Article

Decarbonizing Urban Transport: Policies and Challenges in Bucharest

Adina-Petruța Pavel [ID] and Adina-Roxana Munteanu *[ID]

UNESCO Chair Engineering for Society, National University of Science and Technology Politehnica Bucharest, 060042 Bucharest, Romania; adina.pavel@upb.ro
* Correspondence: adina.munteanu@upb.ro; Tel.: +40-743-107-484

Abstract

Urban transport is a key driver of greenhouse gas emissions in Europe, making its decarbonization essential to achieving EU climate neutrality targets. This study examines how European strategies, such as the Green Deal, the Sustainable and Smart Mobility Strategy, and the Fit for 55 package, are reflected in Romania's transport policies, with a focus on implementation challenges and urban outcomes in Bucharest. By combining policy analysis, stakeholder mapping, and comparative mobility indicators, the paper critically assesses Bucharest's current reliance on private vehicles, underperforming public transport satisfaction, and limited progress on active mobility. The study develops a context-sensitive reform framework for the Romanian capital, grounded in transferable lessons from Western and Central European cities. It emphasizes coordinated metropolitan governance, public trust-building, phased car-restraint measures, and investment alignment as key levers. Rather than merely cataloguing policy intentions, the paper offers practical recommendations informed by systemic governance barriers and public attitudes. The findings will contribute to academic debates on urban mobility transitions in post-socialist cities and provide actionable insights for policymakers seeking to operationalize EU decarbonization goals at the metropolitan scale.

Keywords: public transport; Bucharest; decarbonization

1. Introduction

Transportation is a major contributor to greenhouse gas (GHG) emissions in Europe. As of the late 2010s, transport emissions accounted for approximately 25% of the EU's total GHG emissions; this share was on an upward trajectory. In response, the European Green Deal outlines an ambitious vision for achieving climate neutrality by 2050, including a targeted 90% reduction in transport-related GHG emissions by mid-century [1]. Achieving these goals requires systemic changes in urban mobility, shifting away from private fossil-fuel vehicles toward more sustainable modes such as electrified public transport, cycling, and walking.

Decarbonizing urban transport is not only a technical challenge but also a complex policy issue involving multiple governance levels. While numerous high-level strategies and roadmaps for transport decarbonization exist at the EU level (including the Sustainable and Smart Mobility Strategy and the "Fit for 55" package) we have identified insufficient scholarly analysis on how these strategies translate into measurable progress at the local level, especially in Central and Eastern Europe, specifically for Romania. This paper addresses that gap. It provides a context-specific, integrative policy and governance analysis

focused on Bucharest, a post-socialist capital with distinct challenges: high car ownership growth, institutional fragmentation, underinvestment in sustainable infrastructure, and weak public engagement mechanisms.

The study's original contribution lies in bridging the disjuncture between EU/national climate goals and on-ground implementation in Bucharest. Drawing on the multi-level governance perspective and referencing the "Avoid–Shift–Improve" framework for sustainable mobility, we evaluate how policy priorities are interpreted and operationalized in Bucharest's urban mobility system. The research objective is thus: to assess the alignment between EU and Romanian decarbonization policies and Bucharest's implementation practices, and to derive a framework that includes recommendations based on lessons for governance, stakeholder coordination, and systemic reform.

Bucharest is an interesting case. With a population of approximately 1.8–2 million and a metropolitan area exceeding 2.5 million, the city faces multiple challenges (e.g., high motorization rates, rising car ownership, severe traffic congestion, and poor air quality). At the same time, it possesses one of Europe's densest public transport networks and a potentially strong base for the transition toward sustainable mobility. Understanding how Bucharest leverages (or fails to leverage) this infrastructure within the wider European policy architecture can provide valuable insights for similar urban contexts in Central and Eastern Europe.

Methodologically, the paper relies on a structured secondary data analysis that combines policy review and urban mobility metrics. The analysis draws from a wide range of sources, including EU and Romanian strategic documents, Bucharest's Sustainable Urban Mobility Plan (SUMP), municipal project reports, official statistical databases (e.g., Eurostat, DRPCIV, INS), and public perception surveys (e.g., Eurobarometer, TomTom Traffic Index).

Stakeholder mapping was conducted to identify the roles, interactions, and governance challenges among key actors, including local and national authorities, transport operators, NGOs, and user groups. This mapping integrates a review of institutional mandates, funding flows, and decision-making competences, particularly focusing on governance fragmentation and coordination barriers in Bucharest.

The paper also uses a comparative approach to benchmark Bucharest against selected European cities (Vienna, Amsterdam, Copenhagen, Paris, Budapest), using indicators such as modal share, satisfaction with public transport, and travel time.

Structured in five main sections, the article starts by introducing the topic and outlines the research objectives and their relevance. Section 2 presents the materials and methods, followed by a detailed review of European Union decarbonization strategies. It then examines how these high-level frameworks are reflected in Romania's national strategies. The section concludes with an analysis of urban transport in Bucharest, covering infrastructure quality, public and private mobility trends, and public perceptions of transport sustainability.

Section 3 proposes a reform framework for Bucharest's public transport system. It introduces six strategic pillars, including governance integration, quality upgrades, clean fuels, micromobility infrastructure, disincentives for car use, and behavior change. It also identifies key stakeholders, institutional roles, and governance challenges, and outlines anticipated barriers and mitigation strategies.

Section 4 discusses the implications of the framework considering the academic literature and international best practices, emphasizing transferable insights for other Central and Eastern European cities. It also outlines limitations and directions for future research.

Section 5 concludes by summarizing key findings and offering policy recommendations to support Bucharest's transition toward a decarbonized and equitable urban mobility system.

2. Materials and Methods

The study employed a policy analysis approach, reviewing major European strategies to assess their implications for urban transport decarbonization. It then examined Romania's alignment with these frameworks through national documents.

This study adopted a qualitative policy analysis approach to investigate how European decarbonization frameworks are translated into local-level interventions in Bucharest. The methodological structure (illustrated in Figure 1) includes the following stages: (1) review of EU-level strategies (i.e., European Green Deal, the Sustainable and Smart Mobility Strategy (SSMS), and the "Fit for 55" package); (2) analysis of Romania's national frameworks and institutional settings (i.e., the National Recovery and Resilience Plan (NRRP) [2] and the draft National Sustainable Mobility Strategy [3]); (3) mapping of governance actors and stakeholder roles (i.e., public and private); (4) synthesis of public transport and mobility data (i.e., STB, TBPI); and (5) assessment of implementation gaps and policy recommendations. The result is a framework for Bucharest's public transport system. The analysis is grounded in secondary data (policy documents, statistics, technical reports, and expert commentary) and uses a conceptual framing informed by multilevel governance theory and the "Avoid–Shift–Improve" (ASI) model for sustainable transport transitions.
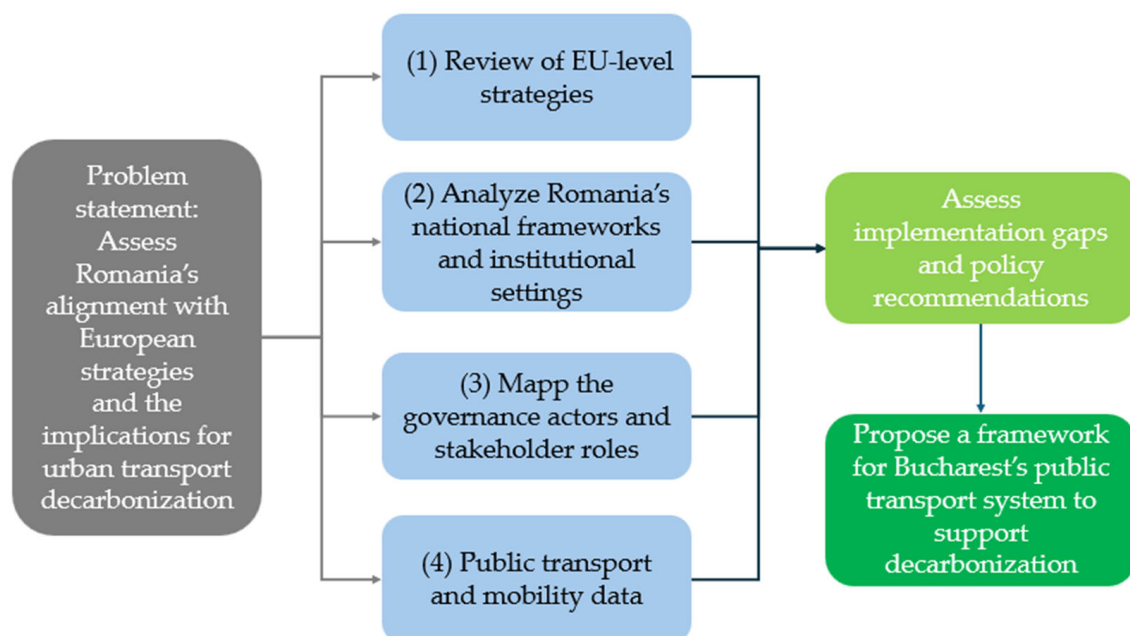

Figure 1. Methodological flow: from problem statement to results.

We reviewed key EU strategic documents: the European Green Deal, the Sustainable and Smart Mobility Strategy (SSMS), and the Fit for 55 legislative package, assessing their implications for urban transport decarbonization. National alignment was explored through Romania's National Recovery and Resilience Plan (NRRP), Sustainable Mobility Strategy, and transport-related policies. Data on Bucharest's public transport system, vehicle fleet composition, and modal shares were collected from local authorities, European mobility databases, and academic sources.

