Vol 6, Issue 3, March 2026 www.ijesti.com E-ISSN: 2582-9734
International Journal of Engineering, Science, Technology and Innovation (IJESTI)

# Assessing Air and Noise Pollution Impacts of Urban Transportation for Sustainable City Mobility Planning

**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 play a vital role in supporting mobility, accessibility, and economic development, but they also contribute significantly to environmental degradation. Rapid urbanization, increasing private vehicle use, traffic congestion, and fuel-based transport have intensified air and noise pollution in cities. Emissions such as $PM_{2.5}$, NOx, CO, and $CO_2$ reduce air quality, while vehicle engines, tire friction, and congestion increase harmful noise exposure. Sustainable solutions such as public transport, electric mobility, micro-mobility, non-motorized transport, and intelligent transportation systems can help reduce these impacts. Therefore, environmental assessment is essential for developing healthier and sustainable urban transport policies.

***Keywords:*** *Urban Transportation, Air Pollution, Noise Pollution, Sustainable Mobility*.

## I. INTRODUCTION

Urban transportation systems have become a critical component of modern city development, supporting economic growth, mobility, and accessibility. However, rapid urbanization and increased dependence on motorized transport have intensified environmental challenges, particularly in the form of air and noise pollution. These two pollutants are now recognized as major urban externalities that directly affect human health, ecological balance, and overall quality of life. Transportation-related emissions such as particulate matter ($PM_{2.5}$), nitrogen oxides (NOx), carbon monoxide (CO), and carbon dioxide ($CO_2$) significantly contribute to urban air degradation, while engine operations, tire friction, and traffic congestion generate continuous noise exposure in densely populated areas. Studies have consistently shown that road transport is one of the dominant sources of environmental pollution in cities worldwide, making it a central focus of environmental impact assessment (Mansour & Aljamil, 2022; Al Alim et al., 2025). In addition, the World Health Organization has repeatedly highlighted that prolonged exposure to traffic-related air and noise pollution leads to respiratory diseases, cardiovascular problems, stress, and sleep disturbances, emphasizing the urgent need for sustainable transportation planning.

The environmental burden of urban transportation varies significantly depending on transport modes, traffic density, and urban infrastructure design. Private vehicles and motorcycles are often identified as the highest contributors to both air and noise pollution due to inefficient fuel combustion and high engine vibration levels, whereas public transport systems such as metro rail and buses demonstrate comparatively lower per-capita emissions. Al Alim et al. (2025) found that motorbikes and private vehicles in South and Southeast Asian cities generated extremely high levels of $PM_{2.5}$ and noise pollution, whereas mass rapid transit systems exhibited minimal environmental impact. Similarly, Morales et al. (2025) emphasized that motorcycles, heavy-duty trucks, and aircraft exceed recommended noise thresholds established by global environmental standards, contributing significantly to urban noise stress. These findings highlight the importance of shifting toward sustainable transport modes such as electric mobility, non-motorized transport, and efficient public transit systems. Furthermore, integrated transport policies under frameworks like Avoid–Shift–Improve (ASI) have been recommended to reduce dependency on fossil fuel-based transportation and improve environmental sustainability.

Technological advancements and intelligent transportation systems (ITS) have emerged as promising solutions to mitigate environmental impacts associated with urban mobility. ITS integrates real-time monitoring, data analytics, and adaptive traffic control mechanisms to optimize traffic flow and reduce congestion-related emissions. Zaky and Soubra (2021) proposed an ITS-based model that dynamically routes vehicles based on pollution levels and noise indicators, demonstrating the potential to significantly reduce urban environmental stress. Similarly, Badi et al. (2023) highlighted the role of surveillance systems and decision-making models such as AHP-MARCOS in improving traffic management efficiency and reducing environmental degradation. In addition, emerging technologies such as unmanned aerial systems (UAS) have introduced new challenges related to noise pollution, which require innovative planning approaches. Tan et al. (2024) demonstrated that optimized flight path planning and noise simulation models can significantly reduce both instantaneous and continuous noise exposure in urban airspace. These studies collectively indicate that technological integration plays a crucial role in addressing the environmental challenges posed by modern transportation systems.

