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STATISTICAL ANALYSIS AND IMPACT ASSESSMENT OF CAR FLEET POLLUTION: CASE STUDY IASI CITY, ROMANIA

BY

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Abstract. This study evaluates the environmental and quality-of-life impacts of the vehicle fleet in Iași, Romania (2020–2023), using the Rapid Impact Assessment Matrix (RIAM). Findings reveal a 7% annual fleet growth, with over 60% of vehicles exceeding 10–16 years in age. RIAM results consistently indicate a significant negative impact (-D) on air quality and urban well-being. While passenger cars and goods transport drive these negative effects, public and special-purpose transport offer mitigating benefits. Current adoption of hybrid and electric vehicles remains insufficient to offset the cumulative pressures of fleet expansion and ageing. The study validates RIAM as an effective integrated assessment tool and provides evidence-based support for policies targeting fleet renewal, low-emission public transport expansion, and mobility management in medium-sized cities.

Keywords: urban mobility, vehicle fleet, air quality, quality of life, RIAM, Iași.

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1. Introduction

Urban mobility has become a critical challenge for contemporary cities, as the continuous growth of private vehicle ownership intensifies environmental pressures and negatively affects urban quality of life. Road transport is one of the dominant sources of air pollution in urban areas, contributing significantly to emissions of nitrogen oxides (NO_x), particulate matter (PM_{2.5} and PM₁₀), carbon monoxide (CO) and carbon dioxide (CO₂) (Barber *et al.*, 2010). Extensive epidemiological evidence links traffic-related air pollution to increased risks of respiratory and cardiovascular diseases, premature mortality, and reduced life expectancy, particularly in densely populated urban environments (Hoek *et al.*, 2002; Kampa and Castanas, 2008; World Health Organization, 2016).

In addition to air pollution, vehicle traffic represents a major source of environmental noise, which has been associated with a wide range of adverse health outcomes, including sleep disturbances, increased stress levels, cognitive impairment, and cardiovascular effects (Babisch, 2005; Stansfeld and Matheson, 2003; World Health Organization, 2018). Traffic congestion further amplifies these impacts by increasing travel times, fuel consumption, and pollutant emissions, while simultaneously reducing transport efficiency and overall urban accessibility (Barth and Boriboonsomsin, 2008; Litman, 2013).

Together, air pollution, noise, and congestion interact to degrade multiple dimensions of urban quality of life. Medium-sized cities face distinct challenges in managing these pressures. Unlike large metropolitan areas, they often experience rapid growth in private vehicle fleets combined with aging vehicle stocks, high reliance on fossil fuels, and limited capacity to implement restrictive mobility policies. In many Eastern European cities, the widespread use of second-hand vehicles compliant with older Euro emission standards continues to exacerbate environmental impacts, despite recent progress in public transport modernisation and the gradual introduction of hybrid and electric vehicles (European Environment Agency, 2020a, 2020b).

Assessing the impacts of urban vehicle fleets therefore requires integrated approaches capable of capturing cumulative environmental and quality-of-life effects. Conventional single-indicator analyses are insufficient to reflect the complex interactions between emissions, noise, congestion, public health, and urban life capacity. Integrated assessment frameworks offer a more comprehensive perspective by combining multiple impact dimensions within a transparent and systematic structure (Sluser *et al.*, 2022). Among these, the Rapid Impact Assessment Matrix (RIAM) has been successfully applied in environmental impact and risk assessment studies to synthesise environmental, social, and economic effects into comparable impact categories (Sluser, 2023).

Applications of the RIAM demonstrate its continued relevance as a structured framework for integrating heterogeneous environmental impacts, while also showing that its application remains largely focused on individual

projects, specific environmental pressures, or sector-specific activities. Recent studies have applied RIAM to environmental assessment under exceptional conditions, such as the COVID-19 pandemic (Abbasi *et al.*, 2024), as well as to resource-extraction and land-use activities (Ferraz *et al.*, 2024), while other recent work has proposed modifications to the traditional RIAM scoring framework in response to methodological ambiguities (Lak *et al.*, 2025). However, its application to an entire urban vehicle fleet, considered as an integrated city-scale system and evaluated across multiple environmental and quality-of-life dimensions, remains comparatively limited.

At the same time, recent transport research has increasingly recognised vehicle fleet composition as an important determinant of urban environmental performance and as a relevant basis for evaluating mobility policies. Pérez Rodríguez and Castellanos Díez (2024), for example, demonstrated the usefulness of vehicle fleet characterisation for assessing the effects of local measures on urban pollutant and greenhouse-gas emissions in Madrid. Similarly, Nisyrios *et al.* (2024) developed a methodological framework combining fleet composition, modal choice, traffic simulation, emission modelling, and future scenarios to evaluate the effects of alternative vehicle fleet configurations on urban emissions. These approaches provide increasingly detailed quantitative assessments of transport-related emissions, focusing primarily on emission outcomes and scenario-based transport modelling.

