RESEARCH & INNOVATION DIVISION
IJIST

Analyzing the Contribution of Transportation in Formation of Smog in District Lahore, Pakistan

Maryam Ayub; Shakeel Mahmood*, Mariam Sarwar
Department of Geography, Government College University Lahore, Lahore, Pakistan
***Corresponding Author Email:** shakeelmahmood@gcu.edu.pk

Citation | Ayub. M, Mahmood. S, Sarwar. M, "Analyzing the Contribution of Transportation in Formation of Smog in District Lahore, Pakistan", IJIST, Special Issue pp 628-636, July 2024
Received | June 18, 2024 **Revised |** June 25, 2024 **Accepted |** June 30, 2024 **Published |** July 04, 2024.

Introduction: Globally, smog has become a growing environmental issue, largely due to rising pollution from both anthropogenic and natural sources. In Lahore, a densely populated city in Pakistan, this problem is intensified by rapid urbanization, transportation emissions, and activities related to industry and agriculture.

Novelty: This research highlights these factors as primary contributors to smog and utilizes a quantitative approach to evaluate their impacts, particularly focusing on the role of transportation in smog formation.

Methodology: The study examines data on vehicular emissions, traffic patterns, and meteorological conditions to explore the relationship between transportation activities and smog. Data collection was performed via an online questionnaire survey. This data was then mapped onto traffic congestion areas and major industrial pollution sources, with charts created to depict public perceptions of the issue.

Results and Discussion: The results show that vehicles are a significant source of smog, emitting NOx, VOCs, and particulate matter (PM). Older vehicles, especially those lacking modern pollution control technologies, emit far more pollutants per kilometer than newer models that adhere to stringent emission standards. Traffic congestion during peak hours leads to extended vehicle idling, which increases fuel consumption and emissions. Additionally, stop-and-go traffic conditions further heighten fuel use and pollutant release.

Concluding Remarks: Tackling transportation-related smog is essential and necessitates effective management and policies at the local, regional, and national levels. Public-private partnerships can be instrumental in advancing cleaner technologies and practices within the transportation sector to mitigate smog.

Keywords: Smog; Transportation Emissions; Lahore; Air Pollution; Vehicular Emissions.

Introduction:

Pakistan is the most urbanized country in South Asia [1], with Lahore, its second-largest city, growing at an annual rate of 4%. Air pollution is a major issue in Lahore, which has a population of 11.1 million people [2] and is frequently listed among the most polluted cities worldwide [3]. Recent years have seen worsening smog, driven by deforestation, rapid urbanization, industrial pollution, heavy traffic, construction activities, crop residue burning, and brick kilns [4].

Smog Formation:

Cities across Pakistan, including Lahore, have experienced severe smog recently. Smog forms when pollutants such as nitrogen oxides, carbon monoxide, and volatile organic compounds—emitted by vehicles, industries, and burning fossil fuels—interact with sunlight. These photochemical reactions, which often occur in summer, produce ground-level ozone (O3), a key smog-causing pollutant. Ground-level ozone has detrimental effects on human health, particularly impacting the respiratory and cardiovascular systems and leading to premature deaths [5].

Smog and its Impacts:

Urban areas in Asia often suffer from smog, and Lahore is no exception, growing at 4% annually [6][7]. Smog exacerbates health issues including asthma, allergies, eye infections, respiratory infections, and cardiac conditions, sometimes resulting in premature death [8]. In recent years, smog has become a pressing concern for both environmental and public health in Lahore, overshadowing the city's cultural heritage. A significant factor contributing to worsening air pollution is transportation, particularly vehicle emissions.

Vehicle emissions are a major source of urban air pollution, releasing harmful pollutants like nitrogen oxides (NOx), volatile organic compounds (VOCs), carbon monoxide (CO), sulfur dioxide (SO2), and particulate matter (PM) [11]. These pollutants undergo atmospheric chemical reactions to form secondary pollutants such as ozone (O3) and fine particulate matter (PM2.5), which are crucial in smog formation [12][13][14]. The rapid increase in vehicles in Lahore has notably elevated air pollution levels and contributed to smog [7]. Traffic congestion exacerbates emissions by causing prolonged idling and reducing the effectiveness of emission control systems [15]. Emission hotspots typically occur in areas with high vehicle density and poor traffic flow [16]. Implementing effective traffic management strategies and congestion pricing is essential to reducing air pollution and smog episodes in the city [8].