Stakeholder mapping identified the institutional fragmentation in Bucharest's urban mobility governance, distinguishing between national actors (Ministry of Transport, Environment), metropolitan/regional bodies (TPBI), and local agencies (City Hall, STB, Metrorex). Policy coherence and coordination challenges were analyzed considering fragmented responsibilities, political turnover, and limited capacity for long-term implementation.

To ensure policy relevance, we included secondary data such as indicators on infrastructure investment, user behavior trends, and public satisfaction surveys. While no new empirical data were collected, the analysis triangulated between policy intentions and real-world implementation challenges, highlighting the governance dynamics that shape decarbonization outcomes.

2.1. European Policy Frameworks for Decarbonizing Urban Transport

2.1.1. The European Green Deal and Urban Mobility

The European Green Deal (2019) sets the strategic vision: climate neutrality by 2050 with a 90% reduction in transport-related GHG emissions [1]. It promotes a modal shift toward public transport, walking, cycling, and low-emissions vehicles. One flagship initiative, the EU Mission on Climate-Neutral and Smart Cities, aims for 100 climate-neutral cities to test integrated decarbonization models by 2030. Urban transport lies at the core of this mission.

The Intergovernmental Panel on Climate Change (IPCC) defines climate neutrality as a "state in which human activities result in no net effect on the climate system [...] balancing of residual emissions with emissions removal as well as accounting for regional or local bio/geophysical effects of human activities that, for example, affect surface albedo or local climate" [4].

According to one study, climate neutrality for a city under this mission is assessed across three scopes of greenhouse gas (GHG) emissions: (1) direct emissions (scope 1) from sources within the city's boundaries such as transport, buildings, and waste; (2) indirect emissions (scope 2) from the consumption of grid-supplied electricity, heating, or cooling; and (3) emissions (scope 3) from waste and wastewater management [5]. These assessments encompass CO_2, CH_4, N_2O, and, where applicable, industrial gases such as HFCs, PFCs, SF_6, and NF_3.

The guidance outlines core strategies; however, implementation depends on tracking scope 1 to 3 emissions, stakeholder engagement, and long-term investment. Bucharest currently lacks an integrated emissions-monitoring framework and the systematic stakeholder dialogues necessary to align with the Mission's standards.

While Bucharest has initiated steps toward sustainable mobility and energy efficiency, it lacks a comprehensive framework for tracking and reducing emissions across all these scopes. Aligning with the Cities Mission framework would require not only policy commitments but also robust emissions monitoring, stakeholder engagement, and long-term investment strategies [6].

2.1.2. Sustainable and Smart Mobility Strategy (2020)

In December 2020, the European Commission released the Sustainable and Smart Mobility Strategy (SSMS)—a dedicated roadmap for the transport sector to achieve the Green Deal's goals. The SSMS lays out 10 flagship action areas across three broad objectives: making transport sustainable, smart, and resilient [7].

Several of these flagship areas directly address urban transport [7]: boosting the uptake of zero-emissions vehicles and infrastructure; making interurban and urban mobility healthy and sustainable; pricing carbon and incentivizing users; and resilience and a just transition. Notably, the SSMS set quantitative milestones to track progress. By 2030, in addition to the 100 climate-neutral cities, it aims for 30 million zero-emissions cars on European roads, and that scheduled collective travel under 500 km is carbon-neutral (implying that trains, coaches, or electric buses should replace short flights and car trips). By 2050, virtually all vehicles, vans, buses, and new heavy trucks, should be zero-emissions.

These milestones underscore the scale of change expected in urban transport fleets and infrastructure over the next decades.

The Commission's strategy also includes an Action Plan of 82 initiatives for 2021–2024 [3]. Many of these initiatives involve legislative proposals or funding programs such as revisions to vehicle emissions standards; guidelines for urban mobility plans, and funding mechanisms under the Connecting Europe Facility and Cohesion Policy, to support public transport investments. The SSMS effectively operationalizes the Green Deal for transport, providing both a vision and a to-do list for EU institutions and Member States.

2.1.3. The "Fit for 55" Package and Transport Legislation

In 2021, the European Commission introduced the "Delivering the European Green Deal" package- commonly known as "Fit for 55" [8], which comprises a set of legislative proposals to cut EU-wide net emissions by at least 55% by 2030 (from 1990 levels). This package has major implications for transport decarbonization and complements the SSMS with binding measures.

Key Fit for 55 components affecting urban transport include stronger CO_2 emissions standards for vehicles; alternative fuels infrastructure regulation (AFIR); ReFuelEU Aviation and FuelEU Maritime; energy taxation; carbon pricing; and renewable energy and energy-efficiency targets.

The EU agreed on tighter CO_2 standards for new cars and vans, which effectively require a phase-out of new internal combustion engine cars by 2035 (i.e., 100% emissions reduction target for new car sales by 2035). This will accelerate the shift to electric vehicles (EVs) across Member States, including in cities [8].

As part of Fit for 55, the proposal for AFIR sets mandatory targets for electric vehicle (EV) charging and hydrogen refueling infrastructure deployment across Europe. This ensures that countries install sufficient charging points along major highways and in urban areas, making it easier for city dwellers to own EVs. The regulation emphasizes the interoperability and user-friendliness of charging networks [3,8]

Fit for 55 proposed revisions to the Energy Taxation Directive to align tax rates with climate objectives for example, favoring electricity over diesel or gasoline [8]. It also extends the EU Emissions Trading System (ETS) to maritime and (in a new separate system, often called ETS2) to road transport and buildings. The inclusion of road transport in carbon pricing means that fuel suppliers will have carbon costs that could be passed on, indirectly encouraging efficiency and cleaner vehicles. However, to protect citizens, revenues can fund sustainable mobility investments or compensate vulnerable groups.

The Renewable Energy Directive was updated by the Fit for 55 packages with a higher target for renewables (40%+ by 2030) and the Energy Efficiency Directive, with new savings obligations [8]. This matters for transport insofar as the electrification of transport yields bigger emissions benefits as the electricity mix becomes greener. EU countries are also encouraged to support renewable energy in transport (such as via electric public transport or green hydrogen for buses).

In summary, the EU's policy framework creates a multi-pronged push for cleaner urban transport: setting long-term visions (Green Deal); planning concrete steps and milestones (SSMS); and enacting binding measures and targets (Fit for 55 laws). These initiatives stress not only technological change (vehicle electrification, clean fuels) but also modal shift and demand management (encouraging public transport, walking, cycling, and new mobility services in place of car-centric mobility). For EU Member States and cities, these strategies provide both an impetus and support (financial and regulatory) to act. Funding from EU instruments, such as the Recovery and Resilience Facility, Cohesion Funds, and

the Horizon Europe research program, are aligned to these priorities, making substantial resources available for urban mobility projects that contribute to decarbonization.

2.2. Romania's National Strategies for Sustainable Urban Transport

Romania, as an EU Member State, has aligned many of its national plans with the European Green Deal objectives, especially through its National Recovery and Resilience Plan (NRRP) [2] and other strategic documents focusing on sustainability. This section reviews Romania's policy landscape for urban transport decarbonization, highlighting both high-level strategies and specific measures targeting urban mobility based on the NRRP and the Sustainable Mobility Strategy and Related Policies.

2.2.1. National Recovery and Resilience Plan (NRRP)-Green Transition Commitments

In 2021, Romania's NRRP was approved, unlocking EUR 29.2 billion in EU funds to support reforms and investments for recovery from the COVID-19 pandemic and to advance the green and digital transitions. The reform's aim is to "enhance the sustainability of the transport sector by supporting its green and digital transition". This broad goal translates into sub-measures such as road transport decarbonization, alternative fuels infrastructure development, and the adoption of a national road safety strategy.

The NRRP allocates approximately 41% of its EUR 29.2 billion budget to climate actions, including transport reforms [9]. This includes developing 30,000 electric vehicle charging points by June 2026 across Romania, modernizing railway lines, and procuring clean buses for municipalities. This massive expansion of charging infrastructure will support the adoption of electric cars and buses, which is particularly important in cities, like Bucharest, where air pollution from vehicles is acute.

While the scale of investment is noteworthy, the execution has been uneven. For instance, the electrification of public fleets is underway but remains limited in scale, especially outside large cities. Similarly, while reforms, like road decarbonization and road safety strategies, are formalized, their enforcement mechanisms, such as low-emissions zones, remain politically sensitive and delayed, as was seen in the rollback of Bucharest's Oxygen vignette [10,11].

Moreover, the adoption of a National Road Safety Strategy aims to improve safety and act as a complement to sustainability, as safer streets encourage walking and cycling. The strategy (now adopted) includes measures, like speed management, better pedestrian infrastructure, and education, indirectly supporting a shift away from car dependency.

As for the second set of key measures, referring to rail and public transport investment, although urban mobility per se is often managed at city level, the NRRP includes funds for railway modernization and zero-emissions public transport. For instance, there are investments to modernize railway lines (to shift more travel to rail) and to procure clean buses for municipalities. Additionally, the Romanian government announced plans to use NRRP funds to acquire dozens of electric or hydrogen buses and trams for cities, and to invest in transit corridors in Bucharest and other major urban areas [9,12]. These investments align with the EU's push for "greening freight and passenger transport" by improving public transit offerings.

Regarding the digital transition in mobility, the NRRP also supports digitalization, such as intelligent transport systems, traffic management, and integrated e-ticketing platforms. In the context of Bucharest, for example, this could mean modernizing the ticketing system for buses/trams/metro and implementing smart traffic control to reduce congestion (a noted weakness, currently) [12].

Through the NRRP, Romania effectively commits itself to deliver concrete outcomes (with EU oversight) in sustainable transport. Many of the measures (e.g., charging stations, clean buses) have direct relevance to urban areas and are anticipated to contribute to cleaner city air and reduced emissions in the coming years.

