Assessing Urban Transport's Air and Noise Pollution Impacts

Pankaj Sharma
M. Tech. in Transportation Engineering, Sat Kabir Institute of Technology and Management, Haryana.

Mukesh Kumar
A.P Civil Department, Sat Kabir Institute of Technology and Management, Haryana.

ABSTRACT

Urban transportation systems contribute significantly to environmental degradation, particularly through air and noise pollution. This study employed a MATLAB R2017b GUI-based model to assess emissions of CO, NOx, PM2.5, and CO_2, along with traffic noise levels, across vehicle types including two-wheelers, cars, buses, and trucks. Results indicated that heavy vehicles are major contributors to both emissions and noise, while high traffic density amplifies the environmental impact. Mitigation strategies such as traffic management, promotion of cleaner fuels, electric vehicles, and roadside green buffers were suggested. The study provides a systematic framework for evaluating and improving sustainable urban transportation.

Keywords: *Urban Transportation, Air Pollution, Noise Pollution, Environmental Impact Assessment.*

I. INTRODUCTION

The rapid urbanization and expansion of cities worldwide have significantly transformed the urban environment, giving rise to complex transportation systems that, while facilitating economic growth and mobility, have also contributed to substantial environmental degradation, particularly in terms of air and noise pollution, which are among the most pervasive and harmful consequences of urban transport activities; urban transportation networks, comprising private vehicles such as two-wheelers and cars, and public or commercial vehicles including buses and trucks, rely heavily on fossil fuels, resulting in the emission of carbon monoxide (CO), nitrogen oxides (NOx), particulate matter (PM2.5), and carbon dioxide (CO_2), with each pollutant presenting unique environmental and health hazards, including respiratory diseases, cardiovascular stress, and long-term climate change impacts, and these emissions are further intensified in high-density traffic corridors where stop-and-go conditions, frequent acceleration and deceleration, and lower average vehicle speeds lead to incomplete combustion and increased pollutant concentrations, while the cumulative effect of multiple vehicles on the road, especially heavy vehicles with larger engines and higher fuel consumption, exacerbates these emissions, thereby creating urban hotspots of poor air quality that often exceed national and international standards; additionally, the acoustic environment in urban centers is profoundly affected by transportation activities, as continuous movement of vehicles generates traffic noise from engines, braking, tire-road interactions, and horn usage, resulting in equivalent noise levels in certain urban corridors exceeding 95 decibels, which not only impairs auditory health but also induces stress, sleep disturbances, reduced cognitive performance, and general discomfort for populations residing or working near high-traffic zones, and these effects are compounded by the urban canyon effect, where buildings and infrastructure reflect and amplify sound waves, increasing noise exposure and making mitigation efforts more challenging; environmental impact assessments (EIAs) have thus become crucial tools for quantifying and understanding the contribution of different vehicle categories to overall pollution levels, with modern approaches employing computational models and simulation tools, such as MATLAB GUI-based frameworks, which allow for the integration of vehicle counts, average speeds, road lengths, distance from the road, and green cover factors to estimate pollutant emissions and noise levels accurately, facilitating comparative analysis of contributions from two-wheelers, cars, buses, and trucks, and providing actionable insights for urban planners and policymakers; studies employing such models reveal that while two-wheelers and cars contribute substantially to total emissions due to their sheer numbers, heavy vehicles such as buses and trucks are disproportionately responsible for NOx, PM2.5, CO_2 emissions, and elevated noise levels, reflecting the higher combustion temperatures, fuel density, and engine power required for their operation, and these findings indicate that urban transport systems cannot be assessed solely by vehicle count but must consider the emission factor, operating conditions, and traffic behavior, which collectively define the environmental burden; total CO emissions in typical urban traffic corridors have been measured at over 318 kg/day, NOx emissions at approximately 124 kg/day, PM2.5 at 10 kg/day, and CO_2 emissions at over 26,000 kg/day, indicating a considerable contribution to greenhouse gas accumulation and moderate to high air pollution, while the equivalent noise level of 96.81 