Health and Economic Impacts:

The impact of smog on Lahore's residents is significant, affecting both health and the economy. Exposure to high levels of air pollution increases the risk of respiratory and cardiovascular diseases, leading to higher healthcare costs and reduced productivity [17]. The city's economy also suffers from the economic costs associated with health issues caused by smog, affecting sectors such as healthcare, tourism, and overall productivity [18].

Study Area:

Lahore, often called the "Heart of Pakistan," is the country's second-largest city and the administrative center of Punjab province [19]. It is ranked as the 42nd most populous urban area globally and the ninth largest metropolis in the Islamic world. Known as the nation's academic and cultural hub, Lahore is situated at a latitude of 31.5204° N and a longitude of 75.3587° E [19]. The city's primary waterway is the River Ravi, and it covers an area of 1,772 square kilometers. Positioned 213 meters above sea level, Lahore also holds historical significance in South Asia.

The District of Lahore comprises several towns, including Iqbal Town, Gulberg Town, Shalamar Town, Ravi Town, Data Gunj Baksh Town, Samanabad Town, Nishtar Town, Cantonment, Aziz Bhatti Town, and Wagha Town [6]. According to the 2017 census, Lahore District had a population of over 11 million, with this number likely having increased since. The

city attracts people from across Pakistan and neighboring regions due to its diverse opportunities. There is a notable disparity between rural and urban populations: approximately 82% of residents live in urban areas, while the remaining 18% reside in rural areas. Lahore is a multicultural metropolis, home to Punjabis, Muhajirs, Kashmiris, Sindhis, and other ethnic groups.

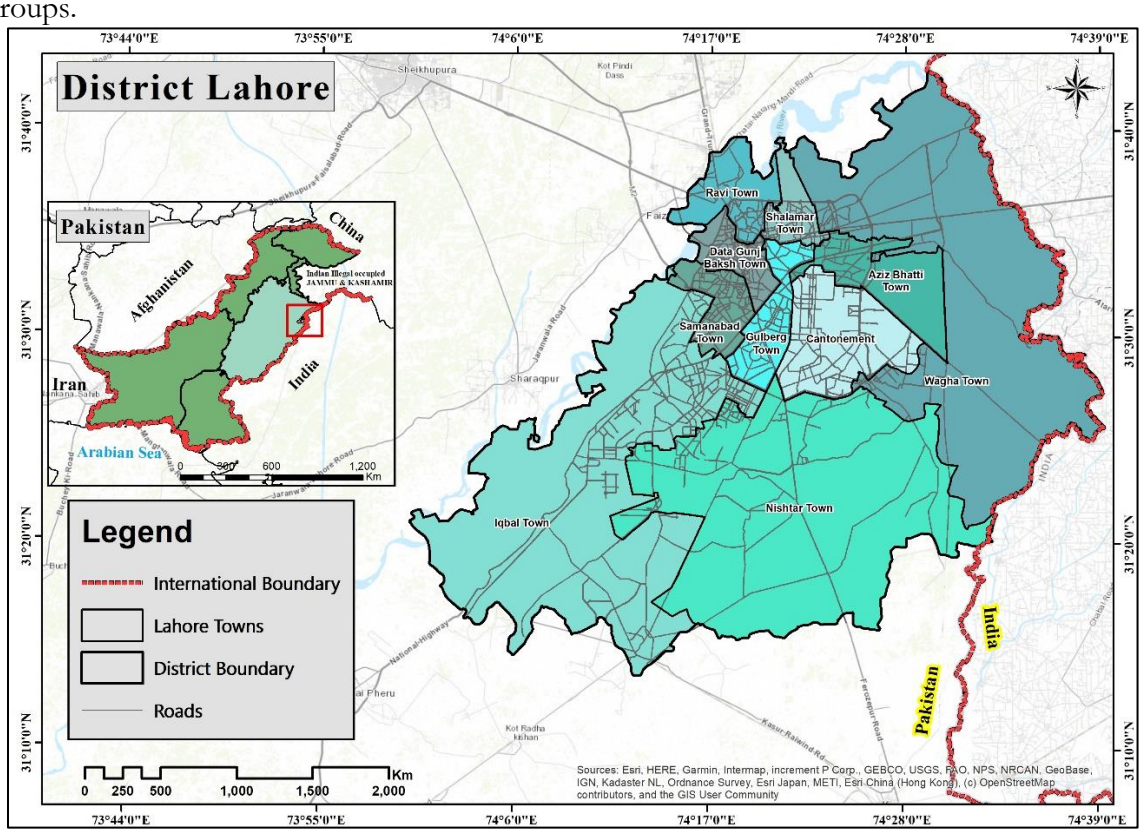

Figure 1: Location of the Study Area

Problem Statement:

Urban areas globally face severe air pollution problems, primarily due to emissions from transportation, which significantly contribute to toxic smog formation. The rise in automobile traffic in cities releases pollutants that adversely affect air quality, human health, and the environment. Understanding the complex relationship between transportation and smog formation is crucial for developing effective strategies and policies to address urban air pollution.