Despite advancements in technology and policy frameworks, urban transportation systems continue to face significant sustainability challenges, particularly in rapidly developing regions. Comparative studies across different countries reveal disparities in transport safety, pollution levels, and public transport efficiency, indicating inconsistent policy implementation and infrastructural development. Janikovičová et al. (2026) reported substantial variations in $PM_{2.5}$ concentrations and noise pollution levels across Visegrad countries, highlighting the need for targeted environmental policies. Similarly, Kuşkapan (2026) demonstrated that micro-mobility systems can significantly reduce urban air and noise pollution, with reductions of up to 24% in $PM_{2.5}$ levels and 18% in noise exposure under sustainable transport scenarios. These findings emphasize that environmental impact assessment of urban transportation systems is essential for identifying pollution hotspots, evaluating mitigation strategies, and guiding sustainable urban planning. Therefore, this study focuses on assessing the environmental impacts of urban transportation systems with specific emphasis on air and noise pollution, contributing to the development of sustainable and health-oriented transport policies for future cities.

## II. RESEARCH BACKGROUND

**Kuşkapan (2026)** examined the existing conditions of air and noise pollution along the micro-mobility routes in Erzurum and further evaluated the anticipated changes under a 2030 sustainable transportation scenario. The study reported that measurements had been conducted at 64 locations, where PM2.5 concentrations were considered for assessing air pollution and sound levels for evaluating noise pollution. It was noted that, based on Turkey’s 2030 sustainability targets, a scenario had been developed for 14 distinct areas to analyze the impact of increased micro-mobility usage. The findings indicated that PM2.5 levels had shown a general decline, with reductions reaching up to 24% in certain regions, while noise pollution had decreased by approximately 18%. Additionally, spatial distribution maps had been generated using ArcGIS 10.3.1 to compare present and projected conditions. The study concluded that micro-mobility played a significant role in reducing urban pollution and offered valuable implications for sustainable urban planning and policy formulation.

**Janikovičová et al. (2026)** investigated disparities in road traffic fatality rates, noise pollution, PM2.5 concentrations, and public transport utilization among the Visegrad Four (V4) countries, namely Czechia, Slovakia, Hungary, and Poland. The study addressed how these differences reflected the implementation and effectiveness of transport policies in the region. A comparative analysis of secondary data obtained from European environmental and transport databases was employed, using a mixed-method approach to examine trends from 2015 to 2023. The findings indicated significant variations in transport safety, air quality, and public transport usage across the countries. It was reported that Poland had the highest road traffic fatality rates, while Czechia performed better in managing noise pollution. PM2.5 exposure remained a major concern, particularly in Hungary and Slovakia. The study further highlighted differing recovery patterns in public transport use following the COVID-19 pandemic and emphasized the need for targeted, sustainable policy interventions.

**Morales et al. (2025)** conducted a systematic review to examine transportation noise pollution as a significant environmental and public health issue, particularly in urban areas experiencing increased traffic density. The authors reported that prolonged exposure to high noise levels had been associated with adverse health effects such as hearing impairment, sleep disturbances, stress, and cardiovascular risks. The study compared noise levels across various transport modes with World Health Organization standards and found that motorcycles, heavy trucks, and auto-rickshaws exceeded recommended limits, while buses slightly surpassed acceptable thresholds. In contrast, subways and streetcars remained within permissible levels. Aircraft were identified as producing the highest noise levels, whereas bicycles generated the lowest. The review further indicated that engine vibrations, exhaust systems, and traffic dynamics were major noise sources. It was concluded that mitigation strategies, including advanced vehicle technologies, infrastructure improvements, and stricter policy enforcement, were essential, though existing measures required stronger implementation.

**Al Alim et al. (2025)** examined the contribution of urban transportation systems to environmental degradation in rapidly urbanizing cities across South and Southeast Asia. The study was conducted in Dhaka, Karachi, Bhopal, and Jakarta, where environmental impacts of various transportation modes were evaluated using key indicators such as $CO_2$ emissions, $PM_{2.5}$ concentrations, and noise pollution levels. Data were compiled from standardized environmental databases, and Pearson correlation analysis was performed using R software to identify relationships among the variables. The findings revealed that motorbikes and private vehicles had imposed the highest environmental burden, with emissions reaching up to 0.25 kg $CO_2$ per passenger-kilometer and $PM_{2.5}$ levels of 172.2 µg/m³, along with noise levels of 90 dB. In contrast, MRT systems and bicycles were found to have minimal environmental impacts. A strong positive correlation between $PM_{2.5}$ and noise levels was also reported, indicating cumulative environmental stress. The study recommended the adoption of sustainable transportation strategies under the ASI framework.