A specific research gap can be identified in the integrated assessment of urban vehicle fleets as systems that simultaneously generate multiple environmental pressures while fulfilling essential mobility functions. An RIAM-based approach can provide a complementary perspective by allowing different vehicle categories to be evaluated within a common framework that incorporates air quality, traffic-related noise, congestion, and urban quality of life. Rather than relying exclusively on individual emission indicators or traffic-performance measures, this approach enables the relative environmental and functional contributions of different vehicle categories to be considered together. The resulting assessment is therefore contextual and integrative rather than algorithmic: the contribution lies in extending the application of RIAM to a city-scale urban mobility system and in using vehicle fleet characteristics as the basis for comparing heterogeneous environmental and quality-of-life effects.

Accordingly, the objective of the research is to assess the environmental and quality-of-life impacts associated with the urban vehicle fleet of Iași, Romania, using official vehicle registration data for the 2020–2023 period and the RIAM methodology. The assessment focuses on the major vehicle categories and their implications for air quality, traffic-related noise, congestion, and urban quality of life. By linking vehicle fleet characteristics with integrated RIAM impact classifications, the research provides a structured basis for interpreting the relative contribution of different vehicle categories to urban environmental pressures and for informing sustainable urban mobility planning (Arnfield, 2003).

2. Materials and Methods

Study Area and Data Sources. The study focuses on Iași municipality, a medium-sized city in north-eastern Romania, which has experienced sustained growth in private vehicle ownership in recent years. Medium-sized cities often face pronounced mobility-related environmental pressures due to ageing vehicle fleets and delayed implementation of restrictive transport policies (OECD, 2020; European Environment Agency, 2020a). The analysis is based on official vehicle registration data for the municipality of Iași covering the period 2020–2023. Data were obtained from national and local authorities, including the Driver’s Licenses and Vehicle Registration Department (DRPCIV), the National Institute of Statistics, and local environmental and transport agencies. Supplementary information on air quality and urban mobility was collected from reports issued by the Iași Environmental Protection Agency and the Municipality, in line with European monitoring practices (European Environment Agency, 2020b). The main variables and their corresponding descriptions are summarised in Table 1.

Table 1
Vehicle fleet data used in the analysis (DRPCIV database, 2026)

Variable	Description	Time period
Total registered vehicles	All registered vehicles in Iași municipality	2020–2023
Passenger cars (M1)	Registered passenger cars	2020–2023
Goods vehicles	Light and heavy goods vehicles	2020–2023
Motorcycles	Registered motorcycles	2020–2023
Buses and minibuses	Public and private transport vehicles	2020–2023
Vehicle age	Share of vehicles >10 years	2020–2023
Fuel type	Gasoline, diesel, hybrid, electric	2020–2023

Figure 1 illustrates the geographical location of the study area within north-eastern Romania. The municipality of Iași was selected because it is representative of medium-sized Eastern European cities experiencing rapid growth in vehicle ownership and increasing transport-related environmental pressures.

Vehicle fleet data include the total number of registered vehicles classified by category (passenger cars, motorcycles, goods vehicles, buses and minibuses, special-purpose vehicles, and agricultural vehicles), age structure, and fuel type (gasoline, diesel, hybrid, and electric). Passenger cars constitute the dominant share of the fleet and represent the main contributors to traffic-related emissions in urban environments (Hoek *et al.*, 2002; Kampa and Castanas, 2008).

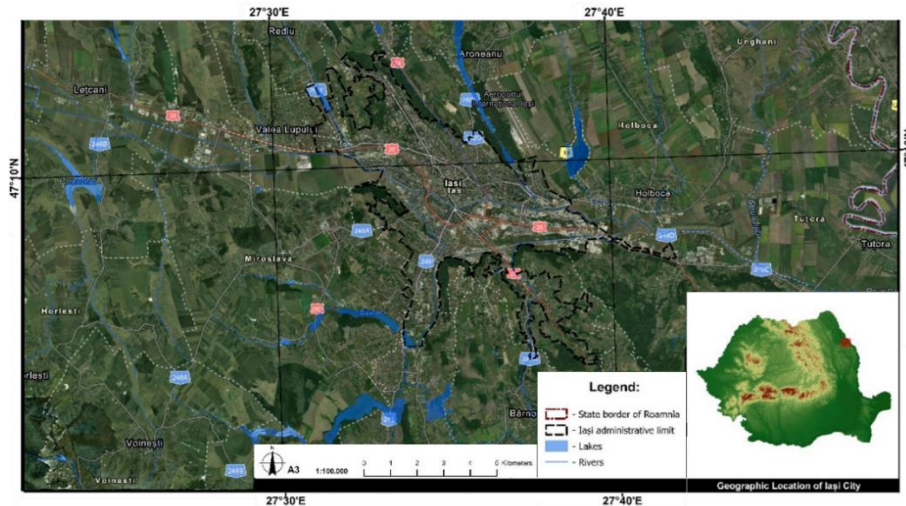


Fig. 1 – Study area – Iasi city.

Vehicle age was used as a proxy for emission performance, as older vehicles are typically associated with higher emissions and lower compliance with recent Euro standards (Seinfeld and Pandis, 2016).