2.2.2. Romanian Sustainable Mobility Strategy and Related Policies

Romania's national approach to sustainable urban transport is multi-faceted: leveraging EU financial instruments (e.g., NRRP, cohesion funds) for immediate investments; developing strategic frameworks (like a sustainable mobility strategy) for long-term guidance; and setting regulatory incentives (like electric vehicles subsidies, SUMPs requirement) to encourage cleaner mobility choices.

In the following paragraphs we shall argue that there is clear alignment with EU-wide frameworks, for instance, the NRRP commitments mirror goals of the EU SSMS and Fit for 55 (alternative fuels, electric vehicles (EV) uptake, public transport modernization and funding mechanism etc.), indicating Romania's intention to contribute to the collective European effort.

Beyond the NRRP, Romania has been formulating broader strategic documents on mobility and transport. Among these is the National Sustainable Mobility Strategy [3], which is a recent initiative aimed at providing a nationwide policy framework for low-carbon, efficient transportation. According to reports from the MobiliseYourCity Partnership [13], Romania's National Sustainable Mobility Strategy (drafted around 2022–2023) presents a "repertoire of 30 types of sustainable mobility measures" designed to help cities plan and implement cleaner transport [13]. These include public transit expansion, bike lane development, Park and Ride facilities, and demand management strategies.

While the full strategy document has not yet been formally published, its existence indicates high-level recognition of urban mobility as a policy priority. Key elements likely covered by the Romanian Sustainable Mobility Strategy and related policies include: the integration of sustainable urban mobility plans; public transport modernization; vehicle electrification incentives; land-use and transit-oriented development; and national targets and monitoring

Romanian cities are encouraged (and in some cases required, in order to access funding) to develop Sustainable Urban Mobility Plans (SUMPs) in line with EU guidelines. Since the 2014–2020 EU programming period, local authorities were required to have SUMPs to obtain EU funds for transport projectsideas.repec.org. The national policy reinforces SUMP adoption for all large cities, ensuring strategic planning for public transport, non-motorized modes, and intermodality. The strategy likely calls for more ambitious SUMPs that go beyond fleet renewal to address land use, intermodal hubs, and digital solutions, as recommended by urban policy experts [5,14–16].

National and EU co-financing, including through the Regional Operational Programme (ROP) and the NRR, have supported significant improvements in urban transport. The Romanian Ministry of Development has a dedicated program for improving urban public transport [9], reflecting goals from the Romanian Recovery Plan to invest in green mobility. For example, new trams and buses and the rehabilitation of tram lines have been deployed in cities such as Bucharest, Cluj-Napoca, and Timișoara. As of 2024, Bucharest is receiving 100 energy-efficient trams, co-financed by the EU, while several municipalities have invested in compressed natural gas (CNG) and electric buses [17].

Through the Rabla Plus program [16], Romania offers generous subsidies for the purchase of electric and hybrid vehicles. The initiative has contributed to the increasing uptake of EVs, especially the Dacia Spring, one of the most affordable models in Europe, that is manufactured locally [18]. However, gaps remain in EV infrastructure, particularly

in smaller cities and rural areas. Investments supported by the NRRP and AFIR regulation are aiming to expand charging networks.

Recognizing the dependency on cars, Romania's Integrated Urban Development Strategy 2021–2030 [19] calls for better land-use planning to reduce commuting time. It emphasizes connecting Romanian cities via public transport and aligning urban growth with transport infrastructure [20]. While implementation is at an early stage, the policy direction supports densification around transit corridors and discouraging car-centric developments.

Under the EU's Effort Sharing Regulation, Romania must reduce emissions in non-ETS sectors (including transport) by 12% by 2030, compared to 2005 levels [21]. Meeting this requires the government to monitor transport emissions and enforce policies like increasing biofuel blends, renewing vehicle fleets, etc. The Long-Term Decarbonization Strategy of Romania (2020) [15] also includes a dedicated chapter on transport, outlining scenarios for emissions cuts via electrification and modal shift. It notes that without strong measures, transport emissions would continue rising; thus, a mix of interventions is needed (public transport investments, EV adoption, rail freight, etc.).

With this overview, it becomes somewhat apparent that the translation of national strategies into local implementation, especially in a complex urban environment like Bucharest, remains a challenge. Issues include administrative capacity constraints, funding absorption issues, and public resistance or apathy. The next sections delve into the specific context of Bucharest, starting with public perceptions of sustainable transport options and then examining the data on mobility patterns.

Romania's draft National Sustainable Mobility Strategy further consolidates EU priorities at the national level by outlining 30 sustainable measures, from SUMPs to intermodality promotion; however, many of these remain aspirational. Institutional and technical capacity at the municipal level is often insufficient to translate strategic visions into localized action. Moreover, while alignment with EU strategies (Fit for 55, SSMS) is evident, the lack of synchronization between regulatory frameworks and infrastructure development timelines has resulted in fragmented progress.

In sum, Romania's transport decarbonization strategy exhibits strategic coherence and potential. However, the persistent disconnect between national-level planning and local implementation, due to funding bottlenecks, institutional fragmentation, and socio-political resistance, hampers effectiveness. Comparative examples, such as Poland's structured EV charging incentives or the Czech Republic's integration of SUMPs into regional planning, may offer lessons for accelerating Romania's transition.

2.3. Urban Transport in Bucharest: Infrastructure, Private Mobility and Public Perceptions

To craft effective and targeted mobility solutions, it is essential to understand both the current state of urban transport infrastructure and the public's attitudes toward mobility. Bucharest's urban transport landscape is characterized by an extensive public transport network facing operational challenges, alongside a rapidly growing private vehicle fleet. The reality is persistent congestion and environmental pressures. At the same time, public opinion and user behavior significantly shape the city's ability to transition toward sustainable mobility.

This section presents key strategies and projects on Bucharest's public transport system, including infrastructure upgrades and fleet modernization, as well as trends in private vehicle ownership and usage. Insights into public opinion and behavior are also presented to offer a more comprehensive understanding of urban mobility dynamics in the city.

2.3.1. Transport Infrastructure- Quantity vs. Quality Dilemma

Infrastructure quality and configuration significantly influence energy use and emissions in urban transport systems. A recent modelling study [22] demonstrated that smoother pavement surfaces, optimized intersection signal timing, and geometric enhancements can reduce CO_2 emissions by up to 15% in key urban corridors. In contrast, reactive infrastructure expansion, such as road widening without modal shift incentives, risks triggering induced demand. Therefore, in cities like Bucharest, infrastructure decarbonization must prioritize efficient traffic management, micromobility-enabling designs, and demand-side controls to avoid counterproductive outcomes.

Between 2000 and 2024, Bucharest implemented several infrastructure projects to improve urban mobility and ease traffic congestion. These included the construction of key road overpasses (Basarab overpass, Doamna Ghica overpass, Prelungirea Ghencea project), expansion of the city's ring road (A0 Highway), the installation of smart traffic systems, the introduction of dedicated lanes for public transport, and proposals for congestion charges. However, systemic delays, cost overruns, and incomplete implementation have characterized much of this period.

The Basarab Overpass (Pasajul Basarab), inaugurated in 2011, stands as one of the most ambitious urban infrastructure projects in Bucharest. It is the largest cable-stayed bridge in Romania, spanning approximately 1.9 km, and designed to streamline traffic on the northwest axis of the city. While the initial cost was estimated at EUR 112 million, the final cost reached EUR 204 million due to contract modifications and expropriation expenses [23]. Today, it serves an estimated 50,000 vehicles daily, becoming a critical node in the city's transport infrastructure.

The Doamna Ghica Overpass was opened in September 2023; this project was launched in 2019 and experienced over three years of delays. Intended to decongest one of Bucharest's busiest intersections in the northeast, it cost approximately EUR 28 million (excluding VAT) and now plays a significant role in improving traffic flow between central and peripheral districts [24].

The Bucharest Ring Road (A0 Highway) was divided into northern and southern sections. The northern section was expanded to four lanes in 2010, including the construction of a cable-stayed bridge in Otopeni (2011). However, progress in the southern section was slow, with frequent contractor-related delays. Modernization contracts were awarded as early as 2009; however, the work stalled repeatedly.

To enhance bus reliability, Bucharest added approximately 7 km of new dedicated bus lanes, bringing the total to 22 km by 2024. Despite plans for smart traffic lights, implementation remained at the feasibility stage as of 2024, reflecting the limited digitalization of traffic management systems

Discussions around introducing congestion charges to discourage car use in the city center have taken place periodically. In 2012, the idea of a congestion tax was also introduced by the Bucharest Municipality in its Capital City's Energy Strategy [10]. However, no concrete policy had been implemented as of April 2025.

The SUMP for Bucharest–Ilfov [14] outlines a vision to transform public transport by 2030 through investments totaling approximately EUR 7 billion. The plan's core goal is to develop an efficient, integrated, sustainable, and safe transport system that supports economic development and improves quality of life.

Key priorities include metro modernization and expansion, representing 50% of the total investment budget, acquisition of 900 new vehicles, including buses, trolleybuses, and trams, the extension of the tram infrastructure by 41 km, the expansion of dedicated bus lanes to increase speed and service reliability, the development of Park and Ride facilities at urban entry points, and improvements in cycling infrastructure and bike-

sharing systems [14]. Currently, there are seven Park and Ride car parks operational in the Bucharest–Ilfov area. By 2030, the aim is to develop a total of 65 Park and Ride facilities in the region [14].

Collectively, these measures are intended to reduce reliance on private cars and facilitate a modal shift toward greener and collective modes of transport.

Bucharest's infrastructure developments between 2000 and 2024 reflect a sustained effort to address congestion and modernize transport networks. Projects, like the Basarab Overpass, smart traffic lights, and 22 km of bus lanes, are steps in the right direction. However, these projects often suffer from cost overruns, delays, and limited systemic impact due to poor coordination and a reactive planning approach.