**Tan et al. (2024)** investigated the issue of noise pollution generated by low-altitude flights of unmanned aircraft systems (UASs), particularly in urban environments. The study aimed to address noise considerations in UAS flight planning and examined the feasibility of implementing low-noise flight operations at a micro level. A virtual flight simulator was employed to model noise impacts under realistic flight conditions, while flight paths were optimized using a heuristic algorithm. The noise assessment incorporated sound source modeling for practical UAS configurations along with a Gaussian beam tracing method to simulate outdoor noise propagation. Case studies were conducted in both residential communities and metropolitan areas to evaluate variations in noise exposure across different flight paths. The findings indicated that the proposed approach significantly reduced both instantaneous and continuous noise levels compared to conventional shortest-path methods. The study concluded that such techniques could effectively support quieter, sustainable, and environmentally friendly urban air transport systems.

**Badi et al. (2023)** examined the role of information technology in developing intelligent transportation systems aimed at integrating existing and emerging solutions for efficient traffic and transportation network management under dynamic conditions. The authors reported that such systems had been widely implemented in Western countries to enhance traffic safety and reduce losses caused by inadequate planning. However, it was observed that transportation systems in developing countries continued to face significant challenges, including high accident rates, congestion, and environmental pollution from vehicle emissions. The study aimed to identify the most suitable technology to address traffic issues in Libya using multi-criteria decision-making techniques. A hybrid model combining the Analytic Hierarchy Process (AHP) and MARCOS method was employed. The findings indicated that surveillance cameras received the highest priority weight of 28%, demonstrating their effectiveness in improving safety, environmental sustainability, and overall system efficiency.

**Mansour and Aljamil (2022)** reported that traffic congestion had a significant impact on the environment and was identified as a predominant source of both noise and air pollution. The study indicated that the sound generated by vehicles, along with frequent honking, created highly unfavorable environmental conditions. It was observed that the increasing volume of motorized traffic contributed substantially to rising externalities, including vehicular emissions and atmospheric pollutants, which adversely affected environmental quality and led to issues such as global warming and climate change. The authors highlighted that vehicle emissions posed serious long-term risks at both regional and global levels. Based on field data collected during peak traffic periods across different cities, the study found that major pollutants emitted from engines included nitrogen oxides (NOx), carbon monoxide (CO), unburned hydrocarbons (CxHy), sulfur oxides (SOx), particulate matter including aerosols, and carbon dioxide ($CO_2$).

**Zaky and Soubra (2021)** examined the growing environmental challenges of air and noise pollution in urban areas, identifying road vehicles as major contributors to both forms of pollution. The study highlighted that increasing pollution levels had posed significant risks to human health and environmental sustainability, thereby necessitating effective management strategies. The authors proposed an Intelligent Transportation System (ITS) aimed at monitoring and controlling pollution generated by vehicular traffic. Their system was designed to dynamically route vehicles by considering particle emissions and noise indicators alongside real-time urban pollution levels and predefined thresholds. It was observed that such an approach could optimize traffic flow while minimizing environmental impact. Furthermore, the study suggested that the proposed system could be effectively utilized for implementing pollution-based road pricing mechanisms, such as tolls or taxes, to regulate vehicular emissions and encourage environmentally responsible transportation practices.

**Makarova et al. (2020)** observed that the transport sector had been identified as one of the largest contributors to environmental pollution and hydrocarbon consumption. It was reported that fluctuations in oil prices, along with the growing need to mitigate environmental degradation, had prompted countries to adopt alternative technologies. The authors categorized emission reduction measures into three groups: constructive, organizational-technological, and organizational-managerial approaches. It was further noted that improving the environmental sustainability of urban transport systems depended on increasing the share of "green" vehicles, including trams, trolleybuses, electric buses, and natural gas-powered vehicles. The study highlighted that electric vehicles had reduced air pollution, noise, and vibration, enhancing their competitiveness; however, their silent operation was considered a potential risk to pedestrian safety. Additionally, road traffic accidents were found to exacerbate congestion and environmental impact. The selected intersection in Naberezhnye Chelny was analyzed for emissions and noise, and appropriate mitigation measures were proposed.