dB emphasizes the critical concern of traffic-induced acoustic pollution, highlighting that air and noise pollution are intrinsically linked and often exacerbated by similar factors, including traffic congestion, road geometry, vehicle mix, and proximity of residential areas to major roads; mitigation strategies suggested by EIAs encompass traffic flow improvements through synchronized signaling, congestion reduction via carpooling incentives, dedicated lanes for high-occupancy or public vehicles, promotion of electric and fuel-efficient vehicles to reduce emission intensity, and systematic urban planning initiatives such as the development of roadside green buffers, tree plantations, and vertical landscaping, which can absorb pollutants and attenuate sound waves, thereby decreasing both air and noise pollution simultaneously, and these interventions are particularly effective when targeted at corridors with heavy commercial vehicle movement or areas with high population density; furthermore, restricting heavy vehicle access during peak hours or in sensitive zones such as hospitals, schools, and residential neighborhoods, combined with incentives for off-peak freight movement, can further reduce environmental stress, while integration of public transport systems with intelligent scheduling, priority signaling, and seamless multimodal connectivity can decrease reliance on private vehicles, lowering overall emissions and contributing to sustainable urban mobility; another crucial aspect of managing urban transportation environmental impacts is the inclusion of green infrastructure and vegetation cover, which not only serves as a buffer to trap particulate matter and absorb gaseous pollutants but also reduces noise propagation through sound absorption and scattering, improving the microclimatic conditions and enhancing the livability of urban spaces; the deployment of simulation-based EIA tools also facilitates scenario analysis, enabling urban planners to model the potential effects of traffic regulation measures, vehicle electrification, introduction of low-emission zones, and expansion of pedestrian and cycling networks, thereby providing data-driven recommendations for sustainable urban transport development; these models further support policy formulation by enabling visualization of pollutant concentrations, noise exposure, and overall environmental impact in tabular and graphical formats, which assists in prioritizing interventions, assessing compliance with regulatory standards, and planning long-term infrastructure projects that minimize environmental degradation; in conclusion, urban transportation systems are a double-edged sword, promoting connectivity and economic activity while simultaneously imposing significant environmental burdens in terms of air and noise pollution, and comprehensive EIAs, supported by advanced modeling tools and data-driven simulations, provide a necessary framework for understanding these impacts, identifying critical sources of pollution, and designing effective mitigation strategies, which include optimizing traffic flow, promoting cleaner vehicles, enhancing public transport, implementing urban greening initiatives, and regulating heavy vehicle movement, all of which are essential for achieving sustainable urban development, protecting human health, and ensuring a cleaner, quieter, and more resilient urban environment for current and future populations, and such integrated approaches highlight the importance of evidence-based policymaking, interdisciplinary collaboration, and proactive environmental management to mitigate the detrimental effects of urban transportation while maintaining mobility, accessibility, and economic growth in rapidly urbanizing regions.

II. RESEARCH BACKGROUND

Nayeb-Pashaei et al. (2026) examined the growing importance of sustainable transportation networks in the context of rapid urbanization, environmental concerns, and inefficiencies in transport systems. The study reported that the application of multi-criteria decision analysis (MCDA) had enabled the systematic identification, weighting, and ranking of sustainability criteria, including economic, environmental, and social dimensions. It was observed that the Fuzzy Logarithm Methodology of Additive Weights (F-LMAW), integrated with Triangular Fuzzy Numbers (TFNs), had been effectively utilized to evaluate criteria under uncertain conditions. The analysis, supported by expert surveys, literature review, and case findings, introduced five additional sustainability criteria. The results indicated that safety, health, and greenhouse gas emissions had emerged as the most significant factors. The study concluded that transportation design should prioritize human well-being and environmental protection, while economic considerations should be aligned with long-term sustainability.

