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Mitigating Air Pollution in Punjab's Transport Sector: Constraints and Opportunities

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Abstract

Pakistan ranks among the world's most polluted countries, with transport emissions being a major contributor to deteriorating air quality. In Punjab, rising smog poses serious environmental and public health risks, with Lahore's transport sector contributing nearly 83 percent of total emissions, followed by Multan. The government of Pakistan introduced the Clean Air Policy (2023) to tackle this, outlining cross-sectoral interventions for various stakeholders. This study explores barriers and opportunities for mitigating transport-related air pollution through 25 unstructured interviews. Findings reveal key barriers, which include weak interdepartmental coordination in phasing out old vehicles, high import and electricity tariffs that limit electric vehicle (EV) adoption, inadequate EV charging infrastructure, and poor fuel quality. Opportunities include subsidized EVs, improved public transport with feeder networks, and enhanced local capacity to provide Euro V fuel. Policymakers must understand these factors to design targeted interventions, improve air quality, and protect public health.

Introduction

Pakistan grapples with severe seasonal air pollution, which poses significant public health risks. With particulate matter (PM)_{2.5} concentrations consistently exceeding the World Health Organization's air quality guidelines during several winter months, many Pakistani cities rank among the most polluted in the world (Table 1). Air quality was listed as 'hazardous' (the highest level) almost every day

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in Lahore in November–December 2024, with pollutant levels exceeding an air quality index (AQI) level of 1,000 (Khan, 2024). Lahore’s air quality was the worst or second-worst in the world for several consecutive days in late 2024. As a result, the government took measures to reduce emissions through school closures and economic activity restrictions (Figure 1).

Figure 1: AQI and government public health measures



Source: Presentation by Samia Saleem, Punjab Green Development Program.

Punjab produces over 60 percent of Pakistan’s gross domestic product (Chaudhry et al., 2024; Hasan et al., 2021). However, its transport sector is the leading contributor to its air pollution problem. The Urban Unit (Government of Punjab) reports that transport’s total share of emissions is over 80 percent in Lahore. This issue is not unique to Pakistan. Overall, transportation accounts for a significant portion of international trade-related emissions, with estimates going up to 33 percent (Cristea et al., 2013). Additionally, transportation in international trade has been rising due to longer global value chains and more distant sourcing. Road freight constitutes 50 percent of trade-related emissions. As the European Union encourages its importers to reduce carbon footprints through the Carbon Border Adjustment Mechanism and corporate social sustainability policies, it will be necessary for Pakistan to ‘clean up’ both its trade-related production and transport sectors.

According to IQAir, two of the most polluted cities in the world in 2024 were in Punjab—Lahore and Multan (Table 1). Pakistan was the third most polluted country overall, and Lahore was the fifth most polluted city in 2024.

Globally, air pollution contributes to climate change induced by greenhouse gases (GHGs). Locally, it significantly reduces life expectancy, individual welfare, quality of life, and worker productivity. According to the World Health Organization (n.d.), air pollution in Pakistan causes approximately 22,000 premature adult deaths and is responsible for 163,432 disability-adjusted life years lost annually. Local public hospitals report an increase in admissions of both

children and adults with respiratory problems, with patients complaining of throat irritation, burning eyes, and headaches (Sarfraz, 2020).

Table 1: The world's most polluted cities

Rank	Location	Country
1	Byrnihat	India
2	Delhi	India
3	Karaganda	Kazakhstan
4	Mullanpur	India
5	Lahore	Pakistan
6	Faridabad	India
7	N'Djamena	Chad
8	Loni	India
9	New Delhi	India
10	Multan	Pakistan

Source: IQAir's 2024 rankings.

According to Razzaq et al. (2024), when pollutants such as volatile organic compounds, nitrogen oxides, and carbon monoxide 'interact with sunlight, they undergo complex photochemical reactions, forming ground-level ozone and other secondary pollutants that contribute to the dense, yellowish-brown haze characteristic of smog.' Furthermore, the danger of smog, particularly the London Smog, goes beyond PM; it can even negatively impact agricultural production.