Research Objectives:

To analyze the role of transportation-related emissions in the formation of smog in District Lahore.

Methodology:

A survey-based approach has been used to investigate the impact of transportation on Lahore's smog crisis, focusing on multiple pollutants. The goal is to evaluate public perceptions, behaviors, and attitudes toward transportation choices and their effects on air quality in Lahore using survey data.

Research Design:

The research design includes a one-time survey to collect data on transportation habits, perceptions of smog, and other relevant factors among Lahore residents. This design provides a snapshot of the current situation by capturing data at a specific point in time. The study emphasizes both quantitative and qualitative data analysis to gain a thorough understanding of the issue.

Data Collection: Surveys were distributed online through social media platforms, email lists, and online forums. In addition, surveyors conducted in-person interviews at various locations

throughout Lahore, including residential areas, markets, and public transport hubs. Participants were clearly informed about the study's purpose, consent was obtained after ensuring they were well-informed, and all responses were treated with strict confidentiality and anonymity.

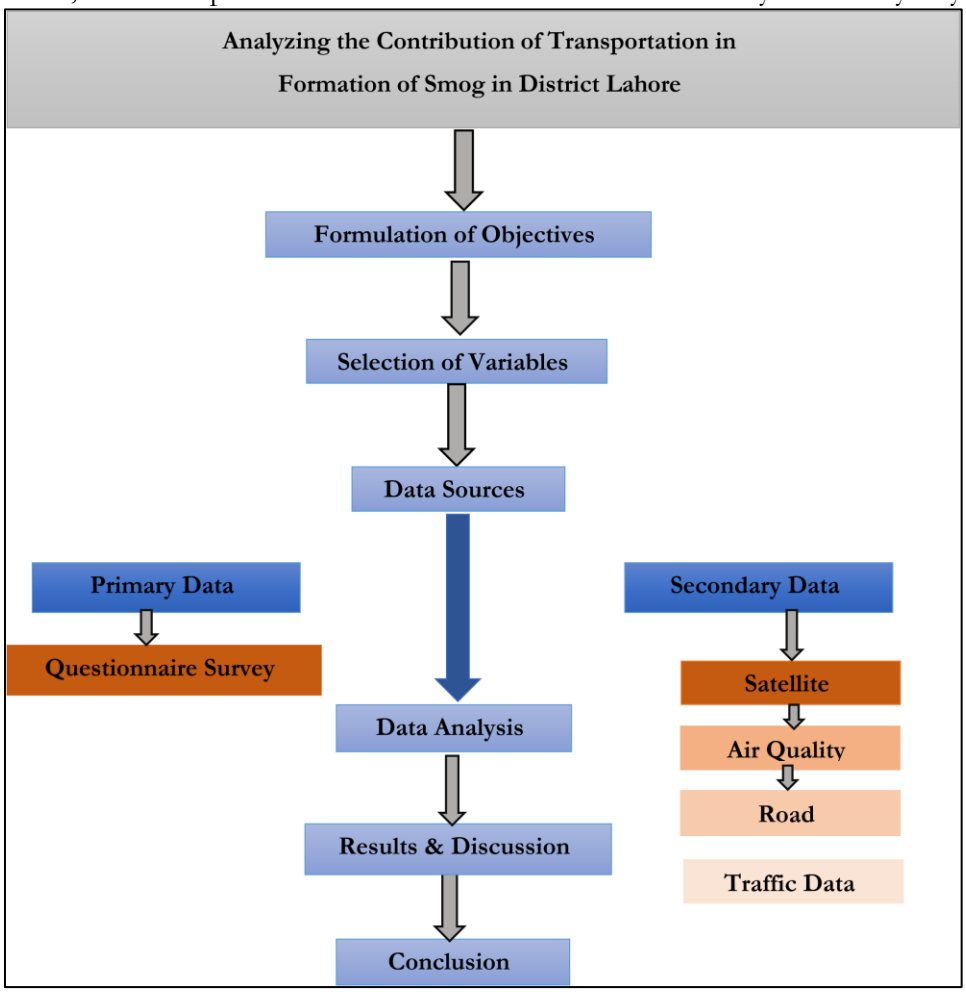

Figure 2: Research Methodology

Sampling:

The survey targeted a diverse range of Lahore residents, representing various demographics and socio-economic backgrounds. A stratified random sampling technique was used to ensure that the sample included different age groups, genders, and geographical locations within Lahore. A sample size of 30 respondents was chosen to achieve a 95% confidence level and a 5% margin of error.