For example, while overpasses reduce local congestion points, they do little to discourage car use or improve overall travel behavior. In contrast, cities, such as Milan or Ghent, have reallocated street spaces toward sustainable modes with greater emissions benefits. Likewise, smart traffic systems in Bucharest remain largely theoretical, with minimal integration across transport modes.

The SUMP for Bucharest–Ilfov targets a EUR 7 billion investment by 2030, with ambitious infrastructure goals: 900 new vehicles; 41 km of new tram tracks; 65 Park and Rides; and a significant metro expansion [14,25,26]. These investments are commendable; however, fragmented institutional roles and unpredictable funding absorption undermine a holistic delivery. The challenge remains to shift from scattered capital projects to integrated mobility systems that prioritize sustainability, reliability, and accessibility.

2.3.2. Public Transport Network and Usage Patterns in Bucharest

Bucharest has a long-standing tradition of public mobility. The city introduced horse-drawn trams in the 19th century and became one of the first European capitals to operate an electric tram line, inaugurated in 1894. Since then, public transport has remained a critical component of the urban mobility system. Despite substantial ridership and infrastructure coverage, challenges related to speed, reliability, and system integration continue to affect the efficiency and attractiveness of public.

The Bucharest–Ilfov region hosts one of the densest surface public transport networks in Europe. It is coordinated by the Intercommunity Development Association for Public Transport Bucharest (TPBI) and operated primarily by Societatea de Transport București (STB) [27].

As of 2023, the Bucharest–Ilfov metropolitan area was served by 200 public transport routes: 168 urban lines (buses, trams, trolleybuses) and 32 regional bus lines serving nearby Ilfov towns [28].

On a regular workday, approximately 2432 vehicles are deployed: 1640 buses, 527 trams and 265 trolleybuses [28]. The bus fleet includes a mix of standard and articulated buses, many of which meet the Euro 6 emissions standard. Major additions include 400 Euro 6 diesel buses, 130 hybrid buses [29], 100 Astra Imperio electric trams [30] and 100 electric buses [17]. Despite these modernizations, the system still faces issues related to aging vehicles and service irregularities. The Trolleybus infrastructure remains outdated and subject to interruptions.

Service Network Highlights: 157 bus lines, including 96 core daytime routes and 24 night buses, 22 tram lines forming a mixed radial–diametral network; and 17 trolleybus lines, although their numbers have declined slightly due to route restructuring [28,31].

Based on a report on sustainable mobility by the Wuppertal Institut [20], Bucharest ranked second overall for public transport among major European cities. This strong position was driven by high affordability, good station density, public transport share, and annual trips per capita. As per this report, only 13% of daily food costs are needed

for a single public transport ticket, making it one of the cheapest systems (only Zurich is cheaper). The station density of 9.74 stations/km^2 in the urban area ensures good access across the city [28]. Moreover, 36% of trips are made by public transport, a slightly lower percentage than Vienna (39%), and a much lower percentage than Budapest (48%) [32]. With 426 trips per year, Bucharest ranks lower than Paris (1037) or Vienna (511) [32], but still shows a solid performance. Overall, Bucharest's affordability and station coverage are major strengths. However, moderate trip frequency suggests that, although public transport is accessible and cheap, citizens may still rely partly on other transport modes (car, walking). Investments to increase service quality and attractiveness could boost usage further.

The Bucharest Metro, operated by Metrorex, consists of five lines (M1–M5), with a total length of 78 km and 63 stations [33]. It remains the backbone of the city's mass transit system, with pre-pandemic ridership reaching approximately 170 million passengers annually. The most recent addition, Line M5, launched in 2020, extends access to the densely populated Drumul Taberei area.

The planned expansions (2021–2030) include, as follows: M4: Extension from Gara de Nord to Gara Progresu (13 stations); M5: Extension from Eroilor to Piața Iancului (6 stations); M6: Connection from 1 Mai to Otopeni Airport (12 stations); M7: Proposed route from Bragadiru to Voluntari (27 stations); and M8: Proposed east–west corridor from Crângași to Dristor 2 (18 stations) [33]. These projects are co-financed by national and EU sources, including Romania's Recovery and Resilience Plan (PNRR) [2].

The metro remains largely separated from the STB-operated network in terms of infrastructure but has become increasingly integrated in terms of fares and user access.

Greenpeace's 2018 urban mobility report [34] rated Bucharest favorably for its low-cost, high-accessibility network but criticized its lack of smart ticketing, high private car usage, and insufficient investment in intermodal hubs. The findings underscore a persistent paradox: a large and affordable system that still struggles to compete effectively with private car use. It highlighted that Bucharest lacks features like a unified smartcard or user-friendly ticket system (now being addressed). The takeaway is that Bucharest has a solid foundation to build on, a significant infrastructure and ridership base, but needs targeted improvements to make public transport truly competitive with cars.

In recent years, Bucharest's public transport network has undergone a series of operational changes aimed at improving service efficiency and regional integration. One of the most significant institutional reforms was the creation of the Intercommunity Development Association for Public Transport Bucharest (TPBI) in 2018 [27], tasked with coordinating mobility planning across the Bucharest–Ilfov metropolitan region. This led to new connections to suburban areas, extending accessibility beyond city limits. Further adjustments occurred in 2022, when TPBI undertook a system-wide reorganization and renumbering of routes, streamlining service structures. Notably, the city–airport express line, previously designated Line 783, was rebranded as Line 100, with fewer stops and improved frequency. However, no major expansion of the internal route network took place during this period. Instead, STB reallocated resources to overcrowded lines, deploying additional vehicles to improve peak-hour capacity.

In September 2023, STB further addressed passenger loads by adding buses and trams on 11 of the busiest routes, enhancing service frequency [35]. Infrastructure maintenance also prompted temporary substitution of trolleybus lines with conventional buses, demonstrating a degree of operational flexibility.

Despite these improvements, Bucharest's surface public transport continues to face challenges, particularly in speed and reliability. Average travel speeds during peak hours can drop to 21.1 km/h [36], primarily due to traffic congestion, limited dedicated lanes,

and the absence of traffic-signal prioritization. Irregular vehicle intervals and "bunching" remain common, caused both by external traffic conditions and fleet shortfalls, including frequent vehicle breakdowns.

A longstanding issue was the lack of fare integration between Metrorex and STB, which historically required separate tickets or, nowadays, cards for different modes. Only in 2021 was a unified fare system introduced, enabling passengers to travel across all public transport services using a single smartcard or mobile app. While this was a major step toward intermodality, technical and administrative harmonization is still ongoing.

To put things in perspective, we have analyzed a series of indicators for Bucharest, alongside Vienna, Amsterdam, Copenhagen, Paris, and Budapest (see Table 1).

Table 1. Comparative urban mobility and quality of life indicators in selected European cities.

Indicator	Bucharest	Vienna	Amsterdam	Copenhagen	Paris	Budapest
Satisfaction with Public Transport (%)	52	95	93	90	88	75
Perceived Good Air Quality (%)	18	75	70	80	68	60
Access to Green Spaces Satisfaction (%)	53	85	80	88	72	65
Feel Safe Walking at Night (%)	57	85	82	83	75	70
Average Daily Travel Time by Public Transport (min)	52	35	30	28	40	45
Car Modal Share (%)	38	27	20	33	29	35
Public transport (%)	44	32	18	20	34	48
Cycling Modal Share (%)	1	7	35	30	3	4

Source: compiled by authors from [32,37–39].

Bucharest lags significantly in satisfaction with public transport (52%) compared to cities, like Vienna (95%) and Amsterdam (93%), despite a relatively high usage rate (~44% modal share). This suggests high dependency but low perceived quality, pointing to a need for investment in reliability, comfort, and service integration.

Cities, like Amsterdam and Copenhagen, with cycling shares of 35% and 30%, show that strategic investment in bike infrastructure correlates with reduced car use and better air quality. Bucharest's cycling rate remains negligible, due to infrastructure and safety barriers, reinforcing the need for dedicated, protected cycling corridors.

Bucharest presents a paradox of relatively high public transport use but poor infrastructure satisfaction, low environmental quality, and weak support for active mobility. The comparison highlights the urgent need for systemic reform, focusing on integration, infrastructure modernization, and public space design, to align with the best practices of leading European cities.

These recent dynamics underscore both the progress made and the structural challenges that remain. While regional coordination and modern fleet acquisitions have improved user experience in some areas, systemic limitations in speed, integration, and reliability continue to hinder the full potential of public transport in Bucharest.

2.3.3. Private Vehicle Ownership and Usage Trends

Bucharest's challenge in decarbonizing transport is compounded by rapid growth in private vehicle ownership over the past decades, a trend marked not only by growing numbers but also an aging and polluting vehicle fleet.

Following the fall of communism in 1989, Romania saw one of the fastest increases in motorization in Europe. Between 1991 and 2012, the number of private cars in Romania increased by 250%, far outpacing the EU average of 36% during the same period [40]. Bucharest, as Romania's economic hub with the highest GDP per capita, led this surge in motorization.

By 2021, Bucharest registered approximately 1.227 million registered cars [41], up from 1.204 million in 2020 [42]. With a population around 1.8–1.9 million, this equates to roughly 650–680 cars per 1000 residents, one of the highest ratios in Europe. For comparison, cities, like London or Paris, are around 300–400 per 1000; even car-friendly US cities, like Los Angeles, are 600 per 1000. Bucharest's figure is on par with some of the most motorized cities in the world.

