International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 06 ISSUE 04 Pages: 50-55
OCLC – 1368736135

Journal Website: http://sciencebring.com/index.php/ijasr

Research Article

Investigation of The Environmental Impact of Motor Vehicles

Submission Date: February 26, 2026, **Accepted Date:** March 22, 2026,
Published Date: April 17, 2026
Crossref doi: https://doi.org/10.37547/ijasr-06-04-04

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ABSTRACT

This study presents a comprehensive analysis of the impact of road transport on environmental systems. One of the key determinants of pollution levels is identified as the average age of the national vehicle fleet, which contributes to an increased frequency and complexity of maintenance and repair interventions. The condition of road infrastructure is also assessed, and the distribution of pollutant emissions is examined with respect to vehicle types and fuel categories. Particular attention is given to identifying and systematizing the adverse environmental consequences associated with anthropogenic impacts.

KEYWORDS

Road transport, motor vehicles, pollutant emissions, environmental impact, fuel types.

INTRODUCTION

The transport system constitutes a fundamental component of economic development and the provision of social services. However, its rapid expansion is associated with increasing environmental pressures, particularly in highly urbanized areas, where high population density and traffic intensity accelerate the accumulation of pollutants [1–10]. A significant proportion of the population is exposed to environmental conditions that do not meet sanitary standards, largely due to transport-related pollution. Air pollution and noise emissions remain the most

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critical challenges associated with modern transport systems.

Vehicular emissions are among the primary contributors to environmental degradation. Exhaust gases from internal combustion engines contain more than 200 chemical compounds, including toxic and carcinogenic substances. The continuous growth of the vehicle fleet has also led to increased carbon dioxide (CO_2) emissions, a major driver of climate change. Despite extensive research, important gaps remain. In particular, insufficient attention has been given to integrated assessments that consider key factors such as fleet age, infrastructure condition, and fuel characteristics. Existing studies often lack a unified approach that simultaneously addresses technological and environmental aspects. The novelty of this study lies in the development of an integrated analytical framework that captures the interdependencies among these factors, enabling a more systematic evaluation of emission patterns.

METHODS

As of 2025, the vehicle fleet of Uzbekistan comprises approximately 4.7 million units registered to private individuals. Passenger cars account for the dominant share of the fleet (92.9%, approximately 4.39 million units), while trucks account for about 0.31 million units and buses approximately 6 thousand units. The analysis is based on statistical data describing the structure and composition of the vehicle fleet, including vehicle categories and age characteristics. Particular attention is given to the role of aging vehicles, which are associated with reduced technological efficiency and higher fuel consumption. The structure of motor fuel consumption was also considered. Compressed natural gas (CNG) accounts for approximately 65% of total fuel consumption, followed by gasoline (24–25%), liquefied petroleum gas (8–9%), and diesel fuel (2–3%). The condition of road infrastructure was analyzed based on categorized road data, including variations in road quality and surface condition.

The methodological approach includes:

- analysis of vehicle fleet structure
- evaluation of fuel composition
- assessment of road infrastructure condition
- comparative analysis of emission distribution by transport mode and fuel type

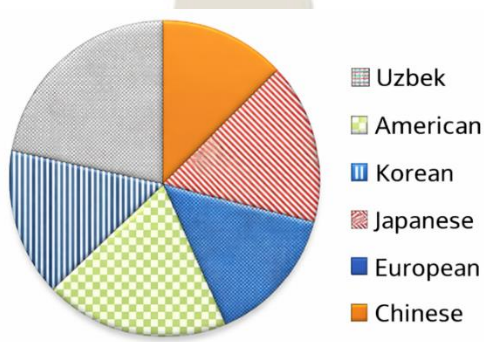

Figure 1 – Distribution of the Average Age of Passenger Cars in Uzbekistan by their origin

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Results and Discussion

As of 2024, the structure of motor fuel consumption in Uzbekistan is characterized by a dominant share of compressed natural gas (CNG), which accounts for approximately 65% of the total fuel used in the transport sector. Gasoline represents around 24–25%, while liquefied petroleum gas (LPG) contributes approximately 8–9%, and diesel fuel accounts for a relatively minor share of about 2–3%. This distribution reflects the country's strategic reliance on natural gas as a primary energy resource and highlights the widespread adoption of gas-powered vehicles. Compared to conventional fuels, the predominance of CNG contributes to lower emissions of certain pollutants; however, the overall environmental impact remains significant due to the scale of vehicle usage and the technological condition of the fleet.