Survey Instrument Development:

A detailed questionnaire was created to gather data from participants, consisting of several sections:

- **Demographic Information:** Age, gender, occupation, residential area.
- **Transportation Habits:** Modes of transport used, frequency of use, distances covered.
- **Perceptions of Smog:** Awareness of smog, concerns about air quality, health impacts.
- **Factors Impacting Transport Choices:** Availability of public transport, views on carpooling and cycling.
- **Suggestions for Addressing Smog:** Policy recommendations, behavioral changes.

Data Analysis:

Survey responses were analyzed quantitatively to identify patterns, trends, and correlations. Descriptive statistics summarized demographic characteristics and survey

responses, while qualitative analysis techniques were used to derive insights from open-ended questions and comments.

Results:

The survey conducted among Lahore residents from diverse demographics and socio-economic backgrounds provided valuable insights into transportation habits, attitudes toward smog, and preferences for addressing air pollution. Findings indicate that many individuals in Lahore prefer using private vehicles, particularly cars and motorcycles, as their primary means of transportation. Public transport options, such as buses and trains, are less commonly used due to issues with accessibility and reliability.

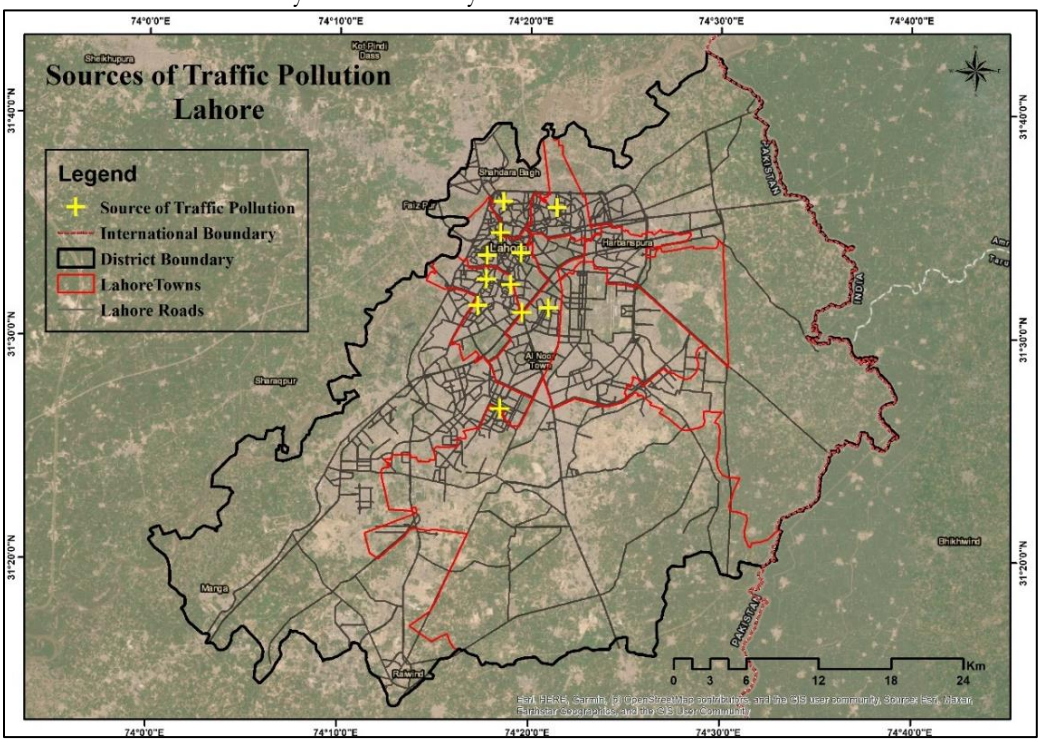

Figure 3: Source of Traffic Pollution

Respondents demonstrated a strong awareness of smog and its harmful health effects, expressing substantial concern about the deteriorating air quality in Lahore. Many reported experiencing respiratory problems and other health issues linked to smog exposure. The availability and quality of public transportation were identified as crucial factors in transportation choices. Participants preferred private vehicles for their perceived convenience and flexibility. Safety and comfort concerns, especially among female respondents and those in areas with limited transport infrastructure, were significant reasons for avoiding public transport.