**Yañez-Pagans et al. (2019)** examined the transportation challenges faced by urban areas in Latin America and the Caribbean and reviewed causal evidence regarding the impacts of various urban transport system interventions implemented globally. The study aimed to identify key lessons and highlight knowledge gaps to inform the design and evaluation of future transport investments. It was reported that causal studies were largely concentrated in specific domains and predominantly conducted in developed countries. The authors noted that empirical challenges, such as the non-random placement of interventions and their network-wide effects, limited the number of causal evaluations. The literature was found to focus mainly on housing impacts, indicating increases in property values and rents, influenced by system quality and perceived permanence. Limited attention had been given to socioeconomic outcomes, primarily employment access, while displacement effects remained largely unexplored. Emerging research utilizing big data and satellite information, along with studies on operational efficiency and user behavior, was also highlighted.

## III. KEY FINDINGS FROM STUDY

| Author (Year) | Objective | Methodology | Key Findings | Research Gap |
|---|---|---|---|---|
| Kuşkapan (2026) | To assess air and noise pollution impacts of micro-mobility systems and future sustainable scenarios | Field measurements at 64 locations; PM2.5 and noise level analysis; GIS-based spatial mapping | PM2.5 reduced up to 24% and noise reduced by 18% under 2030 micro-mobility scenario | Limited long-term validation of micro-mobility policies across diverse cities |
| Janikovičová et al. (2026) | To compare road safety, air pollution, noise, and public transport usage in V4 countries | Secondary data analysis (2015–2023); comparative statistical approach | Significant regional variation; Poland highest fatalities, Hungary/Slovakia high PM2.5 exposure | Lack of micro-level urban transport intervention analysis |
| Morales et al. (2025) | To review health impacts of transportation noise pollution | Systematic literature review | Vehicles exceed WHO noise limits; aircraft highest noise source; bicycles lowest impact | Need for real-time noise mitigation strategies in urban traffic systems |
| Al Alim et al. (2025) | To evaluate environmental impacts of transport in South & Southeast Asian cities | Correlation analysis using R software; secondary datasets | Motorbikes and private vehicles highest emissions; MRT and bicycles lowest impact | Limited policy implementation assessment for sustainable transport transition |
| Tan et al. (2024) | To reduce UAV noise pollution through optimized flight planning | Simulation-based modeling; heuristic optimization; Gaussian beam tracing | Optimized flight paths reduced both instantaneous and continuous noise levels | Need for real-world UAV noise validation in dense urban areas |
| Badi et al. (2023) | To identify ITS solutions for traffic and environmental issues | AHP and MARCOS multi-criteria decision-making model | Surveillance systems ranked highest (28%) for improving efficiency and sustainability | Limited integration with real-time environmental monitoring systems |

| | | | | |
|---|---|---|---|---|
| Mansour & Aljamil (2022) | To analyze effect of traffic flow on pollution and noise | Field traffic data collection during peak hours | High emissions of NOx, CO, SOx, PM, and $CO_2$; strong link between congestion and pollution | Lack of predictive modeling for traffic-induced pollution |
| Zaky & Soubra (2021) | To develop ITS for air and noise pollution management | Algorithm-based dynamic routing model | ITS reduces pollution through real-time traffic routing and control | Limited scalability in developing urban infrastructure |
| Makarova et al. (2020) | To evaluate eco-friendly urban transport strategies | Analytical classification of transport technologies | Electric and green vehicles reduce emissions and noise; safety concerns for EVs | Need for balanced safety–environment optimization models |
| Yañez-Pagans et al. (2019) | To review urban transport interventions and impacts | Systematic review of global causal studies | Transport investments improve property value and accessibility; limited socioeconomic evidence | Lack of studies on displacement and long-term environmental effects |