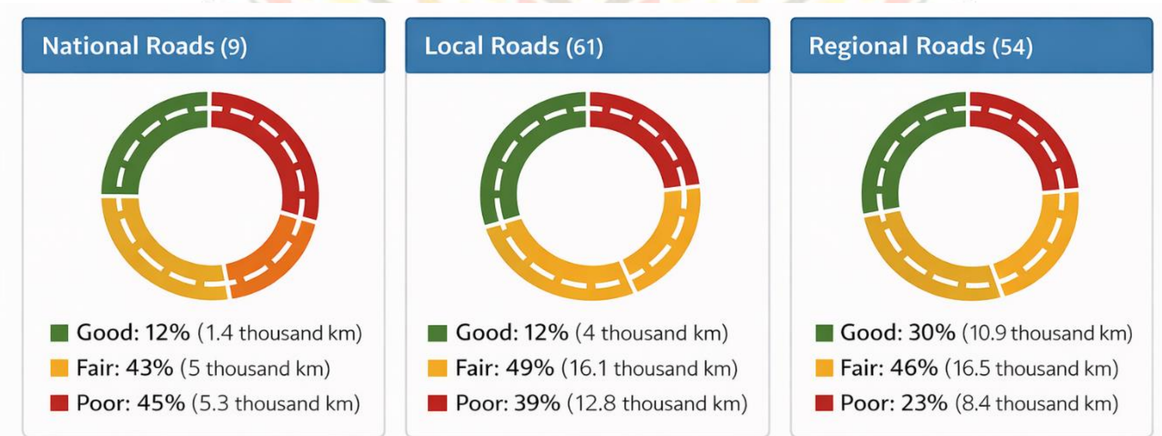

Figure 2 – Distribution of road conditions in Uzbekistan by road category

Significant sections of the road network are characterized by insufficient smoothness, surface irregularities, and reduced structural strength, necessitating continuous maintenance, rehabilitation, and reconstruction. These deficiencies directly compromise vehicle operating safety and increase the likelihood of traffic accidents. The transport infrastructure of Uzbekistan includes several thousand motor transport enterprises engaged in both passenger and freight operations. In addition, a wide network of service stations provides maintenance and repair services, ensuring the technical reliability of the vehicle fleet. Despite the steady increase in vehicle ownership and diversification of transport activities, the environmental impact of road transport has not significantly decreased. Road transport remains the dominant source of air pollution in urban areas, contributing up to 80% of total emissions within populated regions. The condition of road infrastructure plays a critical role in traffic safety. Pavement defects and structural deterioration can lead to hazardous situations, posing risks to all road users. At the same time, road rehabilitation not only improves safety but also enhances transport efficiency and overall quality of life by reducing travel time and increasing comfort. Motor transport enterprises are essential for economic development; however, their environmental impact must be carefully addressed. In the context of rapid fleet growth, it is necessary to implement measures aimed at reducing emissions, including the adoption of cleaner technologies, the use of environmentally friendly fuels, and the development of efficient public transport systems. Therefore, addressing these challenges requires an integrated approach that combines infrastructure improvement with measures to mitigate the environmental impact of transport. Overall, the transport sector contributes approximately 35–45% of total atmospheric pollutant emissions from both stationary and mobile sources in Uzbekistan. Emissions are predominantly generated by road transport (around 60%), followed by rail transport (approximately 30%) and aviation (about 5%) (Figure 3).

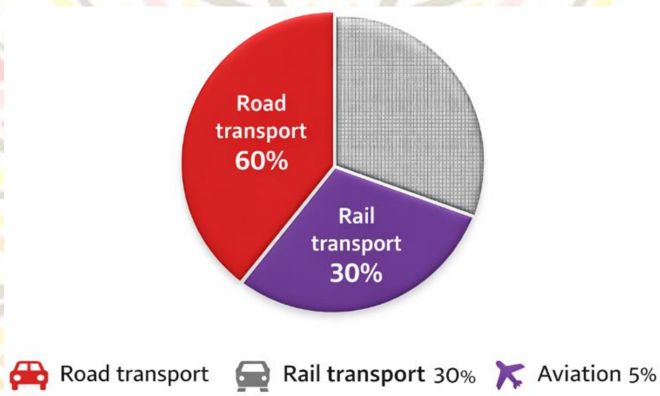

Figure 3 – Distribution of Atmospheric Pollutant Emissions in Uzbekistan by Transport Mode

Emissions from road transport can be further categorized based on the type of fuel used (Figure 4).