To combat smog and improve air quality in Lahore, respondents proposed several measures. These include stricter enforcement of vehicle emissions standards, increased investment in public transportation infrastructure, and the promotion of alternative modes of transportation, such as cycling and walking.

Discussion:

The primary objective of this research is to investigate the contribution of transportation to smog formation in Lahore. A critical review of source apportionment studies conducted in Lahore was undertaken, discussing the strengths and weaknesses of different approaches. Urban air pollutants from road traffic and their effects on human health remain uncertain, particularly concerning particulate air pollution and NO2, which are currently the most concerning pollutants. By applying a precautionary principle and assuming that damage is occurring due to transport emissions, we can quantify the magnitude of the effects and the economic cost of road transport emissions on health.

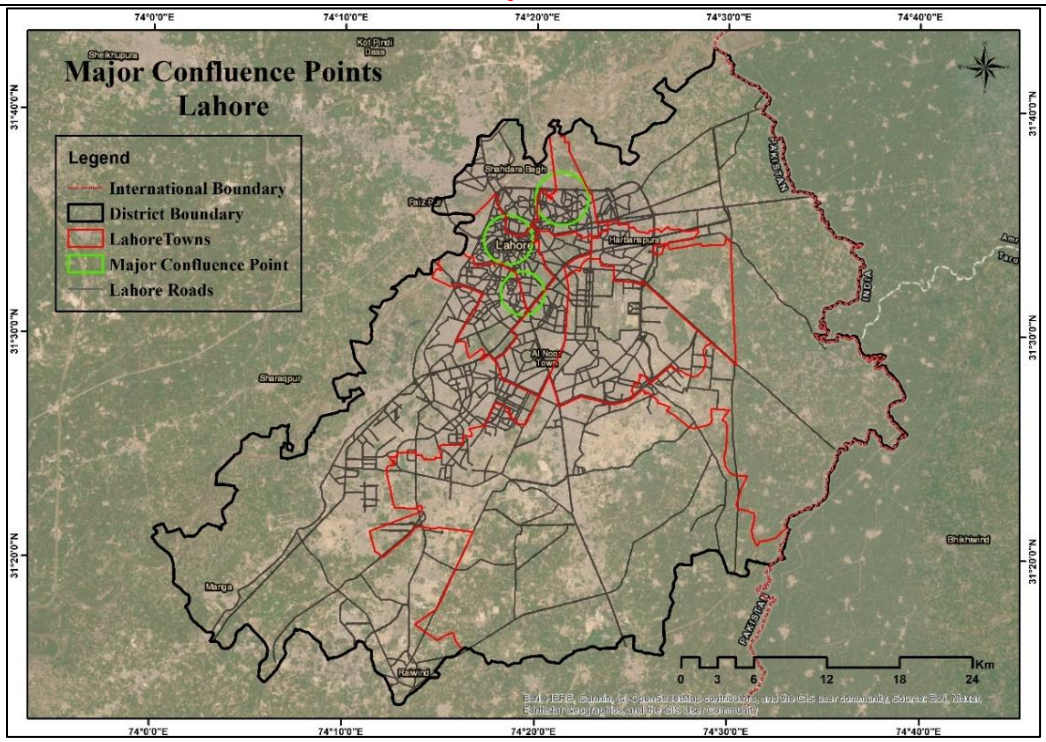

Figure 4: Major Confluence Points

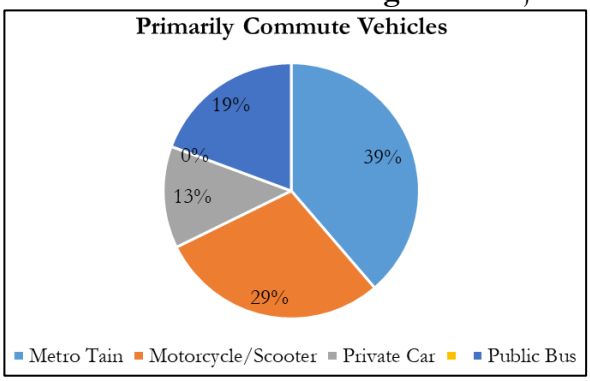

Figure 5: Primarily Commute Vehicles

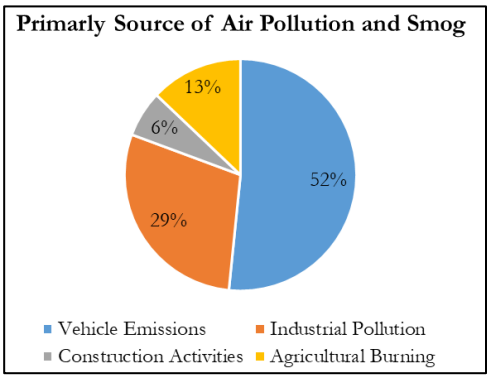

Figure 6: Source of Air Pollution

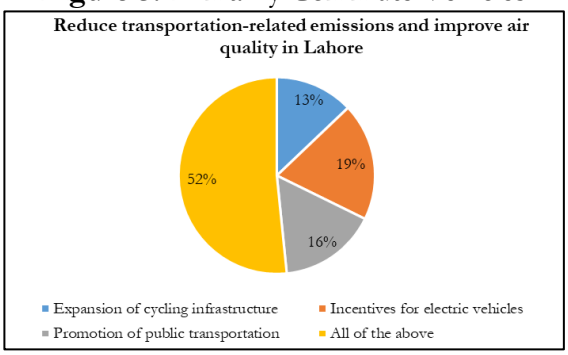

Figure 7: Reduce Transportation emission and improve Air Quality

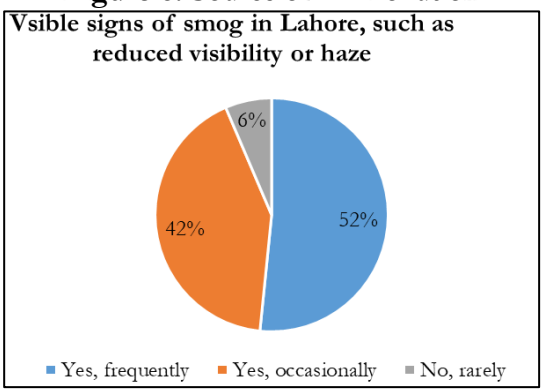

Figure 8: Visible Sign of Smog

Lahore, Pakistan's cultural and commercial hub, experiences significant pollution during winter. Smog, a mix of smoke and fog resulting from vehicle emissions, industrial activities, and weather conditions, is a major issue. Transportation significantly contributes to Lahore's smog. The city, rapidly growing with increasing numbers of vehicles, trucks, buses, and motorcycles, has high emissions. These vehicles release NOx, VOCs, and PM. Smog forms when nitrogen

oxides and volatile organic compounds react with sunlight to produce ground-level ozone. PM, especially PM2.5, reduces visibility and poses severe health risks when inhaled.