Considering the combined impact of six major air pollutants, the transport sector is the largest contributor to emissions in Punjab, Pakistan's largest province in terms of both economic size and population. In contrast, when considering only PM_{2.5}, the World Bank suggests that households are the largest source (Table 2). According to the Asian Transport Observatory (2024), transport sector CO₂ emissions accounted for 22 percent of Pakistan's total emissions in 2023, and 98 percent of transport emissions in 2022 were attributed to road transport. Furthermore, nearly 80 percent of vehicles in Punjab are motorcycles. The Food and Agriculture Organization (2020) estimates that over 40 percent of Punjab's emissions are related to transport.

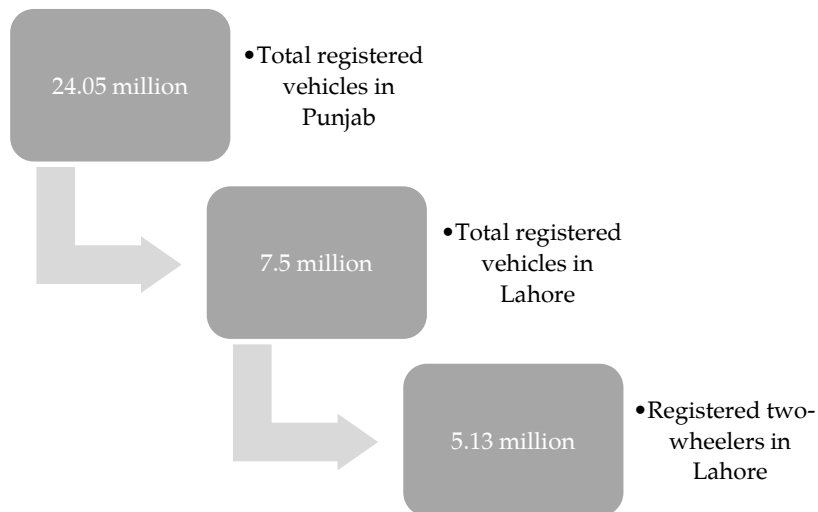
Table 2: Sector-wise emissions

Sector	Emissions (%)
Transport	83.15
Industries	9.07
Agriculture (crop residue burning)	3.90
Waste burning	3.60
Domestic	0.11
Commercial	0.14

Source: Urban Unit (2023).

A surge in the number of road vehicles is primarily why the transport sector has become the leading source of outdoor air pollution. The number of vehicles registered in Lahore increased by 17 million between 2012 and 2023 (Environmental Protection Agency, Punjab, 2024). According to the Excise, Taxation, and Narcotics Control (ET&NC) Department, there were more than 24 million vehicles registered in Punjab in 2024, of which 7.5 million were in Lahore. In Lahore, over five million of these vehicles are two-wheelers, mainly motorcycles (Figure 2).

Figure 2: Vehicles in Punjab and Lahore in 2024



Source: ET&NC Department.

Lahore’s air quality data was initially sourced from non-government entities like the US consulate, the Center for Economic Research in Pakistan, and private households. However, there were concerns about the accuracy of readings, so the

government of Punjab created a system to gather and share reliable daily air quality information online through its Environment Protection and Climate Change Department. These readings registered significantly lower AQI levels than those from private monitors but still showed hazardous conditions.

Recognizing the health impacts of air pollution and the urgency to address the issue, the government of Punjab developed a legal framework to decrease air pollution, called the Punjab Smog and Clean Air Policy (2023). This policy emphasizes transitioning to electric vehicles (EVs), improving public transportation, and phasing out three-wheelers and older vehicles over the next 30 years. Commercial vehicles are required to obtain a fitness certificate from the vehicle inspection and certification system (VICS) through a public-private partnership to qualify for legally mandated route permits. Additionally, road congestion should be decreased using intelligent traffic management systems, and all retail points must supply Euro V fuel.