## IV. CONCLUSION

The environmental impact assessment of urban transportation systems, with specific emphasis on air and noise pollution, highlights a complex interplay between rapid urbanization, mobility demand, and environmental sustainability. The reviewed literature consistently demonstrates that transportation is one of the most significant contributors to urban environmental degradation, primarily through emissions of particulate matter ($PM_{2.5}$), greenhouse gases ($CO_2$), and noise generated from vehicular movement, engine operations, and traffic congestion. Mansour and Aljamil (2022) emphasized that traffic congestion significantly increases pollutant concentration levels, including NOx, CO, SOx, and particulate matter, while also intensifying noise pollution due to frequent vehicle acceleration, deceleration, and honking. Similarly, Morales et al. (2025) confirmed that urban transport noise exceeds World Health Organization safety thresholds in most cases, particularly for motorcycles, heavy-duty vehicles, and aircraft, thereby posing serious risks to human health such as sleep disturbances, cardiovascular stress, and hearing impairment. These findings collectively establish that uncontrolled urban transport growth directly undermines environmental quality and public health in cities. At the same time, comparative studies indicate that the severity of environmental impacts varies significantly across transport modes and urban systems. Al Alim et al. (2025) found that private vehicles and motorcycles contribute disproportionately to both air and noise pollution, whereas mass rapid transit systems and non-motorized transport options such as cycling demonstrate substantially lower environmental footprints. Kuşkapan (2026) further demonstrated that the integration of micro-mobility systems can reduce $PM_{2.5}$ concentrations by up to 24% and noise levels by approximately 18%, indicating that modal shifts toward sustainable transport can produce measurable environmental benefits. Additionally, Janikovičová et al. (2026) highlighted regional disparities in transport efficiency, pollution levels, and safety outcomes across European countries, reinforcing the need for localized policy interventions rather than one-size-fits-all solutions. These findings collectively suggest that sustainable transportation planning must prioritize modal diversification, electrification, and infrastructure redesign to reduce dependency on high-emission transport systems. Technological innovation and intelligent transportation systems (ITS) have emerged as crucial tools for mitigating the adverse environmental impacts of urban mobility. Zaky and Soubra (2021) demonstrated that ITS-based dynamic routing systems can effectively reduce pollution exposure by optimizing traffic flow based on real-time environmental conditions. Similarly, Badi et al. (2023) identified surveillance-based ITS frameworks as highly effective in improving traffic management efficiency and reducing environmental degradation through data-driven decision-making. Moreover, advancements in simulation and optimization techniques, as illustrated by Tan et al. (2024) in the context of unmanned aerial systems, show that noise pollution can be significantly reduced through intelligent path planning and predictive modeling. These technological approaches indicate that the future of urban transportation lies in the integration of smart systems capable of continuously monitoring, predicting, and mitigating environmental impacts in real time. In conclusion, the literature clearly establishes that urban transportation systems are a dominant source of air and noise pollution, but also present significant opportunities for mitigation through sustainable planning, modal shift strategies, and technological innovation. While electric mobility, public transportation enhancement, and micro-mobility systems offer promising reductions in environmental impact, their effectiveness depends on supportive infrastructure, policy enforcement, and public adoption. Furthermore, intelligent transportation systems provide a powerful framework for optimizing urban mobility while minimizing environmental harm. However, gaps remain in long-term empirical validation, integration of real-time environmental monitoring, and the development of universally applicable policy models. Therefore, a holistic approach combining sustainable transport planning, advanced technology deployment, and strong regulatory frameworks is essential to achieve environmentally resilient urban transportation systems in the future.

