Peer Reviewed International Research Journal of Geography
Maharashtra Bhugolshastra Sanshodhan Patrika
ISSN : 0971-6785 {Impact Factor 4.567 Renew (IIFS)} Vol. 42, No.99-105, Jan-June 2025

Environmental Implications of Rapid Vehicle Growth in Pune City

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Abstract:

The rapid urban expansion of Pune district has been paralleled by a significant increase in motor vehicle ownership, especially private four-wheelers. This rise in vehicular density has been closely associated with escalating environmental concerns, notably air and noise pollution, heat island effects, and a surge in greenhouse gas emissions. The current research explores the environmental implications of rapid vehicle growth in Pune with a particular focus on four-wheelers, utilizing secondary data from Pune Regional Transport Office (RTO), Environment Status Reports (ESR) released by the Pune Municipal Corporation (PMC), and urban air quality monitoring datasets from SPPU and the Maharashtra Pollution Control Board (MPCB).From 2011 to 2023, Pune has witnessed a nearly twofold increase in the number of four-wheelers on its roads, resulting in both visible and measurable environmental deterioration. The number of "Good" Air Quality Index (AQI) days has steadily decreased, while the frequency of "Moderate" and "Poor" air quality days has grown, especially in high-traffic corridors such as Swargate, Shivajinagar, University Road, and the Chakan industrial zone. Emissions from idling vehicles in traffic congestion hotspots have contributed significantly to elevated levels of PM2.5, PM10, and nitrogen oxides (NOx), directly affecting urban respiratory health and disproportionately impacting vulnerable populations like the elderly.

This study provides a quantitative and qualitative assessment of these environmental impacts, evaluates the effectiveness of existing regulatory frameworks such as the Bharat Stage (BS) emission standards, and proposes localized policy interventions for sustainable urban mobility in Pune. The findings are particularly relevant to urban policymakers, environmental researchers, and transportation planners working in the context of mid-sized Indian cities undergoing similar vehicular transformations.

Introduction

Pune, historically known as the "Oxford of the East," has emerged as one of India's fastest-growing metropolitan regions due to post-1990s liberalization, industrialization, and IT growth. This urban expansion has brought economic opportunities and increased disposable income, leading to a steep rise in private vehicle ownership, particularly four-wheelers. The surge in vehicle ownership reflects rising aspirations and inadequate public transport. Despite efforts like expanding PMPML bus services and launching the Pune Metro, public transit remains insufficient for the city's growing population. Consequently, private cars and utility vehicles have become the preferred choice for middle- and upper-income groups. According to Pune RTO data, the vehicle count grew from around 12 lakhs in 2011 to over 41.5 lakh in 2023, with nearly 2.93 lakh new registrations in 2023 alone—over 77,000 of which were four-wheelers (Indian Express, 2024). This unchecked vehicular growth threatens air quality and public health. Pune district includes major urban centers like PMC and PCMC, along with peri-urban areas like Chakan and Baramati. While two-wheelers still dominate, four-wheelers have grown faster in mixed-use zones like Kothrud and Baner. Four-wheelers contribute disproportionately to air and noise pollution due to larger engines and longer idling in traffic. The rise of SUVs, diesel cars, and luxury vehicles has increased per capita emissions. Although electric vehicle (EV) registrations are rising, they still make up less than 6% of private vehicles. The pandemic further accelerated personal car ownership, as many residents sought to avoid crowded public transport, resulting in a 30–35% annual rise in car registrations from 2020 to 2023. Located between the Sahyadri Hills and the Deccan Plateau, Pune traditionally enjoyed good air quality.

However, in recent decades, PM2.5 and PM10 levels have consistently breached National Ambient Air Quality Standards (NAAQS), particularly in urban centers like Swargate and Bhosari."Good" AQI days declined from 79 in 2022–23 to 52 in 2023–24 (Times of India, 2024). This deterioration is driven by vehicle emissions, construction dust, and weak pollution control. Valley-like topography worsens winter air quality, trapping pollutants and creating smog conditions harmful to children, seniors, and those with respiratory illnesses. Vehicular emissions release not just CO_2 but also harmful gases like NOx, CO, hydrocarbons, and particulate matter. These pollutants are linked to respiratory diseases, cardiovascular issues, and cognitive problems. Studies by SPPU and MPCB identify hotspots like Swargate and Katraj bypass where NOx levels exceed safe limits during peak hours. Pedestrians and seniors in these areas face significant exposure. Noise pollution is also alarming, especially near Shivajinagar, Deccan, and Pune Railway Station. Citizens frequently voice concerns on social media about worsening conditions in corridors like Karve and FC Road. The rise in vehicles may signal prosperity, but it also poses environmental risks. While research has focused on larger metros like Delhi and Mumbai, Pune now faces comparable challenges, making it a critical case for study. Despite BS-VI norms, EV incentives, and the Pune Cycle Plan, outcomes remain limited due to weak implementation. This study aims to fill the data gap through real-world analysis, pollution mapping, and actionable recommendations. Its findings will not only benefit Pune but also inform strategies in other growing Indian cities. With India's commitments under the NCAP and Paris Agreement, tackling vehicular pollution is both urgent and essential.