Fuel quality greatly influences vehicle emissions. In Pakistan, diesel has high sulfur content and petrol has lower octane ratings, resulting in higher emissions compared to other regions. Older vehicles, especially those lacking modern pollution control devices, emit more pollutants per kilometer than newer vehicles meeting stringent emission regulations. Two-stroke motorcycles, which are less fuel-efficient and more polluting, also contribute to higher emissions. Traffic congestion in Lahore worsens emissions. Peak-hour traffic bottlenecks cause prolonged vehicle idling, increasing fuel consumption and emissions. Stop-and-go traffic further exacerbates fuel use and emissions. As Lahore's traffic grows, so does pollution.

Smog has significant negative impacts on public health and the environment. Elevated levels of PM2.5 and ozone contribute to respiratory and cardiovascular disorders, asthma, and other health issues, particularly affecting the elderly, children, and those with pre-existing conditions. Smog also reduces visibility, damages vegetation, and causes acid rain, which harms ecosystems and agricultural production. Addressing transportation-related smog requires effective administration and policies. Local, regional, and national governments must collaborate to enforce air quality regulations, promote sustainable urban development, and invest in clean transportation infrastructure. Public-private partnerships can aid in adopting cleaner technologies and practices in transportation.

In light of the above, conclusions such as "83% of Lahore's air pollution is caused by the transport sector," based on the sectoral inventory report by Lahore's Urban Unit (Urban Unit, 2023) [20], present an incomplete picture. This figure considers that 80% of transport emissions by mass were CO, while the transport sector's contribution to PM2.5 emissions was only around 35%. Similarly, the 43% contribution of the transport sector reported by FAO [21] is much higher than the 7.7% contribution of the transport sector to Punjab's PM2.5. This 43% figure has been repeatedly used in government policymaking, including in the National Electric Vehicle Policy (2019) and the National Clean Air Policy (2023) [22].