Unless major policy interventions are adopted, car ownership in Bucharest is projected to continue rising in the near term, driven by increasing household incomes and persistent preferences for private mobility. While micromobility and ridesharing attract younger urban users, overall trends suggest that the city may soon exceed 1.5 million registered vehicles. Nevertheless, recent developments point to a gradual shift; although the total vehicle fleet remains old, the pace of growth in registrations has slowed, especially after the sharp increases of the early 2000s and the surge following the 2017 removal of the pollution tax. Notably, the EV market is gaining traction; by early 2024, Romania had over 55,000 electric vehicles, led by models like the Dacia Spring and Tesla [43]. This represents a growing share of new vehicle sales. If policies aimed at limiting imports of high-emissions used cars are reintroduced and incentives for clean vehicles are maintained, the national fleet could gradually modernize.

Figure 2 compiles the annual data for Bucharest from 2000 through 2024, including the number of registered personal cars and the GDP per capita. The GDP per capita is given in EUR (nominal, current prices) for consistency. The data regarding registered cars were supplied by the Romanian Driving License and Vehicle Registration Directorate (DRPCIV) and GDP from the National Institute of Statistics (INS) [44].
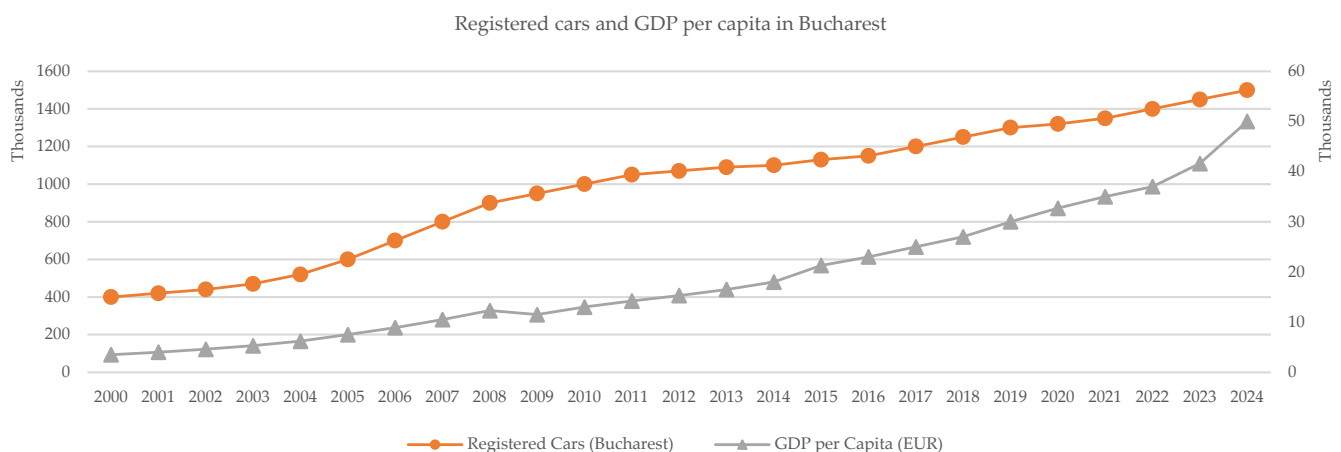

Figure 2. Registered cars and GDP per capita in Bucharest between 2000–2024. Source: compiled by authors based on [45–48].

The correlation coefficient of 0.92 between Bucharest's GDP per capita and car numbers suggests that rising incomes are strongly associated with increased car ownership. However, this should not be interpreted as an inevitable trajectory. In cities, like Vienna or Copenhagen, a rising GDP coincided with falling car usage due to proactive policies that disincentivized driving and improved alternatives. By contrast, Bucharest's negative correlation (−0.81) between the population and the GDP may indicate that economic growth is

increasingly concentrated among mobile suburban populations, who depend more heavily on private cars due to sprawl and public transport gaps.

The policy implication is clear: unless constraints are introduced on car use and more attractive multimodal alternatives are developed, rising incomes will continue to fuel car dependency. The failure to reintroduce a "polluter pays" tax or establish meaningful low-emissions zones reflects a political unwillingness to challenge car culture. Without fiscal or regulatory deterrents, the modest growth in EVs and hybrids (now about 10% of new sales) will not be sufficient to reverse emissions trends. Importantly, the aging fleet, with an average of 15.3 years [45,49], with over 33% above 20 years [45], continues to anchor the city in a high-emissions equilibrium.

In this context, Bucharest contrasts sharply with peer cities, like Budapest and Warsaw, which have begun implementing stricter low-emissions zones, congestion pricing pilots, or vehicle entry restrictions. Bucharest's current path, of high ownership, weak enforcement, and an underwhelming EV infrastructure, risks locking the city into a cycle of worsening congestion, pollution, and modal inefficiency.

The 2022 propulsion data (Table 2) reveal that Romania's car fleet remains overwhelmingly dependent on internal combustion engines, with petrol and diesel vehicles accounting for more than 90% of new registrations; this creates a long-term carbon lock-in that could frustrate decarbonization goals for at least another decade. Yet the sharp, incentive-driven expansion of hybrid and battery-electric segments (recording annual growth rates above 50% and 90%, respectively) demonstrates a high elasticity to fiscal stimuli, such as the "Rabla Plus" [16] subsidy, implying that stronger price signals, coupled with disincentives for diesel, could materially accelerate the transition. Diesel's continued absolute growth, however, exacerbates Bucharest's NO_2 and particulate matter exceedances and underlines the scientific rationale for aligning vehicle taxation with real-world emissions. At the same time, electric vehicle adoption will plateau unless the charging infrastructure is deployed at scale; current coverage outside major cities remains inadequate relative to EU benchmarks. Finally, even a fully electrified fleet would not, by itself, deliver the required emissions cuts, highlighting the need for parallel demand-side measures (public transport enhancement, parking reform, and eventual road pricing) to reduce overall vehicle-kilometers travelled rather than merely lowering the per kilometer tailpipe intensity.

Table 2. Structure of the vehicle stock in Bucharest by propulsion type during 2021–2022.

Propulsion Type	2021 Vehicles Stock	2022 Vehicles Stock	2021–2022 (No.)	2021–2022 Δ (%)	2023 and Current Trend (Indicative)
Gas	3,994,225	4,013,423	+19.20	+0.5%	Slight growth
Diesel	4,990,660	5,208,677	+218.02	+4.4%	Plateau/incipient decline
Hybrid	83,771	127,905	+44.13	+52.7%	Accelerating
Electric	13,310	26,186	+12.88	+96.8%	Doubling again

Source: Compiled by authors, based on [48].

Bucharest's road network now operates well beyond its design capacity. Congestion and noxious emissions have become daily fixtures; the city has effectively reached a tipping point. Although absolute ridership on public transport is large, it is still insufficient to counteract the continued growth in private car use. Unless decisive action redirects travel demand toward cleaner modes, both gridlock and pollution are likely to intensify; conversely, improvements that make transit, walking, and cycling genuinely convenient would unlock a sizable latent demand for non-car travel, given the mounting inefficiencies of driving.

A major obstacle to decarbonizing urban transport in Bucharest is the age and emissions profile of its vehicle fleet. Romania has one of the oldest car fleets in the European Union, with an average vehicle age of 15.3 years, significantly above the EU average of 11 years [49]. According to Eurostat [50], in 2023 over 33% of passenger cars in Romania are more than 20 years old, indicating the widespread use of outdated and polluting vehicles. Bucharest continues to host a substantial stock of Euro 3 and Euro 4 vehicles, many of them second-hand diesel imports, which are associated with high NO_x and particulate matter emissions [51]. As a result, the capital has repeatedly exceeded EU air-quality thresholds, prompting infringement proceedings by the European Commission. A 2020 initiative to introduce an emissions-based "Oxygen" vignette [11] targeting older vehicles was withdrawn amid political opposition, leaving a significant number of high-emissions vehicles in circulation and limiting progress on air-quality improvements.

Car dependence is further illustrated by the estimated one million vehicles that enter or circulate within the city each day, a figure buoyed by multicar households and weak parking management. TomTom's 2022 Traffic Index [36] ranked Bucharest seventh worldwide for congestion; drivers lose roughly 115 h per year in traffic, and peak-hour speeds on main arteries often fall below 10 km h^{-1}. Congestion simultaneously fuels, and is fueled by, slow and unreliable bus operations, creating a self-reinforcing cycle of car usage.

Travel survey data reveal that 83% of intra city trips are shorter than 10 km and that 45% are under 3 km (distances ideally suited to walking, cycling, or short transit hops); however, many of these journeys are still made by car [40]. Urban sprawl, dispersed employment, weak cycling infrastructure, and cultural preferences all contribute to this modal mismatch; the statistics highlight substantial "low-hanging fruit" for a shift to sustainable modes if attractive alternatives are provided.

Parking policy remains a critical bottleneck. Historically, on-street parking was free or inexpensive across much of the city, reinforcing car use. Although paid parking has been introduced in the center, illegal parking is widespread, blocking traffic lanes and tram tracks, and degrading pedestrian space. The recent installation of meters and higher fines represents incremental progress; however, enforcement is inconsistent. Urban analysts widely contend that without firm parking management, efforts to improve traffic flow or prioritize transit will be undermined.

Despite strong ridership figures, many residents still prefer cars for short trips (<3 km) due to safety concerns, unreliable transit, and poor infrastructure for cycling and walking. The modal mismatch reflects systemic failures, not user irrationality.

Survey data showing poor satisfaction with air quality, green space, and walkability underline a deeper legitimacy crisis in urban transport policy. The rejection of the 2020 "Oxygen" vignette exemplifies how reform attempts falter without strong civic engagement and equitable design [11].

Critically, EV adoption trends (growing but still <10%) suggest high responsiveness to subsidies like Rabla Plus [16]. However, without the rapid expansion of charging infrastructure, this potential will plateau. Moreover, EVs alone cannot solve congestion or reclaim public space; only a mode shift can.