Das et al. (2026) examined the localized environmental disturbances associated with metro rail construction, despite its long-term sustainability benefits for urban mobility. The study evaluated air and noise pollution impacts along Chennai Metro Rail Corridors 3 and 4 across pre-monsoon, monsoon, and post-monsoon seasons. It was reported that air quality monitoring of PM2.5, PM10, SO_2, NO_2, and CO was conducted using high-volume samplers and portable analyzers, while noise levels were continuously measured through digital sound level meters. GIS-based spatial mapping was employed to identify pollutant dispersion and hotspots. The findings indicated significant seasonal and spatial variations, with PM10 concentrations peaking during the pre-monsoon period. Although pollutant levels largely complied with standards, noise levels often exceeded permissible limits. A strong positive correlation between PM2.5 and PM10 was observed. Health surveys revealed that residents experienced dizziness and respiratory issues, suggesting temporary yet manageable environmental and health impacts.

Kadakath et al. (2025) examined the critical challenges faced by urban transportation systems, particularly focusing on road accidents, noise pollution, and environmental impacts. The authors reported that increasing accident rates had resulted in fatalities, injuries, traffic congestion, and elevated pollution levels. It was observed that high noise levels at signalized intersections adversely affected the quality of life, while prolonged vehicle idling had contributed significantly to carbon emissions and fuel wastage. The study had analyzed accident trends, influencing factors, and future traffic predictions using data on accidents, vehicle ownership, noise levels, and fuel consumption, processed through the Statistical Package for Social Sciences. Carbon emissions were evaluated based on Intergovernmental Panel on Climate Change guidelines. The findings indicated strong statistical relationships among fatalities, injuries, and vehicle registrations, while peak noise levels and emissions were recorded during rush hours, providing valuable insights for sustainable urban traffic management.

Xu et al. (2024) examined the adverse impacts of urban traffic congestion, noting that it had led to reduced traffic efficiency, increased noise pollution, and higher levels of exhaust emissions. The study further indicated that congestion had emerged as a critical indicator of urban health concerns. It was reported that the research primarily focused on pollution arising from congestion by analyzing two dimensions: long-term spatial constraints, such as limited travel routes, and short-term temporal delays caused by congestion. The authors also explored mitigation strategies, including optimizing spatial utilization through public transportation systems like subways and promoting travel scheduling during holidays. To address endogeneity issues, instrumental variable tests were conducted from both temporal and spatial perspectives. The findings revealed that congestion had significantly deteriorated air quality in both the short and long term. The study concluded that coordinated efforts and sustainable urban planning were essential for reducing environmental and traffic-related externalities.

Monteiro et al. (2024) reviewed the critical challenges associated with developing sustainable urban environments, with particular emphasis on the influence of transportation systems and urban form on energy consumption and greenhouse gas emissions. The study aimed to present a comprehensive overview of existing literature while identifying key directions for sustainable urban planning. It was reported that urban design and transport systems were highly interdependent in achieving sustainability objectives. The authors examined various planning dimensions such as urban sprawl, mixed land use, densification, infill development, and public spaces, and their direct effects on transport behavior, modal choices, and energy use. Furthermore, innovative strategies like transit-oriented development and advancements such as electric mobility were analyzed for their potential contributions. The study concluded that holistic and adaptive planning approaches were essential, and emphasized the need for coordinated efforts among policymakers, planners, and communities to ensure sustainable urban development.

Abdullah et al. (2023) emphasized that improving transportation systems and related infrastructure was urgently required, as these were considered key indicators of urban development. The authors explained that “smart transport,” which incorporated modern communication and information technologies, had been increasingly adopted to address challenges in transportation sectors. In their study of Najaf City, it was reported that the smart transportation strategy had aimed to reduce traffic-related noise and air pollution while enhancing mobility and traffic flow efficiency. The researchers had evaluated the existing traffic network and public transport system using field measurements collected through cameras, noise meters, and pollution monitoring devices. The findings indicated that public transport services had been inadequate, with private vehicles dominating nearly 65% of the traffic composition, leading to pollution and noise levels exceeding permissible standards. It was further suggested that intelligent transportation systems, tram networks, and geometric road improvements could significantly mitigate these issues.