During the 20th century, the primary response to the certainty that environmental damage can be attributed to air pollution emissions has been to reduce emissions per vehicle from road transport. Emissions of CO, hydrocarbons, NOx, and particulate matter have been reduced in Europe, reflecting technology's ability to deliver emission reductions [16]. Most vehicles, except modern high-end petrol vehicles with oxidation catalysts, do not have after-treatment devices [21].

Conclusion:

This research employs a survey-based approach to examine the impact of transportation on Lahore's pollution crisis, focusing on multiple contaminants. The methodology collects significant data on public views, behaviors, and attitudes to help reduce transportation-related emissions and address Lahore's smog problem. The survey aims to inform urban transport policy and measures to improve air quality and public health in Lahore. The case study investigates the link between automotive emissions, air pollution, and public health in Lahore, Pakistan's most populous city. By analyzing commuting patterns, air quality data, stakeholder perspectives, and policy initiatives, several key findings emerged, highlighting the urgent need to address the transportation-smog connection and mitigate its impacts. The study identifies transportation as the main cause of Lahore's smog, with vehicle emissions significantly contributing to the city's air pollution. The rapid increase in automobiles, combined with inadequate emissions control and fuel quality regulations, has led to worsening air quality and more frequent smog events, especially in winter. Factors such as traffic congestion, low-quality gasoline, outdated vehicle technology, and insufficient infrastructure also contribute to transportation-related air pollution. To address these core issues, the study suggests several interventions: advocating for sustainable transportation options, improving fuel quality

regulations, implementing effective traffic management techniques, encouraging the use of electric vehicles, integrating land use and transportation planning, raising public awareness, and strengthening monitoring and enforcement. Systematically implementing these proposals can help Lahore improve air quality, public health, and sustainability. However, tackling transportation-related air pollution requires cooperation from government agencies, corporate sector stakeholders, civil society organizations, and the public. By fostering collaboration among these groups, Lahore can effectively address its smog problem and create a healthier environment for its residents.

Recommendation:

Here are some recommendations to reduce the effect of transportation on smog:

Promote Public Transit, Walking, and Cycling:

- Enhance infrastructure to support these modes of transportation.
- Provide fare subsidies for public transit.
- Raise awareness through campaigns to encourage the use of public transit, walking, and cycling instead of relying solely on private vehicles.

Enforce Stricter Fuel Quality Standards:

- Reduce sulfur content in fuels.
- Improve refining processes to enhance fuel quality.

Implement Traffic Management Strategies:

- Introduce congestion pricing and road pricing.
- Enforce vehicle access restrictions in congested areas of Lahore.
- These measures can effectively reduce traffic congestion and minimize emissions from idling vehicles.

Raise Public Awareness:

- Educate the public about the connection between transportation emissions and smog formation.
- Use educational campaigns, community outreach programs, and media initiatives to spread awareness.

References:

[1] M. Ali and M. Athar, "Impact of transport and industrial emissions on the ambient air quality of Lahore City, Pakistan," Environ. Monit. Assess., vol. 171, no. 1–4, pp. 353–363, Dec. 2010, doi: 10.1007/S10661-009-1283-0/METRICS.

[2] M. Nadeem, A. Aziz, M. A. Al-Rashid, G. Tesoriere, M. Asim, and T. Campisi, "Scaling the Potential of Compact City Development: The Case of Lahore, Pakistan," Sustain. 2021, Vol. 13, Page 5257, vol. 13, no. 9, p. 5257, May 2021, doi: 10.3390/SU13095257.

[3] Z. Naveed and U. Khayyam, "Smog and cognitive issues in the school going children of Lahore and Islamabad, Pakistan," Int. J. Environ. Sci. Technol., vol. 20, no. 4, pp. 4151–4166, Apr. 2023, doi: 10.1007/S13762-022-04264-Y/METRICS.

[4] W. Raza et al., "A review on the deteriorating situation of smog and its preventive measures in Pakistan," J. Clean. Prod., vol. 279, p. 123676, Jan. 2021, doi: 10.1016/J.JCLEPRO.2020.123676.

[5] M. Garelnabi, K. Lor, J. Jin, F. Chai, and N. Santanam, "The paradox of ApoA5 modulation of triglycerides: Evidence from clinical and basic research," Clin. Biochem., vol. 46, no. 1–2, pp. 12–19, Jan. 2013, doi: 10.1016/J.CLINBIOCHEM.2012.09.007.