RIAM Methodology. The environmental and quality-of-life impacts of the urban vehicle fleet were evaluated using the Rapid Impact Assessment Matrix (RIAM), also known as the MERI method. RIAM is a structured framework that integrates multiple impact dimensions through a standardised scoring system, enabling transparent comparison across activities and time periods (Sluser *et al.*, 2022; Sluser, 2023). The framework considers two main groups of criteria: (A) the importance and magnitude of the change, and (B) the permanence, reversibility, and cumulative nature of the impact. The scoring ranges and interpretation assigned to each criterion are presented in Table 2.

The RIAM scores were assigned according to the relative importance and expected magnitude of the impacts associated with each vehicle category and impact dimension. The scoring considered the characteristics of the registered fleet, including vehicle category, fleet prevalence, age structure and fuel type, together with the expected contribution of each category to air quality, traffic-related noise, congestion and quality of life. The same scoring principles were applied consistently to all vehicle categories to ensure comparability of the assessment. Negative scores indicate adverse environmental or urban effects, whereas positive scores indicate a net beneficial contribution within the assessed impact dimension. The resulting scores should therefore be interpreted as comparative impact classifications rather than direct measurements of pollutant concentrations, noise levels or traffic intensity.

The environmental score (ES) was calculated as in equation 1 (Eq. (1)-(3)):

$$(A_1 \times A_2) = A_T \quad (1)$$

$$(B_1 + B_2 + B_3) = B_T \quad (2)$$

$$ES = A_T \times B_T \quad (3)$$

Table 2*RIAM scoring framework applied in the study (Sluser et al., 2022)*

Criterion group	Criterion	Score range	Interpretation
A	Importance (A_1)	0–4	Spatial and social relevance
A	Magnitude (A_2)	–3 to +3	Intensity and direction of change
B	Permanence (B_1)	1–3	Duration of impact
B	Reversibility (B_2)	1–3	Recovery potential
B	Cumulativeness (B_3)	1–3	Cumulative nature of impact

Impacts were subsequently classified into RIAM categories ranging from major positive (+E) to major negative (–E). The RIAM scores were assigned for each vehicle category based on the relative importance, magnitude, permanence, reversibility and cumulative nature of the identified impacts, considering the fleet characteristics described above. The same scoring logic was consistently applied across all vehicle categories and impact indicators to ensure comparability between assessment results.

Evaluator assumptions. The assessment assumes that the relative contribution of each vehicle category can be consistently characterised using the available fleet data and the RIAM scoring criteria. In assigning the scores, greater negative impacts were associated with vehicle categories characterised by greater fleet presence, older vehicle structure and higher expected environmental pressure, while positive scores were assigned where the functional contribution of vehicles to public services, accessibility, safety or urban mobility was considered to provide an overall beneficial effect. These assumptions were applied consistently across the assessment.

Impact Indicators. To capture the multidimensional effects of the urban vehicle fleet, the assessment considered a set of environmental, mobility, and quality-of-life indicators related to air quality, traffic-related noise, congestion, and overall urban quality of life, as presented in Table 3. These indicators reflect established links between transport activity, environmental degradation, and human well-being (Babisch, 2005; Stansfeld and Matheson, 2003; Litman, 2013; World Health Organization, 2016). The selected indicators were not treated as directly measured variables within the RIAM framework. Instead, they were used as impact dimensions for the qualitative assessment of the environmental and quality-of-life effects associated with each vehicle category.

Table 3
Quality-of-life indicators considered in the RIAM assessment

Impact category	Indicator	Unit / scale	Relevance
<i>Air quality</i>	<i>CO₂, CO, NO_x, PM</i>	<i>Qualitative (RIAM)</i>	<i>Public health</i>
<i>Noise</i>	<i>Traffic-related noise</i>	<i>Qualitative (RIAM)</i>	<i>Well-being</i>
<i>Traffic</i>	<i>Congestion level</i>	<i>Qualitative (RIAM)</i>	<i>Mobility efficiency</i>
<i>Urban quality of life</i>	<i>Health and comfort</i>	<i>Integrated indicator</i>	<i>Urban livability</i>

Impact Classification and Analysis. Based on the calculated environmental scores (ES), impacts were classified according to the RIAM classification system, ranging from major positive (+E) to major negative (−E). The classification was performed separately for each vehicle category and impact dimension, followed by an overall comparison of the resulting impact categories. The assessment was applied to each vehicle category for all analysed years (2020–2023), allowing comparison of impact intensity across categories and over time. This approach supports concise, policy-relevant interpretation of cumulative urban mobility impacts (OECD, 2020).

Assessment Procedure. The assessment procedure was designed to evaluate the environmental and quality-of-life impacts associated with the main vehicle categories registered in Iași during the 2020–2023 study period. The procedure followed a consistent sequence of steps, allowing the different vehicle categories and impact dimensions to be compared within the RIAM framework. First, the registered vehicle fleet was characterised according to vehicle category, fleet size, vehicle age, and fuel type. The vehicle categories considered in the assessment were passenger cars, goods vehicles, motorcycles, buses and minibuses, and special-purpose vehicles. These characteristics were used to establish the relative importance and potential environmental significance of each vehicle category. Secondly, the assessment considered four main impact dimensions: air quality, traffic-related noise, traffic congestion, and urban quality of life. For each vehicle category, the potential direction and magnitude of the identified impacts were evaluated using the RIAM criteria presented in Table 2.