Mousavimasouleh et al. (2022) examined the prioritization of transportation options in densely populated urban areas with a focus on sustainable development. The study considered multiple transportation modes, including walking, taxis, buses, and bicycles, and analyzed their combinations within the context of Tehran. It was reported that data were initially collected from public transport users regarding their travel preferences. Subsequently, expert opinions from Tehran Municipality were incorporated to evaluate transportation alternatives based on sustainability criteria. The analytic hierarchy process (AHP) was employed to optimize and rank these criteria. The findings indicated that air pollution and noise pollution were identified as the most significant factors, with respective weights of 0.33 and 0.24. Furthermore, the combined bicycle-walk mode was ranked as the most preferred option, while the bus-bicycle combination was the least preferred. It was also observed that a notable disparity existed between public preferences and sustainability-oriented transportation priorities.

Ribeiro et al. (2021) examined the growing trend of urbanization, noting that cities had increasingly become attractive hubs for population growth and economic activities. They observed that this rapid expansion not only posed significant environmental threats but also created a range of challenges and opportunities for individuals, organizations, businesses, and governments. The authors highlighted that achieving a high quality of urban life required improved efficiency in assets, buildings, infrastructure, and urban systems, alongside the preservation of the natural environment. Their study reviewed existing literature to analyze the current urban context, key challenges, and the evolving concept of smart cities. It was reported that future cities would rely heavily on advanced and adaptive transport systems to ensure sustainable, resilient, and inclusive mobility. The findings suggested that an integrated smart mobility approach had the potential to enhance transport network efficiency while addressing climate change and citizens' needs.

Huu and Ngoc (2021) examined the transportation scenario in Vietnam's major urban areas and reported that private motorcycles had been the dominant mode of transport due to their suitability to existing socio-economic conditions, infrastructure, and travel habits. However, they observed that the rapid increase in motorcycle ownership and density had led to significant issues such as traffic congestion, noise, and air pollution, which gradually influenced public perception regarding private vehicle usage. It was further noted that the public had urged authorities to implement policies to limit the growth of fossil fuel-based vehicles. The authors highlighted that the success of such policies depended on the availability of affordable and socially compatible alternatives. They found that electric two-wheelers, supported by expanding public transport networks, had emerged as a promising sustainable option. The study aimed to assess traffic conditions and emphasized the transition toward greener mobility solutions, along with recommending measures to promote electric vehicle adoption.

Mavrin et al. (2020) reported that road transport had been identified as one of the primary sources of atmospheric pollution in urbanized areas, with emissions having increased significantly since 2013. They attributed this rise mainly to the poor condition of transport infrastructure and inefficient control systems. The authors emphasized that the development of evidence-based approaches to enhance traffic management efficiency through modernization of infrastructure and control mechanisms had become both practically and theoretically important. In their study, problematic areas within the street and road network of a medium-sized city were analyzed. They further developed simulation models of selected areas using a discrete-event approach supported by a road traffic library. Based on these models, several modernization measures were proposed. The results of computer-based experiments, conducted with modified configurations, demonstrated that the selected area possessed considerable potential for improving traffic flow parameters and consequently reducing environmental impacts.

Gössling et al. (2019) examined the exposure of active mode users, including pedestrians and bicyclists, to negative externalities arising from motor vehicle traffic, such as injury risks, noise, and air pollution. It was reported that these adverse conditions not only directly affected users but also discouraged the adoption of active travel modes, thereby reinforcing a cycle of increased motorized transport and associated environmental and health impacts. The study evaluated these effects by analyzing the additional distances traveled by bicyclists to avoid high-traffic roads, based on survey data collected from 491 members of German-Austrian bicycle organizations. It was found that respondents cycled approximately 6.4% longer distances to minimize exposure to traffic-related hazards. Furthermore, the incremental private costs of these detours were monetized and estimated at a minimum of €0.24 per cycle-kilometer. The findings suggested that conventional transport planning had often overlooked such impacts, leading to disproportionate investment in road infrastructure rather than active transport facilities.