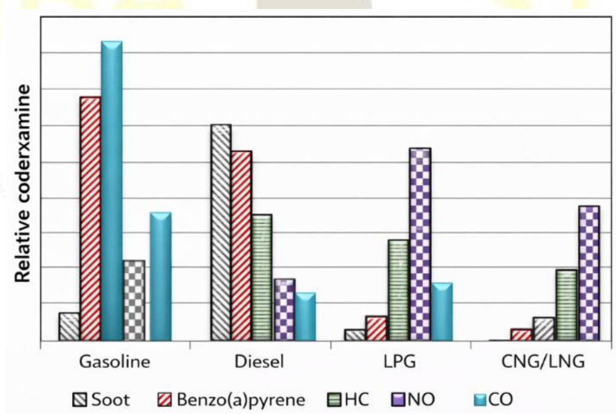

Figure 4 – Distribution of Pollutant Emissions in Road Transport by Fuel Type Used

Vehicle exhaust emissions, containing carbon oxides, nitrogen oxides, sulfur compounds, hydrocarbons, and, in some cases, lead compounds (from leaded gasoline), represent one of the primary sources of air quality degradation in urban and peri-urban areas. These pollutants contribute to the formation of smog, acid rain, and the greenhouse effect, posing significant risks to human health, ecosystems, and biodiversity Environmental contamination from road transport extends beyond atmospheric pollution. Petroleum products entering soil and water bodies as a result of vehicle leaks or fuel station operations cause severe ecological damage, including groundwater contamination, aquatic toxicity, and disruption of ecological balance. In addition, the wear of tires and brake components generates micro-scale particles of rubber and metals, which accumulate in soils and remain insufficiently studied but are considered potentially hazardous Road transport also significantly alters soil composition and microbial activity. The accumulation of heavy metals and hydrocarbons degrades soil structure, reduces fertility, and disrupts microbial ecosystems, ultimately affecting plant growth and agricultural productivity. Furthermore, transport-related activities generate substantial amounts of waste, including used oils and other hazardous materials, the disposal of which remains a major environmental challenge. In particular, wastewater generation is a critical issue associated with vehicle maintenance. Wastewater is produced during vehicle washing, component cleaning, battery servicing, and various mechanical and chemical processes. Its composition varies depending on the type of operation and often includes oil residues, heavy metals, and chemical contaminants. Improper handling of such wastewater can lead to soil and water pollution. Additionally, construction and maintenance of transport infrastructure require substantial extraction of natural resources, including soil, water, and mineral materials. These activities disturb natural landscapes and ecosystems, affecting both flora and fauna and contributing to biodiversity loss. Therefore, vehicle maintenance and repair processes, while essential for ensuring operational reliability, impose a considerable environmental burden. This underscores the need for continuous monitoring and the implementation of effective environmental management practices aimed at minimizing their negative impacts.

Conclusion

The results of this study demonstrate that road transport is the dominant source of environmental pollution in Uzbekistan, accounting for up to 80% of emissions in urban areas and approximately 35–45% of total atmospheric pollutant emissions. The structure of fuel consumption, characterized by the predominance of compressed natural gas (CNG), reduces certain types of emissions; however, the overall environmental impact remains significant due to the scale of vehicle usage and the aging condition of the fleet. The findings also indicate that road infrastructure quality directly affects vehicle efficiency, fuel consumption, and emission levels. Poor road conditions, combined with the continued operation of technologically outdated vehicles, contribute to increased environmental pressure. In addition to direct emissions, road transport has a complex environmental impact, including soil and water contamination, resource depletion, and ecosystem disturbance. Maintenance and repair processes further intensify these effects through wastewater generation and hazardous waste production. Overall, the environmental impact of road transport is multifaceted and requires an integrated approach to mitigation. Key measures should include fleet modernization, improvement of road infrastructure, wider adoption of cleaner fuels and technologies, and the implementation of effective environmental management practices.

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