Third, the RIAM criteria were assigned consistently for each vehicle category and impact dimension. Criteria A₁ and A₂ were used to describe the importance and magnitude of the identified change, while criteria B₁, B₂, and B₃ represented permanence, reversibility, and cumulative characteristics, respectively. The environmental score (ES) was subsequently calculated according to the RIAM equations (1), (2) and (3).

The resulting environmental scores were then converted into the corresponding RIAM impact categories, ranging from major positive to major

negative impacts. The assessment was performed consistently across all vehicle categories and impact dimensions, allowing the relative contribution of each category to the overall environmental and urban quality-of-life impact to be compared.

Finally, the resulting RIAM classifications were compared between vehicle categories and across the 2020–2023 period. This comparison was used to identify the vehicle categories associated with the most pronounced negative or positive impacts and to support the interpretation of the overall effects of the urban vehicle fleet in Iași.

Assessment uncertainty. Given the qualitative and semi-quantitative nature of RIAM, a degree of uncertainty is inherently associated with the assignment of evaluator scores. The assessment was therefore designed to emphasize the relative differences between vehicle categories rather than absolute numerical estimates of environmental impacts. The consistency of the scoring criteria across all categories was used to minimize evaluator-related variability. The resulting RIAM classifications were interpreted in conjunction with the underlying fleet characteristics and should be considered indicative of relative impact magnitude rather than as direct measurements of environmental conditions.

3. Results and Discussion

Vehicle Fleet Evolution and Structural Characteristics. The analysis of vehicle registration data for Iași over the 2020–2023 period indicates a continuous expansion of the urban vehicle fleet, with an average annual growth rate of approximately 7%. Passenger cars constituted the dominant vehicle category throughout the analysed period, followed by goods transport vehicles and motorcycles. Although the share of hybrid and electric vehicles gradually increased, gasoline- and diesel-powered vehicles continued to represent most of the registered fleet, indicating the persistent predominance of conventional propulsion systems.

A further important characteristic of the fleet was its relatively advanced age structure. More than 60% of the registered vehicles were older than 10–16 years, suggesting a substantial proportion of vehicles with potentially lower emission performance than newer vehicle generations. This age profile may contribute to increased environmental pressure associated with urban road transport, particularly when combined with the continued dominance of conventional gasoline and diesel vehicles.

The observed fleet evolution was further examined using descriptive indicators, including the annual change in total registrations and the relative contribution of each vehicle category. Given the limited four-year observation period (2020–2023), the analysis was restricted to descriptive trends rather than inferential statistical testing. This approach allows the main structural changes in

the fleet to be identified without overstating the statistical significance of short-term variations.

Additionally, the fleet structure observed in Iași is broadly consistent with patterns reported for medium-sized cities in Eastern Europe, where the continued use and import of second-hand vehicles contribute to fleet ageing and the persistence of older vehicle technologies (European Environment Agency, 2020a, 2020b). Recent studies from other European urban areas have similarly identified vehicle fleet composition, vehicle age, and the gradual penetration of low-emission vehicles as important factors influencing the environmental performance of urban mobility systems.

Changes in fleet composition have also been shown to influence urban transport emissions and the effectiveness of local mobility policies. However, direct numerical comparisons between Iași and other cities should be treated with caution because of differences in fleet structure, traffic conditions, data availability, and assessment methodologies.

In the context of Iași, the simultaneous growth of the vehicle fleet, the high proportion of older vehicles, and the predominance of conventional fuel types therefore represent important structural characteristics for interpreting the subsequent RIAM assessment of environmental and quality-of-life impacts. The results are consequently interpreted in terms of broader urban mobility patterns rather than as a direct ranking of cities.

The present assessment does not provide a direct emission inventory for NO_x , PM_{10} , $\text{PM}_{2.5}$ or CO_2 , as the available dataset consists primarily of vehicle registration and fleet-structure information. Consequently, the RIAM assessment should not be interpreted as a quantitative estimate of pollutant emissions. Instead, the observed fleet characteristics, including vehicle category, age and fuel composition, are used to support the relative assessment of potential environmental impacts.

RIAM Impact Assessment Results. The RIAM assessment revealed distinct impact patterns among the vehicle categories considered in Iași during the 2020–2023 study period. As presented in Table 4, passenger cars exhibited the most pronounced overall negative impact classification, followed by goods vehicles and motorcycles. In contrast, buses and minibuses and special-purpose vehicles received positive overall RIAM classifications. The results indicate that the contribution of individual vehicle categories to environmental and quality-of-life impacts differs considerably according to their role and characteristics within the urban transport system.

The results presented in Table 4 show that passenger cars represent the vehicle category associated with the strongest overall negative impact, classified as –D. This category received a –D classification for air quality, congestion, and quality of life, while the impact associated with traffic-related noise was classified as –C. The consistently negative classifications across the assessed dimensions indicate that passenger cars constitute the principal source of negative

impact within the evaluated urban vehicle fleet. Their dominant position within the fleet, together with the relatively advanced age of a substantial proportion of registered vehicles and their intensive use in urban mobility, provides an important context for interpreting these results.