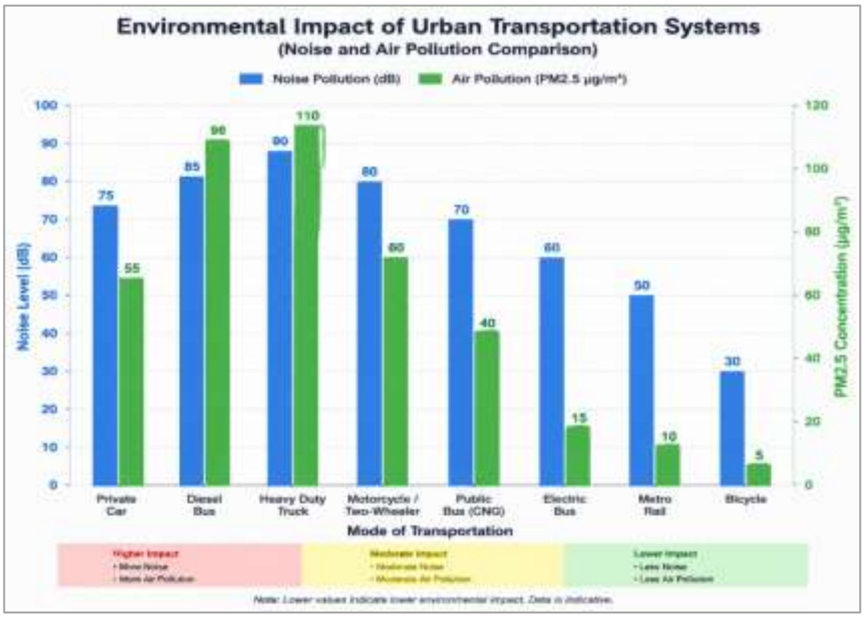
III. METHODOLOGY

The methodology adopted for assessing the environmental impact of urban transportation systems involved a structured and quantitative approach, utilizing a MATLAB R2017b GUI-based model to simulate real-world traffic scenarios and estimate pollutant emissions and noise levels. The study focused on four main vehicle categories: two-wheelers, cars, buses, and trucks, representing a typical urban traffic mix. Key input parameters for the model included vehicle count, average speed, road length, distance from the road, and green cover factor, which were essential to accurately calculate emissions of carbon monoxide (CO), nitrogen oxides (NOx), fine particulate matter (PM2.5), carbon dioxide (CO_2), and the equivalent noise level in decibels (dB). Data for traffic volume and vehicle distribution were collected from local transport authorities and observational surveys in selected urban corridors. The model incorporated emission factors for each vehicle type based on fuel type, engine capacity, and operational conditions, allowing for differentiation between light and heavy vehicles and accounting for their relative contributions to total pollution. Noise assessment included engine, braking, tire-road interaction, and horn usage, with adjustments for distance from the road and presence of roadside vegetation. Simulation runs were performed to generate output tables, graphs, and summaries, enabling comparison of environmental impact across vehicle types. The GUI allowed for visualization of results, export to CSV for reporting, and scenario analysis for potential mitigation measures such as traffic management, cleaner fuels, and increased green cover. This methodology provides a systematic, reproducible framework to quantify and analyze the contribution of urban transport to air and noise pollution, supporting sustainable planning and policy formulation.