The goal of this study is to identify the challenges stakeholders face in reducing air pollution in Punjab and explore opportunities for doing so, especially in the transport sector. To achieve this, 25 in-depth unstructured interviews were conducted across relevant provincial government departments. These consultations revealed that the transition mandated by the Clean Air Policy is, unfortunately, rife with challenges. Political and bureaucratic constraints arise from changes in government, shifts in priorities, and delays in policy approvals due to different power dynamics. Institutional obstacles, such as poor coordination among stakeholders and a lack of funding, are major barriers to obtaining vehicle emissions monitoring equipment or developing traffic management infrastructure. There are also regulatory issues, as mechanisms to remove unfit vehicles from roads or to regulate the sale of substandard fuel are entirely absent.

Literature Review

Transport-related air pollution is a major issue in South Asia's large population centers, contributing to serious public health concerns in the region (Bandara & Thilakarathne, 2025) and specifically in Pakistan (Aziz & Bajwa, 2007; Ilyas et al., 2010; Malik et al., 2012). According to the Global Alliance on Health and Pollution (2019), nearly 125,000 excess deaths occur annually in Pakistan. This problem exists across the developing world, including low- and middle-income countries, where it leads to an estimated 6.5 million excess deaths each year. However, little

progress has been achieved (Fuller et al., 2022). Economic policy uncertainty fuels pollution, but political stability can help mitigate it (Farooq et al., 2023).

The risks associated with air pollution add to the climate-related risks to which Pakistan is already vulnerable, which include floods, droughts, and high temperatures. Each of these climate risks brings its own health challenges. Floods increase the likelihood of diarrhea and gastroenteritis, skin and eye infections, respiratory illnesses, and malaria. Droughts increase the risk of malnutrition, including anemia, night blindness, and scurvy. High temperatures elevate the risk of heat stroke, cardiovascular disease, and respiratory diseases like chronic pulmonary disease and lung cancer, along with dengue and malaria infections (Khan, 2024). Alarmingly, the poorest regions, i.e., Balochistan, rural Sindh, and southern Punjab, are the most vulnerable (Malik et al., 2012). Few households have access to high-quality data on their individual exposure to pollution, and further research is needed to understand the impacts of exposure to PM₁ (as opposed to standard PM_{2.5} measurements), in addition to the heterogeneous impacts of different pollution sources on individuals (Vilcassim & Thurston, 2023).

A significant portion of Punjab's air pollution originates from the transportation sector. This merits a shift to EVs, which presents further challenges. EV adoption depends on various interconnected factors, among these, the availability of charging stations. Barriers to adoption can be categorized as technical, policy, economic, infrastructural, and social (Adhikari et al., 2020). In Nepal, infrastructural barriers (e.g., a lack of charging stations), economic barriers (e.g., the relatively high cost of EVs), and poor government planning (e.g., building charging stations and providing fiscal incentives to subsidize EV purchases) were considered paramount (Adhikari et al., 2020).

Similar barriers are found in Pakistan and elsewhere (Qadir et al., 2024). An analysis of electronic word-of-mouth demonstrates that potential EV customers have specific concerns. These include costs, how EVs differ from standard combustion engine vehicles, the reliability of EV technology, battery safety and environmental friendliness, the availability of infrastructure and repair facilities, and the performance and image of EVs. Furthermore, the extent to which EVs reduce emissions depends on how the electricity powering them has been generated. If coal or oil needs to be burned to produce the electricity used to charge EV batteries, the carbon footprint will not be significantly reduced.

Legal Framework

Over the past two decades, legal cases brought to court have driven policy changes and led to the creation of formal government institutions to implement those policies. The first of these was the Lahore Clean Air Commission, which was established following a 2003 court case against the government of Punjab regarding the use of four-stroke rickshaws and compressed natural gas. A decade later, legal action prompted the formation of the Climate Change Commission in 2015, followed by the Smog Commission in 2016, Punjab's first smog policy in 2017, and the Judicial Water and Environmental Commission in 2018.