Table 4
RIAM impact scores by vehicle category

Vehicle category	Air quality	Noise	Congestion	QoL	Overall
<i>Passenger cars</i>	−D	−C	−D	−D	−D
<i>Goods vehicles</i>	−C	−C	−C	−C	−C
<i>Motorcycles</i>	−A	−A	−A	−A	−A
<i>Buses & minibuses</i>	+B	−A	+B	+B	+B
<i>Special-purpose vehicles</i>	+C	−A	+C	+C	+C

Goods vehicles were classified as −C across all assessed impact dimensions, including air quality, noise, congestion, and quality of life. Although their overall impact was less pronounced than that associated with passenger cars, the consistent negative classification across all indicators indicates a substantial contribution to the cumulative environmental and urban mobility pressures. This result is particularly relevant in the context of goods transport, where vehicle operation contributes simultaneously to traffic activity, environmental pressures, and congestion within the urban area.

Motorcycles exhibited a lower overall impact classification, with −A assigned consistently across all assessed dimensions. Although the direction of the impact remained negative, the lower classification compared with passenger cars and goods vehicles indicates a comparatively less pronounced contribution to the integrated RIAM impact under the assessment framework applied in this study.

In contrast, buses and minibuses exhibited a mixed impact pattern. Their impact on air quality, congestion, and quality of life was classified as +B, whereas traffic-related noise received a −A classification. The positive overall classification (+B) therefore reflects the balance between the negative noise impact and the positive contribution associated with the other assessed dimensions. This pattern indicates that the role of buses and minibuses within the urban transport system extends beyond their direct environmental burden and includes their contribution to mobility and accessibility.

A similar but more pronounced positive pattern was observed for special-purpose vehicles, which received +C classifications for air quality, congestion, quality of life, and overall impact, while their noise impact was classified as −A. The positive overall classification reflects the role of these vehicles in essential urban functions, including emergency services, police, and sanitation. Consequently, although their operation may generate environmental pressures,

their contribution to essential urban services and mobility-related functions results in a positive integrated RIAM classification within the assessment framework used in this study. This interpretation is consistent with the broader understanding of transport systems in which vehicle impacts must be considered in relation to their specific urban functions and societal benefits (Litman, 2013; OECD, 2020).

The overall pattern identified in Table 4 is also consistent with previous evidence linking road-traffic activity to air pollution, environmental noise, and adverse effects on urban well-being. Traffic-related exposure has been associated with increased health risks and reduced urban livability, particularly in areas characterized by high transport intensity (Hoek *et al.*, 2002; Babisch, 2005; Kampa and Castanas, 2008). Within the present assessment, the strongest negative classification was associated with passenger cars, while the positive classifications of buses, minibuses, and special-purpose vehicles emphasize the importance of considering both the environmental burden and the functional role of different vehicle categories.

Figure 2 provides a consolidated visualization of the RIAM impact scores for the five vehicle categories. The normalized scores facilitate a direct comparison of the relative direction and magnitude of the integrated impacts identified through the RIAM assessment. The figure clearly illustrates the predominance of negative scores for passenger cars, goods vehicles, and motorcycles, in contrast to the positive scores obtained for buses and minibuses and for special-purpose vehicles.

As illustrated in Fig. 2, passenger cars recorded the lowest normalized RIAM impact score (−4), confirming their position as the vehicle category with the strongest overall negative impact. Goods vehicles followed with a score of −3, while motorcycles recorded a less pronounced negative score of −1. In contrast, buses and minibuses achieved a positive score of +2, whereas special-purpose vehicles recorded the highest positive score of +3. The graphical representation therefore reinforces the pattern identified in Table 4, highlighting a clear distinction between vehicle categories associated with predominantly negative impacts and those associated with positive integrated impacts within the RIAM framework.

Overall, the RIAM results demonstrate that the environmental and quality-of-life implications of the urban vehicle fleet are not uniform across vehicle categories. Passenger cars and goods vehicles emerge as the principal categories associated with negative integrated impacts, while buses and minibuses and special-purpose vehicles show positive overall classifications. These differences reflect the distinct roles of the vehicle categories within the urban transport system and provide a basis for the subsequent discussion of impact mitigation and sustainable urban mobility measures.

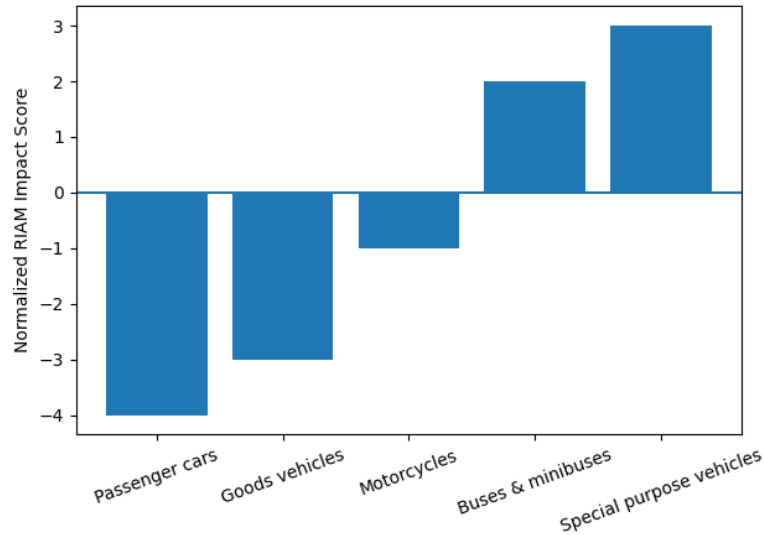


Fig. 2 – Vehicle category impacts based on the RIAM assessment in Iași.