IV. RESULT

The environmental impact assessment of the selected urban transportation system revealed that traffic contributes significantly to both air pollution and noise pollution, with the intensity varying across vehicle types. Using the MATLAB R2017b GUI model, emissions and noise levels were calculated for two-wheelers, cars, buses, and trucks, incorporating key parameters such as vehicle count, average speed, road length, distance from road, and green cover factor. The results indicate that total carbon monoxide (CO) emissions from the urban road section were 318.262 kg/day, primarily due to incomplete fuel combustion in all vehicle types, with cars contributing the highest proportion because of their higher numbers, followed by two-wheelers, while buses and trucks contributed relatively less. Nitrogen oxides (NOx), measured at 124.081 kg/day, were predominantly emitted by heavy vehicles such as buses and trucks, reflecting high engine combustion temperatures and diesel usage, which makes them major contributors to air quality degradation. Fine particulate matter (PM2.5) emissions totaled 10.271 kg/day, which, although lower in mass, pose a greater health risk due to their ability to penetrate deep into the respiratory system. Carbon dioxide (CO_2) emissions were the highest among all pollutants, reaching 26,083.381 kg/day, highlighting the strong carbon footprint of the urban transport corridor. Noise pollution assessment revealed an equivalent noise level of 96.81 dB, indicating a high noise impact that is likely to affect residents, pedestrians, and workers along the corridor. Heavy vehicles were identified as the main source of traffic noise due to engine sound, braking, vibration, and tire-road interaction, whereas high traffic density and stop-and-go conditions amplified overall noise exposure. The air pollution status was classified as moderate, requiring mitigation measures, whereas the noise pollution status was categorized as high, indicating significant environmental stress. Overall, the results demonstrate that heavy vehicles are disproportionate contributors to both emissions and noise, while the large number of smaller vehicles, such as two-wheelers and cars, also significantly affects air quality due to their cumulative volume. The findings underscore the necessity of integrated traffic management strategies, promotion of public and electric transport, congestion reduction, and roadside greening to mitigate environmental impacts. The GUI-based assessment provides a systematic, user-friendly platform to evaluate different vehicle categories, quantify their contributions, and inform policy decisions for sustainable urban transportation planning.

Bar Graph



Environmental Impact of Urban Transportation Systems (Noise and Air Pollution Comparison)

The bar graph titled "Environmental Impact of Urban Transportation Systems (Noise and Air Pollution Comparison)" visually illustrates the comparative environmental burden of various modes of urban transportation based on two key parameters: noise pollution (measured in decibels, dB) and air pollution (represented by PM2.5 concentration in μg/m³). Each transportation mode, including private cars, diesel buses, heavy-duty trucks, motorcycles/two-wheelers, public buses (CNG), electric buses, metro rail, and bicycles, is depicted on the x-axis, while the y-axes display respective values for noise (left, blue bars) and PM2.5 (right, green bars). The graph indicates that heavy-duty trucks and diesel buses generate the highest levels of both noise and air pollution, highlighting their disproportionate contribution to urban environmental degradation, whereas bicycles and metro rail show minimal impact. Private cars and motorcycles/two-wheelers exhibit moderate pollution levels, reflecting the combined effect of vehicle volume and emission intensity. Electric buses and CNG-powered public buses show lower emissions, demonstrating the effectiveness of cleaner fuel technologies. Color coding and the legend clarify which bars correspond to noise and air pollution. Overall, the graph emphasizes that traffic type, fuel, and vehicle density are critical determinants of urban environmental impact, and it underscores the importance of adopting cleaner technologies, promoting non-motorized transport, and implementing traffic management and urban planning strategies to mitigate both air and noise pollution.