## V. FUTURE SCOPE

The future scope of environmental impact assessment of urban transportation systems, particularly in relation to air and noise pollution, is highly promising due to rapid advancements in technology, increasing environmental awareness, and global policy shifts toward sustainability. One of the most significant future directions lies in the integration of real-time environmental monitoring systems with intelligent transportation systems (ITS). Future research can focus on developing AI-driven platforms that continuously collect, analyze, and respond to pollution data ($PM_{2.5}$, NOx, $CO_2$, and noise levels) in real time. Such systems can dynamically regulate traffic flow, suggest alternative routes, and even control congestion pricing mechanisms to minimize environmental impacts. With the advancement of Internet of Things (IoT) sensors, smart cities will be able to build highly responsive transportation networks that not only optimize mobility but also actively reduce pollution exposure at micro and macro urban scales. Another important future scope lies in the expansion of electric and hybrid mobility systems. As battery technology improves and charging infrastructure becomes more widespread, electric vehicles (EVs), electric buses, and micro-mobility solutions such as e-scooters and bicycles are expected to dominate urban transportation networks. Future studies can focus on lifecycle environmental assessments of EVs, including battery production, disposal impacts, and energy sourcing from renewable grids. Additionally, the integration of renewable energy sources such as solar-powered charging stations can further enhance sustainability outcomes. Research can also explore policy frameworks that incentivize EV adoption, including subsidies, carbon credits, and congestion-free zones for zero-emission vehicles. Urban planning and infrastructure design also present a major area for future development. The concept of “15-minute cities” and transit-oriented development (TOD) can significantly reduce dependency on private vehicles by ensuring accessibility to essential services within short distances. Future research can evaluate the effectiveness of compact urban design in reducing both air and noise pollution levels. Furthermore, the development of noise barriers using advanced materials, green corridors, and urban forestry can serve as natural mitigation strategies. GIS-based spatial analysis and remote sensing technologies will play a crucial role in identifying pollution hotspots and optimizing urban land-use planning for environmental sustainability. Emerging technologies such as autonomous vehicles (AVs) and unmanned aerial systems (UAS) also open new research pathways. Autonomous vehicles have the potential to reduce traffic congestion and improve fuel efficiency through optimized driving patterns, thereby lowering emissions and noise levels. However, their large-scale adoption requires careful study of mixed traffic environments, safety implications, and infrastructure readiness. Similarly, UAS and urban air mobility systems introduce new challenges related to aerial noise pollution, requiring advanced simulation models and regulatory frameworks for sustainable integration into urban airspace. Finally, future research must emphasize interdisciplinary approaches combining transportation engineering, environmental science, data analytics, and public policy. There is a need for long-term longitudinal studies that assess the cumulative impact of transportation interventions on urban ecosystems. Additionally, greater focus should be placed on social equity, ensuring that sustainable transportation solutions are accessible to all population groups, including low-income and marginalized communities. Overall, the future scope of this field lies in building smart, low-carbon, and health-centric urban transportation systems supported by advanced technologies, sustainable infrastructure, and evidence-based policymaking aimed at achieving global environmental sustainability goals.

## REFERENCES

1. Kuşkapan, E. (2026). Long-term impact of micro-mobility on air and noise pollution: A GIS approach. *Urban Climate*, *65*, 102774.
2. Janikovičová, S., Pártlová, P., & Pollák, F. (2026). Comparative analysis of Road Safety, Air Pollution, Public Transport and Noise Disturbance Policies in the V4 countries. *Transportation Research Procedia*, *93*, 57-70.
3. Morales, J. J. P., Resuello, J. L. S., Camacho, M., & Estorico, G. C. (2025). Noise Pollution in Urban Transport: A Systematic Review of Health Impacts from Buses, Trains, and Motorcycles. *Int. J. Innov. Sci. Res. Technol*, *10*, 564-576.
4. Al Alim, M., Hoque, M., Hore, S., & Hore, R. (2025). Environmental impacts of transportation in rapidly urbanizing South and Southeast Asian Cities. *Smart Construction and Sustainable Cities*, *3*(1), 16.
5. 15.Tan, Q., Li, Y., Wu, H., Zhou, P., Lo, H. K., Zhong, S., & Zhang, X. (2024). Enhancing sustainable urban air transportation: Low-noise UAS flight planning using noise assessment simulator. *Aerospace Science and Technology*, *147*, 109071.
6. Badi, I., Bouraima, M. B., & Muhammad, L. J. (2023). The role of intelligent transportation systems in solving traffic problems and reducing environmental negative impact of urban transport: *Decision Making and Analysis*, 1-9.
7. Mansour, A. I., & Aljamil, H. A. (2022, January). Investigating the effect of traffic flow on pollution, noise for urban road network. In *IOP Conference Series: Earth and Environmental Science* (Vol. 961, No. 1, p. 012067). IOP Publishing.
8. Zaky, M. O., & Soubra, H. (2021). An Intelligent Transportation System for Air and Noise Pollution Management in Cities. In *VEHITS* (pp. 333-340).
9. Makarova, I. V., Gabsalikhova, L. M., Sadygova, G. R., & Magdin, K. A. (2020, March). Ways to improve safety and environmental friendliness of the city's transport system. In *IOP Conference Series: Materials Science and Engineering* (Vol. 786, No. 1, p. 012072). IOP Publishing.
10. Yañez-Pagans, P., Martinez, D., Mitnik, O. A., Scholl, L., & Vazquez, A. (2019). Urban transport systems in Latin America and the Caribbean: lessons and challenges. *Latin American Economic Review*, *28*(1), 1-25.