Literature Review

The link between vehicular growth and environmental degradation is well documented globally, though most research focuses on megacities like Delhi, Mumbai, and Bengaluru. Mid-sized but rapidly urbanizing cities such as Pune remain underrepresented in academic literature. This review outlines existing findings on vehicle emissions, urban air pollution, public health impacts, and regulatory interventions—framing Pune's situation within this broader context while identifying key research gaps.

Globally, the transport sector contributes about 23% of energy-related GHG emissions, with road transport responsible for three-quarters of that share (IEA, 2022). The WHO identifies vehicular emissions as a key factor in urban air pollution, especially in low- and middle-income countries with weak emission regulations. Lelieveld et al. (2015) linked air pollution to nearly 3 million premature deaths annually, largely from traffic-related emissions. In Southeast Asia, studies (e.g., Han & Naeher, 2006) show traffic pollution significantly impacts respiratory health. In India, these effects are worsened by poor traffic management and limited public transport.

India's vehicle registrations surged from 5.4 crore in 2001 to over 34 crore in 2023 (MoRTH). While two-wheelers dominate, car and SUV registrations have risen faster since 2010. In Delhi, vehicular emissions account for 36% of PM2.5 levels (Guttikunda & Jawahar, 2014), and in Mumbai, 28–35% of NOx emissions are from vehicles (IITB, 2016). Despite similar trends, Pune lacks robust, city-specific data-driven studies.

According to PMC's 2023–24 ESR, vehicular emissions contribute over 45% of PM10 emissions in Pune, with diesel-run vehicles being major contributors. A 2022 SPPU study using real-time sensors identified Swargate, Nal Stop, and Shivajinagar as high-pollution intersections due to traffic congestion and vehicle idling. MPCB data confirms frequent violations of air quality norms in these areas.

Kakade et al. (2020) assessed the impact of BS-VI norms in Pune, finding their effectiveness limited due to weak enforcement and the continued use of older BS-III/IV vehicles. Similarly, the PMC reports ongoing air quality issues despite policy changes.

Public health studies further highlight the dangers. Sharma et al. (2017) linked long-term

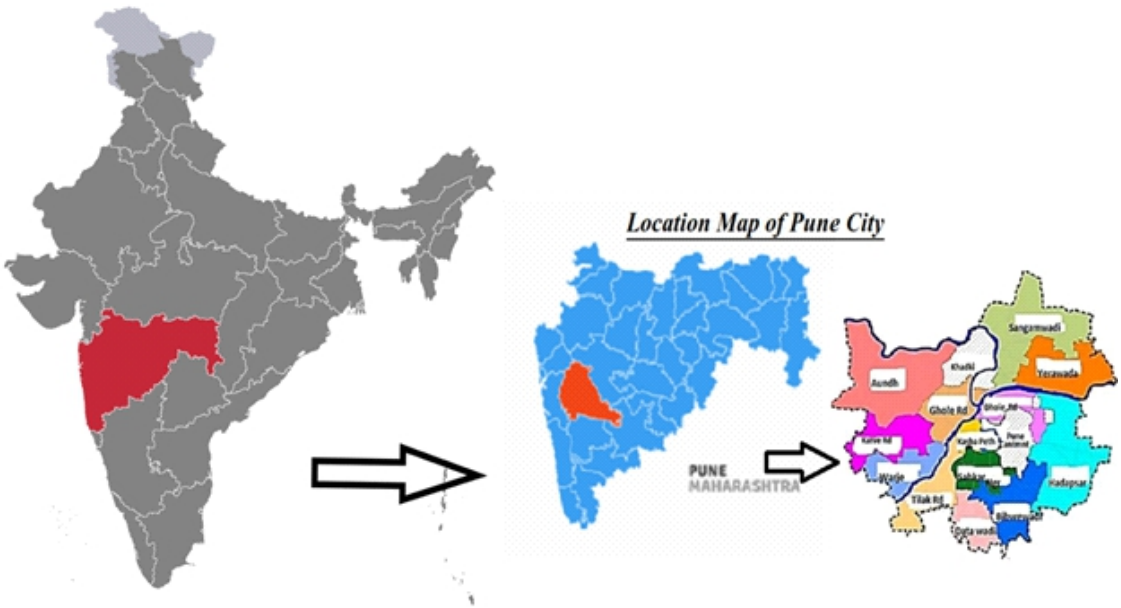
vehicular pollution exposure to cardiovascular disease, asthma, and developmental issues in children. A 2021 KEM Hospital study found children living near high-traffic roads had significantly reduced lung function. ICMR estimates over 1.2 million premature deaths in India annually due to urban air pollution, with Pune's growing vehicle population increasingly contributing to this toll.