The government of Punjab introduced its first smog policy in 2017, but the initial health advisory system for air pollution was not implemented until 2022. This was followed by the Clean Air Policy in 2023 and the chief minister's Smog Mitigation Plan in 2024.

The government of Punjab published comprehensive reports on the state of the environment in 2022, 2023, and 2025. Its initiatives extend beyond short-term air pollution control, also addressing water and plastics pollution. Other long-term goals include energy efficiency, green financing, and solar power, all under the Punjab Green Development Program, which the World Bank financially supports.

Among the program's achievements are the installation of 30 air quality monitoring stations and 15 water quality monitoring stations, the deployment of energy-efficient equipment and solar panels in public buildings, the initiation of emission certificates, the introduction of electric public buses, and the creation of a USD 50 million environment and climate change endowment fund. The fund will be registered as a Section 42 company and used to support research and projects aimed at reducing GHG emissions, including pilots of resource-efficient and cleaner production technologies and other demonstration activities.

The Clean Air Policy's 2030 targets are quite ambitious in some areas but could be more aggressive in others (Table 3). For example, the transport sector accounts for over 80 percent of emissions, so achieving a 25-percent GHG reduction will be difficult if only 10 percent of private vehicles have passed emissions tests and received VICS certificates. Additionally, there is no target for phasing out conventional rickshaws and motorcycles, which constitute the majority of road vehicles and often use low-quality fuel. Thus, achieving a 25–30-percent reduction in PM and major air pollutants is especially ambitious.

Table 3: Punjab’s Clean Air Policy targets

Target	Timeline
A 30-percent reduction in the PM _{2.5} and PM ₁₀ concentrations of 2021 (annual average) in the most polluted cities (Lahore, Faisalabad, Gujranwala, Multan)	By 2030
A 25-percent reduction in the major air pollutant (NO _x , SO _x , ozone, CO, and CO ₂) concentrations of 2021 (annual average)	By 2030
A 25-percent reduction of provincial GHG emissions	By 2030
100 percent installation and operationalization of 30 air quality monitoring stations and dashboards	By 2024
Ensuring at least 10 percent of Punjab’s registered private vehicles have valid emission certificates under VICS	By 2030
A 10-percent increase in urban forest cover around major polluting cities (three cities)	By 2030
100 percent conversion of conventional brick kilns to zig-zag or other suitable technology	By 2030
Providing grant support to small and medium enterprises in at least five industrial sectors to pilot resource-efficient and cleaner production technologies	Continue
Ensuring spaces in cities/towns left for parks are developed as green areas	Continue

Source: Presentation by Samia Saleem, Punjab Green Development Program.

Various measures can be taken in the field to improve air quality and reduce harm from high levels of air pollution. However, some can only be used temporarily, as they have their own side effects. For schools, these measures include adjusting schedules, implementing carpool systems, temporarily closing schools, and moving to online classes. Many of these actions decrease instructional time and quality, which can harm children’s educational progress, as was seen during COVID-19 lockdowns. Other measures limit economic activity, such as restricting market hours, banning industrial activity and heavy vehicles, following standard operating procedures for open cooking, and prohibiting open barbecues.

Implementing the Punjab Smog and Clean Air Policy (2023) involves several government departments, given the multi-sectoral sources of the smog problem. Key parties include the following:

- Transport Department
- Environment Protection and Climate Change Department (formerly the Environment Protection Department)
- Oil and Gas Regulatory Authority (OGRA)
- Traffic Engineering and Transport Planning

- ET&NC Department
- Planning and Development Board

Research Objectives and Methodology

We discuss some of the transport sector-related policies enacted by Punjab's Clean Air Policy, identifying stakeholder constraints.