In sum, Bucharest's transport system is caught in high congestion, a high emissions equilibrium driven by an ageing diesel heavy fleet, inadequate parking control, and persistent cultural attachment to the car. Reversing these trends will require a coordinated package of fleet renewal incentives, robust parking enforcement, and rapid enhancements to the speed, reliability, and coverage of sustainable modes.

2.3.4. Public Perceptions Regarding Public Transport

Public perception in Romania regarding urban transport is undergoing gradual change but still reflects years of underinvestment in public transit and the aspirational value of car ownership.

This section examines resident satisfaction with public transport, mode preferences, and attitudes toward environmental and policy issues related to urban mobility. According to the European Commission 2020 Report [32], only 53% of Bucharest residents are satisfied with their public transport. Nationally, other Romanian cities fare somewhat better (Cluj-Napoca and Oradea, for instance, have seen improvements in public transport and report higher satisfaction), but Bucharest, despite its extensive network, suffers from reliability and comfort issues that dampen user satisfaction.

A local academic survey of the quality of urban transport in Bucharest [52] revealed that most of the respondents use public transport regularly (commuting to work and daily activities), yet only a quarter reported being satisfied with its quality. Reported issues included overcrowded vehicles, irregular service, and insufficient maintenance, suggesting a significant disconnect between usage rates and perceived quality. Moreover, a decade ago, the main issue was the request for information regarding timetables and journey times.

Car ownership in Romania has historically been seen as a symbol of personal success and freedom, especially after the 1990s transition. Bucharest has a high motorization rate, with over 656 cars per 1000 inhabitants in 2020 in Bucharest [53] compared to the average number of passenger cars per 1000 inhabitants, which was 560 in the EU in 2022 [54]. Surveys suggest that many Bucharest residents view the car as more convenient and reliable than public transport for their daily commutes, citing door-to-door travel time and comfort (private space, air conditioning) as advantages.

On the other hand, awareness of the environmental downsides of car-centric transport is rising. According to a 2020 poll by the Romanian Urban Mobility Association, about 70% of Bucharest respondents acknowledged that traffic congestion and car pollution are serious issues harming quality of life. There is conceptual support for measures to reduce pollution - e.g., 64% agreed that the city should invest more in public transport and cycling infrastructure to improve air quality [32]. However, there is a classic "collective action" dilemma: individuals agree generally on the need for sustainable transport, but many are hesitant to change their own habits absent visible improvements.

What would make public transport more attractive in Bucharest? Feedback commonly includes increased frequency (shorter waiting times); better reliability (stick to schedule to avoid long delays); improved comfort (modern vehicles with A/C, less overcrowding); and more routes connecting peripheral areas. Safety and cleanliness also come up, though they are secondary to efficiency concerns. Notably, ticket cost is less of an issue- Bucharest has very low fares by European standards (a one-trip ticket is about 3 lei, EUR 0.60) and even offers monthly passes at around EUR 15. Indeed, Bucharest's low fares are cited as one of its strengths in international comparisons. This suggests that affordability is not the main barrier; service quality is.

Public transport in Bucharest suffers from an image problem. A trust indicator in the EU cities survey showed Bucharest near the bottom in terms of residents' trust in local public transport operators (similar low levels of trust are seen in cities like Rome) [32]. Scandals or negative press (e.g., breakdowns, strikes, or management inefficiencies at the transport company) have occasionally eroded public confidence. Conversely, cities that successfully turned around their systems (like London, with a bus revitalization in the 2000s or Paris, with a public transport expansion) saw public perception improve in tandem with visible changes. This underlines that winning public trust requires delivering results-

newer buses, digital real-time information, responsive customer service- so that people can see that the system is modernizing.

In Romania, there are signs of a generational shift in mobility preferences. Younger people appear more inclined to use alternative modes of transport, such as ride-hailing, biking, and e-scooters, and are generally less attached to car ownership than previous generations. In Bucharest, the rapid expansion of services, like Uber, Bolt, and bike/scooter-sharing, over the past five years indicates a growing demand for convenient alternatives to private cars, especially among those in their 20s and 30s. A 2023 study found that 87.4% of Romanian youth aged 18–26 had used Uber services, highlighting a widespread openness to new mobility solutions [55]. These services often complement public transit as first- or last-mile options; however, they also act as substitutes when transit fails (such as during subway disruptions when Uber usage spikes). This pattern underlines both the potential and necessity of strengthening the city's public transport backbone.

When it comes to policy measures, Romanian public opinion can be volatile. A proposal to introduce a congestion charge or paid parking in Bucharest is often met with immediate pushbacks from drivers' associations and a segment of the public. However, experiences elsewhere show that public opinion can be swayed by strong evidence of benefits. If, for example, a pilot pedestrianization of a central street led to a popular new public space, or if new bus lanes demonstrably cut commute times for thousands, more people may favor such interventions. Currently, most Bucharest inhabitants would likely oppose strict car restrictions (a legacy of seeing the car as essential); however, they overwhelmingly favor improving public transport. Thus, the pragmatic route for policymakers is to focus first on carrots (better transit) before sticks (driving disincentives), and to communicate the environmental and health rationales for change. The EU's climate goals, and the city's smog problems, provide a compelling narrative that is slowly entering mainstream discourse.

In summary, public perception in Bucharest is a mix of frustration and aspiration: frustration with the current state of transit (which leads many to stick with cars), and aspiration for a city with cleaner air and better mobility options. Bridging this gap is partly a communication challenge and largely a policy delivery challenge. Succeeding in projects that tangibly improve the daily commute will be key to shifting attitudes in favor of sustainable transport.

3. Results: A Framework for Bucharest's Public Transport System

This section synthesizes the findings from prior sections, drawing on European Union directives, national strategies, public perception, empirical data, and international best practices, to propose a structured framework for reforming Bucharest's public transport system. The proposed framework includes both policy interventions (the what) and stakeholder roles and responsibilities (the who), acknowledging that effective reform requires coordinated, multi-level governance and sustained political will. The framework was constructed keeping in mind best practices from Vienna, Amsterdam and Copenhagen.

Vienna demonstrates that a combination of affordable pricing and excellent service can dramatically shift people toward public transport; its EUR 365 annual ticket and extensive [56], reliable network led to more transit passholders than cars, showing that affordability and quality must go hand in hand. The modal split in Vienna is approximately 38% public transport, 27% walking, 7% cycling, and only about 28% private car [57]. Vienna's per capita transport emissions are among the lowest for a city its size.

Amsterdam's case highlights the transformative power of active mobility—with dense cycling infrastructure and emission-free transport goals, the city reduced car dependency while maintaining a highly integrated and efficient public transport system. As a result, about 36% of all trips in Amsterdam are made by bicycle [38].

Meanwhile, Copenhagen showcases the impact of a long-term, integrated approach: prioritizing cycling, planning urban growth around transit, and disincentivizing car ownership through high taxes and limited parking, all while engaging the community to build a support for change system. By 2018, 49% of journeys in Copenhagen have already been made by bike, with more bicycles than cars crossing the city center; by 2025, the city aims to achieve a 50% cycling modal share for work and education trips while becoming the world's first carbon-neutral capital [39].

3.1. The Proposed Framwork

We have summarized strategic targets for Bucharest's public transport system in Table 3. Based on the targets, we included in our framework the following aspects: an integrated governance approach; service and infrastructure upgrade; micromobility enablement; investment for fleet electrification; and public awareness leading to behavior change.

Table 3. Summary of strategic targets for Bucharest's public transport system.

Pillar	2030 Targets	Priority Actions 2025–2030	Lead Actors	Funding Sources
Integrated governance	TPBI to a single point of accountability; $\geq$40% CO_2 cut in SUMP 2.0;	Integration of STB and Metrorex Fares; B-Smart ticket;	City Hall, TPBI, Parliament	Public–Private Partnership models
High-quality public transport	60% mode share; public transport speed $\geq$ 18 km h^{-1}	Signal priority at intersections for busses; 120 km dedicated bus lanes;	TPBI, STB, Metrorex	Romania's National Recovery and Resilience Plan
Micromobility	100 km bicycle lanes	Pedestrian zones and sidewalk upgrades; hub bike parking;	City Hall, Sector administrations	Recovery and Resilience Facility; Ministry of Environment (Revenues from ETS)
Demand Management for private transport	Paid parking, Low-emissions zone, inner ring, congestion pilot	Dynamic tariffs; "Oxygen" vignette;	City Hall, National Government	Local taxes; User charges;
Alternative fuels and electrification	30% e-taxis; 3000 chargers	Fleet upgrade; Taxi mandate; public-private charging	City Hall, MoT, private sector	Romania's National Recovery and Resilience Plan Green bonds
Public awareness and Culture	70% residents rate public transport "reliable"	Public campaign for biking; car-free days; CO_2 displays	NGOs, media, TPBI	STB/TBPI budget Local Taxes

Source: Compiled by authors using [3,25,28,29,40,58,59].

All these interventions need to be part of a coherent framework agreed upon at all levels of governance. The established timeline for implementation (short-term wins, like painting bus lanes and procuring buses in 1–2 years, medium-term projects, like a pilot tram extension or bike network by 2025, long-term projects, like full metro line extensions and, maybe, a congestion charge by 2030). Setting measurable targets, such as reaching a public transport modal share of 60%, and reducing average trip emissions by 30%, etc., will help to track progress.

3.1.1. Integrated Governance Approach

Research on large-city transitions shows that institutional fragmentation is a primary barrier to mode shift [60]. Bucharest's governance aspects are currently split among the STB (surface modes of transport), Metrorex (metro), six district administrations (roads, passages, the Ministry of Transport (large-scale infrastructure projects), and several other national agencies. Reform could begin by upgrading TPBI to a single point of accountability, granting a statutory mandate over planning, contracting, fares, and data for all modes, including ride-hailing interfaces. An updated SUMP, formally adopted by the General Council and aligned with Fit-for-55 targets, should establish a $\geq$40% CO_2-reduction goal for 2030 and embed transit-oriented development in the land-use code. This legal anchoring guards the strategy against electoral cycles and unlocks cohesion-policy co-financing.