Overall, the RIAM results demonstrate that the environmental and quality-of-life implications of the urban vehicle fleet are not uniform across vehicle categories. Passenger cars and goods vehicles emerge as the principal categories associated with negative integrated impacts, while buses, minibuses and special-purpose vehicles show positive overall classifications. These differences reflect the distinct roles of the vehicle categories within the urban transport system and provide a basis for the subsequent discussion of impact mitigation and sustainable urban mobility measures.

The findings are also broadly consistent with recent research emphasising the importance of vehicle fleet composition in determining the environmental performance of urban mobility systems. Pérez Rodríguez and Castellanos Díez (2024) demonstrated that changes in the circulating vehicle fleet can influence the effectiveness of local measures aimed at reducing transport-related emissions, while Nisyrios *et al.* (2024) showed that alternative fleet compositions can produce substantially different emission outcomes when evaluated through traffic and emission modelling.

The present results complement these approaches by considering not only the potential environmental pressure associated with different vehicle categories, but also traffic-related noise, congestion, and quality-of-life effects within a common RIAM framework. Direct quantitative comparison remains limited, however, because the cited studies employ different datasets, modelling approaches and assessment indicators.

Policy Implications and Impact Mitigation Measures. The persistence of a significant negative RIAM classification (−D), particularly for passenger cars, indicates that technological improvements alone may not be sufficient to

offset the combined pressures associated with continued fleet growth and an ageing vehicle stock. The results therefore support an integrated approach to urban mobility and environmental planning that addresses both vehicle characteristics and travel behaviour. Key measures may include accelerated fleet renewal through vehicle scrappage schemes and incentives for the adoption of low-emission vehicles, the development of low-emission or congestion-restricted zones in central urban areas, and strengthened enforcement of periodic technical inspections to improve compliance with applicable emission standards (World Health Organisation, 2021).

At the same time, reducing the environmental pressures associated with private vehicle use requires the development of effective alternatives to individual motorised transport. The expansion and modernisation of public transport services, together with improved cycling and pedestrian infrastructure, can support a shift towards more sustainable travel modes. Complementary measures promoting car-sharing and electric mobility may further contribute to reducing traffic volumes and transport-related emissions, as demonstrated by experiences reported for several European cities (Pucher and Buehler, 2008; Ercan *et al.*, 2015; Firnkorn and Müller, 2015).

Fleet electrification represents another important component of the transition towards lower-emission urban mobility. Electric vehicle concepts can reduce dependence on conventional fossil-fuel propulsion and offer potential environmental benefits, particularly in urban applications, although their overall sustainability also depends on factors such as energy storage, electricity supply and charging infrastructure (Eberle and von Helmolt, 2010). In the context of the present study, increasing electrification may therefore contribute to reducing the air-quality pressures associated with conventional vehicles, but it should be considered alongside broader measures addressing congestion, mobility demand and urban transport organisation.

From an urban planning perspective, the RIAM results provide a comparative basis for identifying vehicle categories and mobility-related pressures that may require greater attention in the development of environmental and transport strategies. The predominance of negative impacts associated with passenger cars and goods vehicles supports prioritising measures aimed at reducing dependence on private vehicles, improving traffic management, and strengthening sustainable transport alternatives. Conversely, the positive RIAM classifications obtained for buses, minibuses, and special-purpose vehicles highlight the importance of maintaining and improving public transport and essential public-service functions within urban mobility strategies.

The implementation of such measures should therefore not be considered solely in terms of emission reduction. Reducing dependence on private vehicles and strengthening alternative mobility options can also contribute to improved accessibility, mobility efficiency, safety, and overall urban quality of life. In this context, the RIAM assessment can serve as a screening and prioritisation tool for

urban mobility planning, helping to identify categories and impact dimensions requiring greater attention. It is not intended to replace detailed emission inventories, traffic modelling, or environmental monitoring, but rather to provide an integrated comparative perspective that can complement these approaches.

Methodological limitations. Several limitations should be considered when interpreting the results.

First, the assessment is based primarily on vehicle registration and fleet-structure data and does not include direct measurements of pollutant concentrations, traffic-related noise, traffic flows, or vehicle-specific emission rates. Consequently, the RIAM scores should not be interpreted as quantitative measurements of environmental concentrations or emissions, but as comparative classifications of the relative impacts associated with different vehicle categories.

