nevertheless, persistent bottlenecks restricting limited funding face fragmented governance silos along with inconsistent enforcement frameworks that have yet to be resolved by Iranian cross-border pollution diversions.To move away from treating the anti-smog strategy as an emergency response towards a more sustainable long-term approach, the following is recommended:Due to budget limitations, the provincial government should consider designing comprehensive legal frameworks along with risk-sharing strategies to incentivize PPPs in EV infrastructure, air monitoring and urban reforestation. Climate Finance from domestic and foreign donors could also be captured by issuing dedicated green bonds as well as by establishing impact investment vehicles.

The Punjab EPA needs stronger enforcement capabilities such as taxing mechanisms for penalties, faster judicial actions against polluters, and institutional autonomy. In tandem, greater openness and responsiveness requires investment in public-facing digital systems for reporting municipal grievances, inspector monitoring programs and automated enforcement systems.Master plans for Lahore and adjacent cities need to integrate air quality management as a key consideration. These include enforcing low emission zones, controlling sprawl through regulated land use zoning, mandatory integration of green roofs alongside vertical gardens on buildings, and construction curtailment during smog season based on real-time air quality metrics.Also, the Lahore Development Authority has become a major player in integrating environmental features into holistic urban planning. Through initiatives like Miyawaki forests, construction dust regulations, and green zoning in new developments, LDA's contributions reflect a growing alignment between infrastructure policy and air quality goals. To further sustain these long-term design changes, more collaboration with the EPA and transport authorities will be critical.

Pakistan should initiate bilateral talks with India regarding cross-border air pollution control which may be done within SAARC or UNESCAP environmental cooperation frameworks. A shared system for early haze warning issuing alongside joint mitigation strategies for crop burning would enable better region-wide management.Expanding rooftop solar panels at

Lahore's public institutions, within housing societies, and at commercial centers would help avoid the use of diesel generators as well as the fossil-fuel-based electricity. Subsidies should be streamlined to foster wider adoption with net-metering support. Active public participation should be integrated into the school curriculum, community green audits, and incentive systems for pollution-reducing habits. Social media campaigns and traditional media must be leveraged all year round—not only during smog season—to encourage behavioral change.As a whole, these recommendations seek to strengthen Punjab's early achievements, address critical gaps in implementation, while providing a solid multi-sector framework for sustained air quality management. Smog is not merely seasonal; it is crafted by policy and infused with behavior and systemic actions. Securing Lahore's future as a livable and breathable city requires sustained, inclusive governance efforts backed by science.

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