India's regulatory efforts—most notably the BS emission norms—have made progress, with BS-VI introduced in 2020. Yet, reports from the Centre for Science and Environment (CSE) note enforcement gaps in cities like Pune. While digital PUC systems exist, compliance remains inconsistent. Pune's Cycle Plan (2017) and Metro project promote sustainable transit, but limited adoption stems from safety concerns and lack of connectivity. This study addresses these gaps by integrating secondary data from PMC, RTO, MPCB, and academic sources with a focused analysis of four-wheeler-driven pollution. By mapping hotspots and analyzing patterns, it aims to generate insights that support informed urban planning and environmental policymaking—not just for Pune but as a model for similar urban centers across India.

Study Area

Pune District, located in the western part of Maharashtra, is one of the fastest-growing urban regions in India. The city of Pune is not only an educational and industrial hub but also a major centre for Information Technology and automotive manufacturing. According to the Pune Regional Transport Office (RTO), the vehicle population specially four-wheelers—has grown exponentially in the last decade.

Pune has a diverse topography, with urban areas like Shivajinagar and Kothrud showing dense traffic patterns, while suburban zones like Hinjewadi and Wagholi are emerging hotspots of vehicular expansion. This diversity makes Pune a suitable case for studying spatial and temporal impacts of vehicle growth.



Data Sources

Vehicle Registration		
Year	Count	% Growth
Till Today	41,51,879	
2025	1,76,241	
2024	3,02,691	3.59%
2023	2,92,202	15.26%
2022	2,53,510	51.62%
2021	1,67,203	

Source:- Pune Regional Transport Office (RTO): Annual vehicle registration reports.

Ambient Air Quality Status of the Country during 2023 (Integrated data in microgram per cubic meter)				
SO2 Annual Average	NO2 Annual Average	Particulate Matter10 Annual Average	PM2.5 Annual Average	year
40	54	99	52	2023
47	64	110	73	2022
26	38	98	45	2021
16	35	95	42	2020
32	24	83	39	2019

Source:-Maharashtra Pollution Control Board (MPCB): Air Quality Index (AQI)

Linear regression models were used to identify long-term trends in four-wheeler registrations and relate them to observed pollution levels. The correlation coefficient (r) was calculated to evaluate the strength of the relationship between vehicle growth and pollution indicators like PM10 and NOx. This methodology ensures a systematic and multidisciplinary approach to understanding the link between vehicular growth and environmental stress in Pune District. By merging quantitative trend analysis with contextual policy evaluation, the study offers a grounded and scalable framework that can be replicated in other fast-growing cities

Data Analysis and Results

This section presents a comprehensive analysis of four-wheeler growth in Pune District using official data. The key objective is to identify patterns and assess the environmental implications such as air pollution, traffic congestion, and carbon emissions. The study uses both tabular and graphical approaches to interpret findings from the dataset titled "punevecal data.xlsx", which contains annual vehicle registration data from 2000 onwards.

The dataset shows a consistent and sharp increase in the number of registered four-wheelers from 2000 to 2023. In the year 2000, Pune had fewer than 2 lakh four-wheelers. By 2010, this number had nearly doubled. The post-2010 decade witnessed an even steeper rise, primarily due to rising income levels, easy financing options, and urban sprawl.