Second, the qualitative and semi-quantitative nature of RIAM introduces a degree of uncertainty related to evaluator judgement and the interpretation of the scoring criteria. Although the same assessment principles were applied consistently across all vehicle categories, a certain degree of subjectivity cannot be completely excluded.

Finally, the analysis covers the 2020–2023 period and therefore reflects the fleet characteristics and mobility conditions represented by the available data rather than long-term future trends. These limitations should be considered when comparing the results with studies based on direct measurements, emission inventories, or transport simulation models.

4. Conclusions

This study assessed the environmental and quality-of-life impacts associated with the urban vehicle fleet in Iași, Romania, by integrating official vehicle registration data for the 2020–2023 period with the Rapid Impact Assessment Matrix (RIAM). The assessment provides an integrated perspective on the effects associated with different vehicle categories, considering air quality, traffic-related noise, congestion, and urban quality of life within a common evaluation framework.

The results indicate that the continuous expansion and relatively advanced age of the vehicle fleet represent important environmental and urban mobility pressures. Passenger cars were identified as the vehicle category associated with the most pronounced negative impacts, while goods vehicles also contributed substantially to the overall negative impact. In contrast, buses and minibuses and special-purpose vehicles showed positive overall RIAM classifications, reflecting their contribution to accessibility, mobility efficiency, and essential urban services despite their associated environmental impacts.

The findings indicate that the gradual introduction of hybrid and electric vehicles has not fundamentally changed the overall impact pattern of the urban fleet during the analysed period. Consequently, improvements in vehicle

technology need to be considered together with fleet renewal and broader urban mobility measures to reduce the cumulative environmental pressures associated with vehicle use.

From a methodological perspective, the study demonstrates the potential of RIAM as an integrated framework for comparing multiple environmental and quality-of-life dimensions associated with urban vehicle fleets. By combining fleet characteristics with a structured impact assessment, the approach provides a transparent basis for identifying vehicle categories that require greater attention within sustainable urban mobility planning.

The main contribution of the study is the development and application of an RIAM-based integrated assessment framework for comparing the environmental and quality-of-life implications of different vehicle categories within a medium-sized Eastern European city. The contribution is therefore primarily contextual and integrative, extending the use of RIAM from conventional project- or activity-based assessments towards city-scale urban fleet assessment. The framework can provide a basis for comparative assessments in other cities facing similar mobility challenges.

Future research should strengthen the present approach by incorporating more detailed quantitative information on emissions, traffic intensity, air quality, noise exposure, and spatial patterns of environmental impacts. The integration of GIS-based assessment and more detailed mobility scenarios could further improve the applicability of the framework for urban transport planning and environmental decision-making

REFERENCES

- Abbasi S., Modibbo U.M., Kolashlou H.J., Ali I., Kavousi N., *Environmental impact assessment with rapid impact assessment matrix method: during disaster conditions*, *Frontiers in Applied Mathematics and Statistics*, **10**, <https://doi.org/10.3389/fams.2024.1344158> (2024).
- Arnfield A.J., *Two decades of urban climate research: A review of turbulence, exchanges of energy and water, and the urban heat island*, *International Journal of Climatology*, **23**(1), 1–26, <https://doi.org/10.1002/joc.859> (2003).
- Babisch W., *Noise and health*, *Environmental Health Perspectives*, **113**(1), A14–A15, <https://doi.org/10.1289/ehp.113-a14> (2005).
- Barber J.R., Crooks K.R., Fristrup K.M., *The costs of chronic noise exposure for terrestrial organisms*, *Trends in Ecology & Evolution*, **25**(3), 180–189, <https://doi.org/10.1016/j.tree.2009.08.002> (2010).
- Barth M., Boriboonsomsin K., *Real-world carbon dioxide impacts of traffic congestion*, *Transportation Research Record*, **2058**(1), 163–171, <https://doi.org/10.3141/2058-20> (2008).
- Eberle U., von Helmolt R., *Sustainable transportation based on electric vehicle concepts: A brief overview*, *Energy & Environmental Science*, **3**(6), 689–699, <https://doi.org/10.1039/B921002J> (2010).