Integration of STB and Metrorex Fares

Historically, Bucharest's surface transit (STB buses/trams/trolleys) and its metro were run as separate systems (with STB funded by City Hall and Metrorex by the national government) [61]. This led to separate ticketing and fare structures. In recent years there have been a few attempts at integration; these were limited or short-lived. For example, since 2017, STB has offered special transfer tickets valid on both buses and the Metro for a short period; a 120 min integrated ticket costs RON 5 ($\approx$EUR 1) [61]. However, these products are often restricted (e.g., only for certain routes or not broadly publicized) and do not represent a permanent unified fare. Indeed, even an integrated bus and metro airport pass was discontinued in 2024, reflecting the operational challenge of coordinating two authorities [61]. A key difficulty is that subsidies and revenue are managed separately. The Metro's budget comes from the National Transport Ministry; STB is subsidized by the city. The alignment of fares and passes will require inter-agency agreements [61].

As of 1 August 2021, a major reform finally established a single fare zone across Bucharest-Ilfov and full fare integration [61]. Under the new system, any surface transit trip costs RON 3 for 90 min of use, and a combined ticket costs RON 5 R for 120 min on both surface vehicles and the Metro [61]. In practice, this means that riders can buy one ticket (or tap once) and use as many buses/trams/metro trains as they like within the time limit. Importantly, these fares are the same across all STB lines (urban and suburban) and valid in Ilfov as well, truly unifying what had been "urban" vs. "metropolitan" zones. Still, previous, separate multi-ride and period passes largely remain under each operator. In summary, past integration was piecemeal; however, since 2021, Bucharest has a functioning integrated fare scheme (with a RON 5 transfer ticket) managed by the TPBI authority.

B-Smart Ticket

Vienna provides a proven model for an attractive annual pass. Since 2012 Wiener Linien offers a "365-EUR ticket", an annual pass costing EUR 365 (exactly EUR 1 per day) that is valid on all transit in the core Vienna zone- U-Bahn (metro), trams, buses, S-Bahn (regional rail), and even the tram-train to neighboring suburbs [57]. This flat rate is much lower than the cost of 12 monthly passes; its simplicity (one price, unlimited use) drove high uptake. By 2019 roughly 822,000 Viennese had bought the ticket, in a city of about 1.9 million residents [57]. The price has remained stable at EUR 365; it is credited with encouraging transit use and reducing bureaucracy (no need to remember to renew monthly). A Bucharest B-Smart annual pass modelled on Vienna's would likewise allow unlimited travel for a fixed price (proposed at EUR 365) no matter how often or how far a person travels. By comparison, Vienna's scheme covers most travel modes and has shown that a low-cost annual cap can greatly boost public transport's appeal.

Bucharest's public transit already uses modern validators (on buses and trams) that accept contactless payment. We propose a "B-Smart" brand based on the existing card scheme [62] to clearly communicate to the public that riders would tap a single card or bankcard at the validator and be charged automatically, with built-in fare capping limits per day and per year. This mirrors Vienna's approach.

To highlight the integrated pass (a distinct card, issued by TBPI [62]), it is important to see how it compares to today's fares. As of mid-2025, the official fares (including VAT) are:

- STB (surface transit)- single mode: Monthly pass (30 days) = 80 lei, Annual pass = 700 lei [62]. (For example, a 6-month pass costs 400 lei, reflecting a slight discount for longer validity.)
- Metrorex (metro only): Monthly pass = 100 lei (this was raised from 80 lei in January 2025) [63], Annual pass = 900 lei. (Other fares: a single ride is now 5 lei, a 10-ride pack is 40 lei.)
- Integrated STB and Metrorex: Monthly pass = 140 lei (covering both networks [62,63]), Annual pass = 1200 lei

Despite existing EUR 240 annual options, uptake may be limited due to confusing fare structures, low public awareness, and monthly financial barriers for those unable to pay upfront. Our proposed B-Smart pass would allow for monthly deductions or banking integrations, increasing adoption.

Proposing a B-Smart pass would position Bucharest as EU-aligned, modern, and committed to smart city goals; it would clearly communicate the focus on long-term ridership growth and reducing car dependency.

3.1.2. Increasing Quality of Public Transport

Despite having one of Europe's densest networks, Bucharest's surface public transport averages 21.1 km/h [36] due to congestion during peak hours. It has a moderate user satisfaction score [32,52]. Evidence from several cities, such as Vienna and Zurich, indicate that speed, reliability, and seamless payment drive ridership more than mere network size. This means that high priority interventions should include extending the sectors where the busses/trams have priority over general traffic; integrated ticketing; and ensuring that passenger information is available.

Bus/tram priority over general traffic ensures that buses and trams have signal priority at intersections. This technology is relatively inexpensive and ensures that a late-running bus can be provided with more green lights, crossing approximately 300 intersections with signal priority, thereby improving punctuality. The TPBI-led "Smart & Green Mobility Integrated System" [64] (part of the 2016–2030 SUMP) aims to equip intersections with signal priority and a traffic management center covering approximately 260 intersections with systems capable of PT priority, although this is not yet activated [65]. There are plans to expand Public Transport Management (PTM) and integrate PT signal priority, potentially covering approximately another 100 intersections, pending funding [65].

Moreover, dedicated lanes on radial boulevards could be expanded. Currently, in Bucharest, there are less than 25 km of dedicated lanes [66] for buses. The impact is significant as, during rush hour, a sector of 3 km of roads is now completed in 3 min compared to 25 min before [66]. Moreover, a North–South bus rapid transit corridor could halve peripheral commute times and increase the attractiveness of public transport compared to the use of the private vehicles.

One of the main complaints of passengers [52] is the lack of information on the real-time arrivals of buses and trams. Therefore, the installation of real-time arrival LED displays at the 200 busiest stops should significantly improve this situation. Moreover, ground-level

station shelters, lighting, and CCTV should be upgraded, reflecting survey findings that comfort, and safety are decisive for women and older riders.

The bus routes should be improved for efficiency via network data use. Bucharest may have redundancies that can be streamlined to provide more frequent services on core routes. Micro-mobility or on-demand shuttles for less dense areas, rather than big buses running mostly empty, could also be explored. Another optimization point could be related to the timing of scheduled buses to increase interconnectivity.

3.1.3. Micromobility Enablement: Achieving 100 km of Lanes in 5 Years

Over 83% of trips in Bucharest are under 10 km and 45% are below 3 km [32]; however, cycling represents less than 1% of the mode share [37]. This mismatch suggests a significant latent potential for micromobility, should the infrastructure and incentives align. Cities, like Copenhagen [67] and Amsterdam [38], demonstrate that the mode shift toward cycling occurs only when physically protected bike lanes, safe intersections, and end-of-trip amenities (e.g., secure parking) are available and interconnected.

We propose a five-year implementation plan for 100 km of protected bike lanes, forming a cohesive grid that links residential districts ("dormitory areas") with central destinations (universities, workplaces, parks). Implementation would follow a phased approach, as follows:

- Year 1: Feasibility study, public consultation, and design of priority corridors (i.e., North–South "Spine" (Victoriei to Pipera/Băneasa), East–West Axis (Unirii to Titan/Pantelimon), Along the Dâmbovița River (West–Center), Southern Districts and Outer Areas (Calea Rahovei, Șos. Alexandriei, Giurgiului Blvd, Olteniței Blvd);
- Years 2–3: Construction of approx. 50 km of primary lanes, starting with high-demand boulevards (e.g., Calea Victoriei, Kiseleff, Decebal);
- Years 4–5: Completion of the remaining 50 km, network integration, and installation of bike parking at 50 major public transport hubs.

The plan also recommends that Calea Victoriei becomes a weekend pedestrian and cycling corridor, gradually evolving into a permanent car-free zone, following the successful example of Lipscani. Key pedestrian areas (Old Town, Piața Universității) should be upgraded into shared spaces, improving safety and walkability.

Micromobility should also include regulated e-scooter parking, the mandatory integration of shared mobility apps with TPBI's journey planner, and the designation of specific "last mile" corridors. To prevent clutter and improve usability, e-scooter docking areas should be placed near metro exits and university campuses.

Financing will prioritize EU sources, such as the Recovery and Resilience Facility (PNRR) and EU Cohesion Funds, which already support green urban mobility in Romania [64]. Past projects (e.g., 48 km of cycling infrastructure) have been co-financed via carbon trading revenues from the Ministry of Environment [68]. Remaining costs would be covered by national environmental programs and local budgets. The estimated total cost, at EUR 200,000/km, meaning EUR 20 million in total [68], would be spread over five years, and will be partially offset by reduced congestion and pollution costs.

Following models from Copenhagen and Amsterdam, Bucharest must combine infrastructure, incentives, and disincentives (e.g., reduced car parking) to enable sustainable micromobility. Implemented properly, this network could unlock a significant shift away from private car use, especially for short, frequent urban trips.

3.1.4. Discouraging Private Vehicle Use: Aligning Prices with Externalities

Bucharest already ranks as the seventh worst globally for congestion; drivers lose 115 h/year [36]. The frequency of personal vehicle use is unlikely to decrease in the

absence of economic incentives. The city should implement several measures that would support a behavioral shift: paid parking; low-emissions zones; congestion charging; and fuel/energy policies.