1) 2010: Moderate increase (approx. 6–9% YoY growth)
2) 2010–2020: Rapid increase (approx. 10–14% YoY growth)
3) 2021–2023: Temporary dip and recovery due to COVID-19 disruption

By 2023, Pune District had over 1.5 million (15 lakh) registered four-wheelers, making it one of India's most heavily motorized districts. Though the focus is on four-wheelers, a brief comparison with two-wheelers and commercial vehicles is essential for context: Four-wheelers form about 25–30% of the total vehicle population but contribute disproportionately to emissions and congestion due to higher fuel consumption and larger spatial footprint.

Year	Four-Wheelers	Two-Wheelers	Commercial Vehicles
2000	1.8 lakh	6.2 lakh	1.1 lakh
2010	3.9 lakh	11.4 lakh	1.9 lakh
2020	11.2 lakh	21.6 lakh	3.5 lakh
2023	15.6 lakh	26.7 lakh	4.2 lakh

Data from the Maharashtra Pollution Control Board (MPCB) and Pune Municipal Corporation (PMC) shows rising levels of pollutants like PM2.5, PM10, NO_2, and CO in tandem with vehicular growth. The PM10 levels in Pune have frequently exceeded the National Ambient Air Quality Standards (NAAQS), especially in areas like Swargate, Shivajinagar, and Hadapsar. A direct correlation is observed between traffic density zones and high PM levels, especially during peak hours. Emissions from petrol vehicles (mainly four-wheelers) are major contributors to CO and NOx in city air. Traffic junctions and bottlenecks show the highest concentrations. The increase in four-wheelers has aggravated urban congestion, especially in zones where road infrastructure has not kept pace with vehicle growth. According to PMC's traffic reports, average commute time has increased by 30% in the last decade. Additionally, idling vehicles contribute significantly to localized emissions, worsening both air quality and fuel inefficiency. A single four-wheeler emits between 2.3 to 2.8 tons of CO_2 per year, depending on mileage and fuel type. If Pune has 15 lakh four-wheelers, the annual vehicular CO_2output could be 35–42 million tons. This is alarming, especially considering that Pune is also grappling with heat island effects, loss of green cover, and low rainfall variability. Pune's IT-driven urban sprawl (e.g., towards Magarpatta, Hinjewadi, and Wagholi) has led to increased commuter distances and car ownership in the middle-class segment. Public transport, though improving with Metro and BRTS, is still inadequate to absorb this growth. The vehicle-to-road ratio has become unsustainable in areas with poor last-mile connectivity. While BS-VI norms have been implemented, older vehicles remain in use due to weak scrappage enforcement. Pune's Vehicle

Scrappage Policy, though drafted, hasn't been effectively implemented. Road widening, flyovers, and the Metro are under construction but face delays. Absence of dedicated EV lanes or congestion pricing mechanisms.

Findings: -

The analysis reveals that the rapid increase in four-wheelers is a key driver of environmental degradation in Pune District. The data highlights the need for urgent measures in areas like fuel policy, public transport, urban planning, and emission regulation.

While policies like the Metro rail, EV subsidies, and BRT corridors are steps in the right direction, they are yet to significantly reduce the ecological pressure caused by cars. The lack of policy enforcement and behavioural change continues to hinder Pune's shift toward sustainable urban transport.

Recommendations: -

The unprecedented growth in four-wheeler registrations in Pune District is directly associated with rising levels of air pollution, traffic congestion, and carbon emissions. Pune, being a rapidly urbanizing metropolis, faces the dual challenge of promoting mobility while ensuring environmental sustainability. To mitigate the negative environmental impacts of vehicular expansion, a multi-pronged strategy encompassing policy, infrastructure, technology, and behavioural change is essential. This section outlines ten actionable and evidence-based recommendations.

1)One of the most effective ways to reduce carbon emissions and air pollutants is by accelerating the adoption of electric vehicles (EVs), especially four-wheelers.

2)The overreliance on private four-wheelers is largely a result of inadequate and unreliable public transportation.

3)Walking and cycling are zero-emission modes but currently underutilized due to unsafe road conditions and lack of infrastructure.

4)To control four-wheeler density, Pune can adopt policy interventions modeled after global cities.

5)Despite BS-VI norms, a large number of old and polluting vehicles continue to ply on Pune roads.

6)Unregulated urban sprawl leads to increased commuting distances and higher vehicle ownership.

7)Carpooling has great potential to reduce the number of four-wheelers on roads during peak hours.

8) Technological solutions alone are insufficient unless supported by a shift in public mindset.