- Ercan T., Zhao Y., Tatari O., Pazour J.A., *Optimization of transit bus fleet's life cycle assessment impacts with alternative fuel options*, *Energy*, **93**, 323–334, <https://doi.org/10.1016/j.energy.2015.09.018> (2015).
- Ferraz C.P.A., Manoel M.P. d. S., Chaves J.V.B., Aiello L.H.F., Silva G.S. d., De Medeiros G.A., Ribeiro A.Í., *Environmental Impacts of Mechanized Timber Harvesting in Eucalyptus Plantations in Brazil*, *Forests*, **15**(8), 1291, <https://doi.org/10.3390/f15081291> (2024).
- Firnkorn J., Müller M., *Free-floating electric carsharing-fleets in smart cities: The dawning of a post-private car era in urban environments*, *Environmental Science & Policy*, **45**, 30–40, <https://doi.org/10.1016/j.envsci.2014.09.005> (2015).
- Hoek G., Brunekreef B., Goldbohm S., Fischer P., van den Brandt P.A., *Association between mortality and indicators of traffic-related air pollution in the Netherlands: A cohort study*, *The Lancet*, **360**(9341), 1203–1209, [https://doi.org/10.1016/S0140-6736\(02\)11280-3](https://doi.org/10.1016/S0140-6736(02)11280-3) (2002).
- Kampa M., Castanas E., *Human health effects of air pollution*, *Environmental Pollution*, **151**(2), 362–367, <https://doi.org/10.1016/j.envpol.2007.06.012> (2008).
- Lak M.G., Gheybi M.J., Chehreghani S., *Application of the modified RIAM method in assessing the environmental impact of municipal solid waste management scenarios (A case study)*, *Heliyon*, **11**(2), e41808, <https://doi.org/10.1016/j.heliyon.2025.e41808> (2025).
- Litman T., *Transportation and public health*, *Annual Review of Public Health*, **34**, 217–233, <https://doi.org/10.1146/annurev-publhealth-031912-114502> (2013).
- Nisyrios E., Amorim M.R.S., Cantelmo G., Gkiotsalitis K., Antoniou C., *Impact assessment of future fleet compositions in vehicle emissions in urban areas: A methodological framework and a case study*, *Case Studies on Transport Policy*, **18**, 101285, <https://doi.org/10.1016/j.cstp.2024.101285> (2024).
- Pucher J., Buehler R., *Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany*, *Transport Reviews*, **28**(4), 495–528, <https://doi.org/10.1080/01441640701806612> (2008).
- Rodríguez J.P., Díez H.C., *Effect of local measures on the update of the circulating vehicle fleet and the reduction of associated emissions: 10 years of experience in the city of Madrid*, *Cities*, **152**, 105214, <https://doi.org/10.1016/j.cities.2024.105214> (2024).
- Seinfeld J.H., Pandis S.N., *Atmospheric chemistry and physics: From air pollution to climate change (3rd ed.)*, Wiley, ISBN-13: 978-1-118-94740-1 (2016).
- Sluser B., *Integrated approach on assessment, treatment and management of environmental pollution*, EcoZone Publishing, ISBN 978-606-8625-38-6, (2023).
- Sluser B., Plavan O., Teodosiu C., *Environmental impact and risk assessment*, In C. Teodosiu, A. Hospido, S. Fiore (Eds.), *Assessing progress toward sustainability* (pp. 145–168), Elsevier, ISBN: 978-0-323-85851-9 (2022).
- Stansfeld S.A., Matheson M.P., *Noise pollution: Non-auditory effects on health*, *British Medical Bulletin*, **68**(1), 243–257, <https://doi.org/10.1093/bmb/ldg033> (2003).
- * European Environment Agency, *Air quality in Europe — 2020 report*, Publications Office of the European Union,

<https://www.eea.europa.eu/en/analysis/publications/air-quality-in-europe-2020> (2020a)

- * * European Environment Agency, *Emissions of the main air pollutants in Europe*, Publications Office of the European Union, <https://www.eea.europa.eu/en/analysis/publications/air-quality-in-europe-2020-report> (2020b).
- * * OECD, *Cities in the World - A New Perspective on Urbanisation*, Organisation for Economic Co-operation and Development, https://www.oecd.org/en/publications/cities-in-the-world_d0efcbda-en.html (2020).
- * * World Health Organization, *Ambient (outdoor) air pollution*, [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health) (2021).
- * * World Health Organization, *Ambient air pollution: A global assessment of exposure and burden of disease*, WHO Press, <https://www.who.int/publications/i/item/9789241511353> (2016).
- * * World Health Organization, *Environmental noise guidelines for the European region*, WHO Press, <https://www.who.int/publications/i/item/9789289053563> (2018).

ANALIZA STATISTICĂ ȘI EVALUAREA IMPACTULUI POLUĂRII GENERATE DE FLOTA AUTO: STUDIU DE CAZ – MUNICIPIUL IAȘI, ROMÂNIA

(Rezumat)

Studiul evaluează impactul parcului auto asupra mediului și calității vieții în municipiul Iași, România, pentru perioada 2020–2023, utilizând Metoda Matricei de Evaluare Rapidă a Impactului (Rapid Impact Assessment Matrix – RIAM). Rezultatele evidențiază o creștere anuală de aproximativ 7% a parcului auto, în condițiile în care peste 60% dintre vehicule au o vechime mai mare de 10–16 ani. Evaluările realizate prin metoda RIAM indică în mod constant un impact negativ semnificativ (-D) asupra calității aerului și a condițiilor de viață din mediul urban. Autoturismele și vehiculele destinate transportului de mărfuri contribuie în principal la aceste efecte negative, în timp ce transportul public și vehiculele cu destinație specială generează efecte de atenuare. Nivelul actual de adoptare a vehiculelor hibride și electrice rămâne insuficient pentru a compensa presiunile cumulative generate de extinderea și îmbătrânirea parcului auto. Studiul confirmă eficiența metodei RIAM ca instrument integrat de evaluare a impactului și oferă o bază fundamentată științific pentru elaborarea unor politici orientate către reînnoirea parcului auto, extinderea transportului public cu emisii reduse și îmbunătățirea managementului mobilității în orașele de dimensiuni medii.