V. CONCLUSION

The environmental impact assessment of urban transportation systems demonstrates that vehicular movement in cities significantly affects air quality and acoustic environments, thereby posing risks to human health and urban ecosystem stability. The study revealed that emissions of CO, NOx, PM2.5, and CO_2 from different vehicle types, along with high noise levels, collectively contribute to environmental degradation, with heavy vehicles such as buses and trucks producing disproportionate amounts of pollutants and noise per unit, while two-wheelers and cars contribute substantially due to their higher numbers. The MATLAB GUI-based model provided a systematic, user-friendly platform to quantify these emissions and noise levels, analyze the contribution of each vehicle category, and generate tabular and graphical outputs that facilitate clear interpretation and scenario assessment. Results indicated that urban roads with high traffic density, lower average speeds, and limited green cover experience moderate to high air pollution and high noise pollution, emphasizing the need for targeted mitigation strategies. The study highlights that traffic management interventions, including synchronized signal systems, congestion reduction, and promotion of public transport, combined with cleaner fuel technologies and adoption of electric vehicles, can significantly reduce emissions. Additionally, urban planning measures such as the creation of roadside green buffers and strategic placement of vegetation can effectively attenuate noise and absorb pollutants, enhancing the overall environmental quality. The findings underscore the importance of integrating environmental considerations into urban transportation planning and policy formulation, enabling decision-makers to implement sustainable mobility strategies. In conclusion, addressing the environmental impacts of urban transportation requires a multifaceted approach that balances mobility, economic growth, and ecological sustainability, ensuring healthier, quieter, and more resilient urban environments, and the use of simulation tools like the MATLAB GUI model provides a practical framework for continuous monitoring, assessment, and improvement of urban transport systems.

REFERENCES

1. Nayeb-Pashaei, K., Vahabzadeh, S., Hosseinian-Far, A., & Ghoushchi, S. J. (2026). Sustainable urban transportation: key criteria for a greener future. *Spectrum of Operational Research, 3*(1), 103-127.
2. Das, A., David, J. R., Swaminathan, P. P., Chandrasekarabarathi, S., Sudarsan, S. J., & Pandian, P. (2026). Environmental impacts of metro rail construction in chennai on air quality noise pollution and urban sustainability. *Scientific Reports*.
3. Kadakath, R. E., Setty, M. R., Nanjundaswamy, C., Tantri, A., & Naganna, S. R. (2025). Urban transportation challenges: Analysis and the mitigation strategies for road accidents, noise pollution and environmental impacts. *Open Engineering*, *15*(1), 20250123.
4. Xu, S., Sun, C., & Liu, N. (2024). Road congestion and air pollution-analysis of spatial and temporal congestion effects. *Science of the total environment*, *945*, 173896.
5. Monteiro, J., Sousa, N., Coutinho-Rodrigues, J., & Natividade-Jesus, E. (2024). Challenges ahead for sustainable cities: An urban form and transport system review. *Energies*, *17*(2), 409.
6. Abdullah, N. A., Khalaf, D. K., Al-Jameel, H. A., & Ali, M. J. (2023). Selected Indicators of Al-Najaf Road Network: Public Transportation Noise and Pollution. In *E3S Web of Conferences* (Vol. 427, p. 03038). EDP Sciences.
7. Mousavimasouleh, S. O., Salehi, I., Sadeghi, F., Mohammadi Fard, M., & Roshanghalb, A. (2022). Mixed transport network prioritization based on environmental impact and population density. *Journal of Advanced Transportation*, *2022*(1), 6928576.
8. Ribeiro, P., Dias, G., & Pereira, P. (2021). Transport systems and mobility for smart
9. Huu, D. N., & Ngoc, V. N. (2021). Analysis study of current transportation status in Vietnam's urban traffic and the transition to electric two-wheelers mobility. *Sustainability*, *13*(10), 5577.
10. Mavrin, V., Magdin, K., Shepelev, V., & Danilov, I. (2020). Reduction of environmental impact from road transport using analysis and simulation methods. *Transportation Research Procedia*, *50*, 451-457.
11. Gössling, S., Humpe, A., Litman, T., & Metzler, D. (2019). Effects of perceived traffic risks, noise, and exhaust smells on bicyclist behaviour: an economic evaluation. *Sustainability*, *11*(2), 408.