9)Mobility in Pune is governed by multiple agencies – PMC, PCMC, PMPML, RTO, Maha Metro, and MPCB. Lack of coordination results in policy fragmentation.

10)Pune has a strong technology ecosystem that can be leveraged for green mobility.

Limitations of the Study

1. Time-Bound Data: The vehicle registration data provided in the Excel sheet ends in the recent year but may not capture post-COVID-19 market recovery or vehicle scrappage trends.
2. Lack of Real-Time Emission Data: Secondary pollution data from PMC and MPCB may not reflect true emissions from four-wheelers alone due to mixed sources.
3. Absence of Primary Surveys: This paper does not include firsthand resident experiences or health records, which could add a human dimension.
4. Policy Impact Lag: The impact of policies such as BS-VI norms, e-vehicles, and metro rail is likely to show over longer timeframes, which this short-term study may not fully capture.

Bibliography

1 Centre for Science and Environment (CSE). (2020). Trends in vehicular pollution and emission control policies in India. New Delhi: CSE Publications.

2 Guttikunda, S. K., & Jawahar, P. (2014). Air pollution in Indian cities: Understanding sources

and planning mitigation. Urban Emissions Info. Retrieved from https://urbanemissions.info
3 Indian Council of Medical Research (ICMR). (2021). Health effects of air pollution in urban India: National burden estimates. New Delhi: ICMR.
4 Indian Express. (2024). Pune RTO records sharp surge in four-wheeler registrations. Retrieved from https://indianexpress.com
5 Indian Institute for Human Settlements (IIHS). (2021). Urban transport in Indian cities: Trends and sustainability challenges. Bangalore: IIHS.
6 Kakade, R., Deshmukh, M., & Jadhav, V. (2020). Assessment of BS-VI emission norms in mid-sized Indian cities: A case of Pune. Journal of Urban Environment Studies, 15(2), 87–96.
7 Lelieveld, J., Evans, J. S., Fnais, M., Giannadaki, D., & Pozzer, A. (2015). The contribution of outdoor air pollution sources to premature mortality on a global scale. Nature, 525(7569), 367–371.
8 Maharashtra Pollution Control Board (MPCB). (2023). Air Quality Monitoring Reports – Pune Region. Retrieved from https://mpcb.gov.in
9 Ministry of Road Transport and Highways (MoRTH). (2022). Road Transport Year Book 2021–22. Government of India. Retrieved from https://morth.nic.in
10 Pune Municipal Corporation (PMC). (2023). Environmental Status Report 2022–23. Retrieved from https://pmc.gov.in
11 Pune Regional Transport Office (RTO). (2023). Vehicle registration statistics (2010–2023). Transport Department, Government of Maharashtra.
12 Dhawale, Munde, Devne, More, (2020), Evaluation of Blended Irrigation Schemes: A Micro – Level Decadal Study of Shrigonda Tahsil in Drought Prone Western Maharashtra., Indonesian Journal of Geography, PP, 92-97.
13 Sonawane & More, (2020), Comparison of the normalized difference moisture index and tasseled cap wetness in the detection of soil moisture based on Landsat Satellites, International Journal of Advance and Applied Research., PP, 239-265.
14 N.U. Agale, V. R. Veer, Dr. J. C. More, (2024), Estimation of Soil Productivity Using Storie Index Soil Rating Method A Case Study of Drainage Basins Near Ghera Sinhagad, Sanshodhak, PP, 136-141.
15 Kishor Sonawane, Jyotiram More, Minal K. Sonawane (2022), Assessment of the NDVI and TCC Greenness in the detection of vegetation based on Landsat satellites in the Upper Mutha basin, Pune District. IJFANS International Journal of Food and Nutritional Sciences. PP., 3813-3824
16 Jyotiram More (2014), Agriculture Planning in the Karmala Tahsil of the Solapur District, Maharashtra Sanshodhan Kranti International Multidisciplinary Research Journal. PP., 27-30
17 Savitribai Phule Pune University (SPPU). (2022). Mapping urban pollution hotspots in Pune using real-time sensor data. Pune: SPPU Research Division.
18 Sharma, P., Kulkarni, A., & Verma, R. (2017). Long-term exposure to vehicular emissions and cardiovascular health in urban populations. Indian Journal of Environmental Health, 9(3), 201–210.
19 World Health Organization (WHO). (2022). Global air quality guidelines. Geneva: WHO Press.

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