We conducted 25 unstructured telephone interviews with relevant provincial government departments responsible for implementing the Clean Air Policy. A snowball sampling mechanism was employed after initial stakeholders were identified on LinkedIn. These interviews focused on departmental challenges and opportunities related to implementing the Clean Air Policy. They lasted up to 90 minutes, and respondents from the following departments were interviewed (in descending order of the number of interviewees):

- Environment Protection and Climate Change Department
- OGRA
- Transport Department
- Traffic Engineering and Transport Planning
- ET&NC Department
- Industries
- Planning and Development Board
- VICS
- Punjab Information Technology Board
- State Bank of Pakistan
- A handful of other energy-related departments

Before discussing specific aspects of the Clean Air Policy's transportation initiative, it should be noted that, overall, respondents emphasized the need for an integrated system to effectively reduce air pollution. Conducting thorough research and development is crucial for collecting accurate data at the government level. Providing affordable options, such as improved public transportation, is the most effective approach to addressing this issue. This strategy encourages commuters to opt for public transit when faced with congestion charges and high parking fees. Most importantly, changing travel behavior requires a deliberate, long-term, sustainable plan to lower air pollution, which can only be achieved through awareness campaigns and multiple incentives.

In this study, we consider policies that attempted to reduce road transport-fueled air pollution, focusing on three types of vehicles: commercial vehicles, private vehicles, and two- and three-wheeled vehicles. These policies include VICS, upgrading fuel quality to Euro V standards, phasing out old vehicles, transitioning to EVs, and initiatives to decrease road congestion.

Vehicle Inspections: Attempting to Reduce Pollution from Commercial Transport

The government of Punjab established VICS to test and certify vehicles, reinspecting those failing to meet emission standards. As of 2025, there are 39 VICS centers in Punjab, of which only 3 are operational in Lahore. Public sector vehicles were the first to be inspected, but nearly a third failed emission testing (Environmental Protection Agency, Punjab, 2024).

The Clean Air Policy introduced a new system for commercial vehicle permitting, which encountered significant implementation difficulties. Prior to the new policy, commercial vehicles were required to run on approved, permitted routes from the Transport Department, which, in turn, required the payment of a token tax to the ET&NC Department.

With the new policy, commercial vehicles are required to pass emission testing and obtain VICS certificates prior to paying the token tax. Unfortunately, relatively few commercial vehicles met emission standards and went on to pay the token tax, leading to a revenue shortfall. As a result, the ET&NC Department began collecting the token tax from owners even if their commercial vehicles had not received VICS certificates.

In the end, few vehicles are being inspected, and the policy's impact on emissions is limited. Plans to test private vehicles have not yet been operationalized, and with only three VICS stations in Lahore, they remain a distant goal. Further, Qin-Qi three-wheelers cannot even be inspected as they are unregistered.

Upgrading Fuel Quality to Euro V Standards: Reducing Private Vehicle Emissions

A government initiative aimed at reducing emissions from all vehicles, including private ones, involved raising fuel quality to Euro V standards. The government eliminated tariffs on refining machinery for the upgraded fuel standards. However, domestic refineries complain that they still face competition from imported fuel,

including smuggled fuel from across the Baloch border. Currently, around 35 percent of petroleum products are refined locally. The remainder is imported.

The regulatory system for monitoring and enforcing fuel quality is weak. As the relevant regulatory organization, OGRA has limited authority to test fuel sold to consumers and no authority to enforce standards. At most, it can report low-quality fuel to the district government.

Retail points are meant to test their own fuel and report on quality to OGRA, but the moral hazard inherent in this mechanism makes it ineffective.

OGRA outsources some testing to the Hydrocarbon Development Institute of Pakistan, but it is unclear how testing sites are selected and how many are tested.

Customers can report adulterated fuel via an app called 'Reh Guzar,' although this is an ineffective mechanism as vehicle owners are unlikely to be able to identify low-quality fuel.

Given the high cost of improved fuel, many vehicles, especially motorcycles and rickshaws, use adulterated fuel. Extremely poor-quality fuel, sometimes derived from used motor oil, is sold in small informal shops commonly known as *dabba* stations. OGRA has no power to close these shops, and district governments are already stretched thin.