[6] A. Abbas, S., Khattak, Z. A., Ur Rehman, I., Mahmood, "Vehicular emissions scenario and associated human health impacts in Lahore, Pakistan," Environ. Pollut., vol. 267, pp. 115–454, 2020.

[7] B. Butt, A. R., Sarfraz, M., Ali, M. S., Shahzad, "Air Quality Assessment of Lahore Division, Pakistan: Spatial and Seasonal Variations.," Environ. Model. Assess., vol. 26,

no. 1, pp. 15–31, 2021.
[8] M. Farooqi, S. I., Ahmad, S., Ali, M., Danish, "A review on the traffic congestion, air quality and fuel quality in Pakistan.," Transp. Res. Part D Transp. Environ., vol. 84, 2020.
[9] M. A. Khwaja and T. Shams, "Pakistan National Ambient Air Quality Standards: A comparative Assessment with Selected Asian Countries and World Health Organization (WHO)," 2020, Accessed: Jul. 28, 2024. [Online]. Available: www.sdpi.org
[10] F. Khanum, M. N. Chaudhry, and P. Kumar, "Characterization of five-year observation data of fine particulate matter in the metropolitan area of Lahore," Air Qual. Atmos. Heal., vol. 10, no. 6, pp. 725–736, 2017, doi: 10.1007/s11869-017-0464-1.
[11] W. Huang, J., Zhao, H., Wu, H., Lv, "Modeling vehicular emissions and their contribution to urban air pollution in Lahore," Atmos. Pollut. Res., vol. 11, no. 8, pp. 1314–1325, 2020.
[12] L. Zhang, Y., Xie, S., Wei, W., Hu, "A Review of Urban Air Pollution Monitoring and Prediction in Lahore," Curr. Popul. Reports, vol. 5, no. 4, pp. 377–386, 2019.
[13] H. Liu, Q. Li, D. Yu, and Y. Gu, "Air Quality Index and Air Pollutant Concentration Prediction Based on Machine Learning Algorithms," Appl. Sci. 2019, Vol. 9, Page 4069, vol. 9, no. 19, p. 4069, Sep. 2019, doi: 10.3390/APP9194069.
[14] A. R. Naseem, S., Irfan, M., Waheed, A., Butt, "Air pollution and its impacts on human health in Lahore, Pakistan.," Int. J. Environ. Sustain. Dev., vol. 18, no. 2, pp. 183–197, 2019.
[15] L. Wang, Y., Wang, J., Zhang, C., Wang, Y., Li, H., Wang, "Quantitative analysis of the influence of traffic congestion on vehicular emissions in Lahore, Pakistan.," Int. J. Environ. Res. Public Health, vol. 18, no. 7, 2021.
[16] N. Rasheed, A., Rehman, S., Ahmad, "Assessment of traffic congestion and air quality in Lahore, Pakistan," Environ. Sci. Pollut. Res., vol. 26, no. 8, pp. 8091–8103, 2019.
[17] M. Ahmad, M. S., Farooq, M., Khadim, H., Zia-ur-Rehman, "Association of shortterm exposure to air pollution with cardiovascular emergency department visits: A time series study in Lahore, Pakistan," Environ. Res., vol. 195, 2021.
[18] R. A. Shah, M. T., Shamshad, S., Khattak, "Air quality of the urban area of Lahore, Pakistan in relation to metallic pollution.," Environ. Earth Sci., vol. 77, no. 24, pp. 1–9, 2018.
[19] A. Shaheen, N., Ahmad, S., Ali, M., Fida, "Assessment of heavy metals in atmospheric particulate matter of Lahore, Pakistan.," Environ. Sci. Pollut. Res., vol. 25, no. 17, pp. 17004–17014, 2018.
[20] "Sectoral Emission Inventory of Lahore", [Online]. Available: https://urbanunit.gov.pk/Download/publications/Files/8/2023/Emission Inventory of Lahore 2023.pdf
[21] A. U. Bajwa and H. A. Sheikh, "Contribution of Road Transport to Pakistan's Air Pollution in the Urban Environment," Air 2023, Vol. 1, Pages 237-257, vol. 1, no. 4, pp. 237–257, Nov. 2023, doi: 10.3390/AIR1040018.
[22] J. Slater et al., "Modeling Air Pollutant Emission Reductions from Implementation of Pakistan's 2023 Clean Air Policy," ACS ES&T Air, Jun. 2024, doi: 10.1021/ACSESTAIR.4C00003.