E-Bike Integration and Phasing Out Old Vehicles and Three-Wheelers

The government lacks the political will to phase out the most polluting vehicles, including commercial vehicles and three-wheelers (rickshaws). Motorcycles constitute the majority of road vehicles, contributing significantly to pollution.

One issue is the lack of data on these vehicles, many of which are not registered. For example, two-wheelers are illegally converted into three-wheeled vehicles, known locally as Qing-Qis, which are often unregistered. Efforts to ban such vehicles have faced strikes and strong opposition from the Rickshaw Awami Association. Without registration, it is impossible to enforce emission standards or issue traffic fines. The owners of commercial vehicles (trucking) also hold significant political influence, making it difficult to phase them out or require emission testing. The subsidies needed to buy back vehicles, a part of the Clean Air Policy that has not yet been implemented, would be expensive and likely strain the government's administrative capacity.

E-bikes are expensive, and there are valid concerns about battery theft; the development of an anti-theft device for batteries could allay fears.

A related administrative barrier, which appears to be relatively simple to resolve, is that the ET&NC Department has not allowed the registration of electric motorcycles and conventional cycles converted to e-bikes. It has also failed to complete the digitization of existing vehicle registrations.

EV adoption will be hindered if the charging infrastructure is not developed. Furthermore, electricity tariffs keep rising as the government struggles to pay its bills to independent power producers whose plants are outdated and costly to operate.

Initiatives to Reduce Congestion

Along with the three policies already discussed, other initiatives aim to reduce traffic by expanding public transportation and improving traffic flow. Lahore's Orange Line rapid transit train was launched in 2020. Additionally, the city introduced 27 electric buses in February 2025, another positive step. However, their high capital cost, along with expensive electricity, makes it financially challenging to expand this transition further. Moreover, travelers are generally unable to use public transport for 'last-mile connectivity' and often depend on other options like rickshaws. Better integration is needed instead of fragmented policies, including feeder buses and public parking near mass transit.

Machine learning models and specialized software can be used on emissions and traffic data, if available, to improve air quality and decrease energy consumption (Mądział, 2023). The intelligent traffic management system is an artificial intelligence-driven tool that aims to optimize traffic flow, reduce congestion, and enhance overall road safety by adjusting signal timings based on real-time traffic conditions rather than a fixed schedule. However, its implementation faces technological and bureaucratic challenges, such as VIP protocols, which affect signal timing and cause traffic stoppages.

Concluding Thoughts

This study identified multiple barriers to progress, including:

- Political factors—weak political will, lobbying, and shifting priorities
- Institutional challenges—poor coordination

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- Administrative issues—weak digital data for phasing out old vehicles
- Regulatory gaps—the absence of EV laws, poor enforcement, and low-quality fuel
- Infrastructural constraints—limited EV charging infrastructure and road networks
- Behavioral factors—low public awareness and reluctance to adopt public transport or EVs

Subsidies can accelerate the transition from high-emission vehicles to EVs, reducing urban air pollution and GHG emissions. Enhancing public transport, particularly by developing efficient feeder networks, can make mass transit more accessible and convenient, encouraging people to shift from private vehicles to cleaner modes of transport. Additionally, strengthening local capacity to supply Euro V fuel ensures that cleaner fuels are widely available, further reducing vehicle emissions. Understanding and addressing these factors will allow for better-designed and targeted interventions that promote sustainable urban mobility.

Improving coordination between departments to effectively implement current policies is a given, but there are additional steps the government can take to enhance air quality and decrease transportation-related pollution.

First, the government should lead the development of a network of EV charging stations. Banks can be encouraged to provide loans for EV purchases, possibly with subsidized interest rates. They currently hesitate to issue such loans due to the high capital costs and longer payback periods associated with EVs.

Second, publicly supported non-government organizations like Akhuwat could offer loans for electric bike and rickshaw purchases. Lowering import tariff rates on EVs from China could also help reduce these costs.

Finally, the government should support research and development in Punjab and Sindh's auto parts manufacturing sector to begin producing EV spare parts.

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