The use of personal vehicles is correlated to the availability of parking and its costs. Measures could include dynamic curb pricing with license-plate recognition, higher tariffs in the central business district, strict towing, and ring-fence revenue for public transport and cycling projects. However, previous attempts to reform parking (e.g., increasing rates in the city center) have faced strong resistance from both the public and local sectoral authorities. Enforcement remains uneven, with illegal parking often tolerated due to political reluctance and under-resourced policing.

A low-emissions zone should be introduced in central Bucharest, where the oldest, most polluting vehicles are either banned or charged a fee. Many European cities have these zones. Bucharest attempted something akin to this (the "Oxygen Vignette" [11] for pre-Euro4 cars) but withdrew it. This failure was not merely a matter of poor communication but also reflected a lack of inter-institutional coordination, political opposition from both national and local actors, and low public awareness of the air-quality crisis. Reintroducing it with better public communication (highlighting the health impacts of dirty engines) could be successful. A low-emissions zone would push people to use cleaner vehicles or switch modes when entering the city center, aligning with decarbonization goals.

By 2030, the authorities could consider a congestion charge for inner Bucharest during peak hours. However, this is among the most politically sensitive reforms, often perceived as penalizing lower-income drivers in the absence of viable public transport alternatives. This subject is politically sensitive; thus, it should be studied and piloted carefully. Public attitudes remain ambivalent, with surveys showing limited willingness to pay unless transit quality improves significantly. If implemented, it should come only after visible improvements in transit (so that people have options). The charge could be dynamic or just a flat daily fee for entering a central zone, aimed at reducing traffic by, for example, 20%. Experiences in London, Stockholm, and Milan show that congestion pricing can be effective and even gain public support after implementation when people see cleaner air and faster traffic. Nevertheless, these cities have strong metropolitan authorities and sustained public engagement strategies, conditions that Bucharest currently lacks. For congestion charging to succeed, institutional reforms (e.g., stronger metropolitan governance, data-sharing mechanisms) and strategic framing (e.g., equity safeguards and reinvestment promises) are prerequisites.

3.1.5. Alternative Fuels and Electrification

Much of Bucharest's public transport fleet (especially buses) still runs on diesel. The city struggles with air pollution, which is harmful to health and violates EU air-quality rules. Alternative fuels (biofuels, CNG) and electric vehicles could immediately reduce CO_2 emissions by 20–100%, depending on the technology.

Several fleet modernization projects were implemented at STB. Some are still in progress such as the replacement of the euro III diesel buses (~450 units) with e-buses by 2027 [29], funded via NRRP and EIB green loans, and the Astra Imperio tram rollout (2022–2025) [30].

Beyond public vehicles, the city must decarbonize taxis, ride-hail, delivery vans, and private cars. Measures could include, as follows: ensuring that 30% of taxis and ride-hail vehicles are electric by 2030; providing fast charging at ranks; deploying around 3000 public chargers; and prioritizing curbside chargers in pre-1940 housing areas lacking garages.

In September 2023, the Bucharest General Council reported that the number of EV charging points included around 286 charging stations [69]. Moreover, the Bucharest City

Hall announced the installation of 50 electric vehicle charging stations, each with two charging points, at 11 locations within the city. The total investment value is estimated at EUR 3.59 million; the duration of implementation is 15 months [69].

Installing 3000 EV chargers in Bucharest is feasible with an estimated budget of EUR 10.5–15 million. The National Recovery and Resilience Plan [2] committed the funding for the construction of 6500 charging stations by 2026. This rollout is viable through partnerships across European, national, and municipal funding alongside private investment, paving the way for a scalable and sustainable EV-charging network.

Between 2018 and 2023, passenger cars per 1000 inhabitants grew the most in Romania (+26%), ahead of Lithuania and Estonia [50]. However, Romania is noted among the countries whose share of new registrations powered by alternative fuels surpassed 20% in 2023 (~22.8%) [50].

3.1.6. Behavior Change and Public Awareness

Public Awareness could be shifted via "Green" Campaigns about the benefits of using public transport and active modes. A target could be that 70% of residents rate public transport as "reliable and modern" by 2030. Real-time information displays could also display messages like "By taking the tram, you saved X kg of CO_2 today". Additionally, programs in collaboration with schools could be aimed at educating children about sustainable mobility (e.g., safe cycling training, public transport etiquette). Additionally, engaging civil society groups to promote car-free days or bike-to-work days could gather more support and funding for such measures. These "soft" measures can gradually shift social norms. Public perception needs to be managed so that giving up some car convenience is seen as gaining quality of life, not as a loss.

3.2. Stakeholders Involved in the Framework Implementation

Implementing the proposed public transport framework in Bucharest requires coordination among multiple stakeholders, each with distinct roles and interests. Understanding their roles is essential to align incentives, anticipate barriers, and ensure effective execution.

Below, we present, in more detail in Figure 3, the mapping of key stakeholder groups and their contributions to reforming success: the municipality (City Hall of Bucharest and the city halls of each district); the national government; the transport operators; the commuters; and the public.
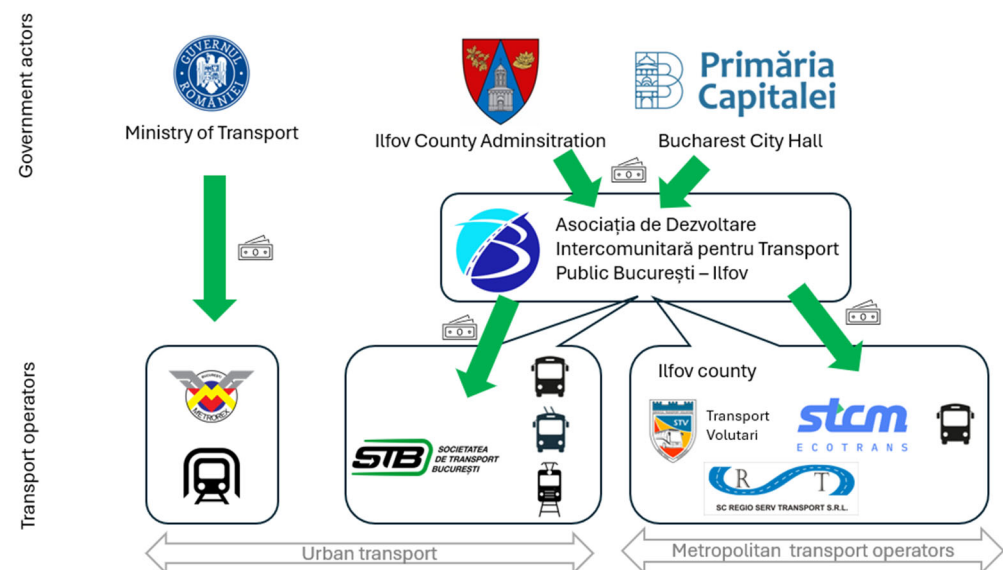

Figure 3. Stakeholders of the public transport in Bucharest- funding and operating.

Bucharest has a governance structure that involves multiple levels of administration, each with its own responsibilities and influences on the city's operations. The city is divided into six administrative districts, each with its own district mayor and local city hall. Additionally, there is a central City Hall that governs the entire municipality, with a focus on managing city-wide issues such as transportation. This overlapping structure has historically resulted in fragmented authority, overlapping mandates, and limited coordination, especially in domains, like public space reconfiguration or bike lane development, which may require both central and sectoral approvals. This has slowed or obstructed key mobility reforms.

The City Hall, led by the Mayor and City Council, is central to local transport reform. They set local policies (like parking rules, bus lanes on city roads) and manage the budget, the STB, and the infrastructure. City Hall also leads urban planning (zoning, street design).

However, their effectiveness has often been constrained by the lack of clear metropolitan authority. While TPBI was created to coordinate the Bucharest–Ilfov mobility system, its role and resources remain limited, often dependent on political consensus between the City Hall and Ilfov County, which is not always forthcoming.

As the City Hall's role is vision-setting, policymaking, infrastructure planning, public communication, enforcement, and funding allocation, we argue that pro-sustainability leadership is needed to champion initiatives, as many involve politically tough choices. Below, we present, in more detail in Figure 3.

Gabriela Firea, mayor of Bucharest between 2016–2020, pushed for various initiatives, including the creation of bicycle lanes, which were part of a broader effort to encourage alternative transportation. She also supported the development of electric public transport, although her sustainability efforts were often overshadowed by other political and administrative challenges.

Nicusor Dan, mayor of Bucharest between 2020–2024 and now several months into 2025 for his second mandate, seems to be one of the most vocal proponents of sustainability in recent years. As a mayor, he has continued many of Firea's initiatives, focusing on urban mobility and sustainability, advocating for measures such as the expansion of bicycle lanes, the development of pedestrian zones, and improving the efficiency of public transportation. His administration has emphasized green policies, including efforts to reduce car traffic and promote more sustainable mobility options such as electric buses.

However, despite this political discourse, implementation has faced strong resistance from local bureaucracies, sectoral city halls, and even the Traffic Police, who rejected several bike lane projects on legal or safety grounds. This reflects deeper institutional frictions and a lack of integrated decision-making mechanisms.

Even though the general political discourse appears to be pro-sustainability, very little progress is made. As of 2025, Bucharest's cycling infrastructure remains limited, with approximately 20 km of officially recognized bicycle lanes. These lanes are primarily located in central areas and are often integrated into existing roadways, sometimes shared with pedestrians. Even though Bucharest City Hall created approx. 50 km of bike lanes [70], the Traffic Police dismantled most of them as they were deemed inappropriate.

The National Government, meaning the Ministry of Transport, Development, and Environment, controls key levers: it oversees Metrorex (the metro operator) and national roads that run through the city; it manages EU funds allocation; and it legislates things like vehicle taxes or traffic laws.

The Ministry of Transport can support Bucharest by prioritizing metro expansion (e.g., the planned M6 line to the airport and the M5 extension) and integrating commuter rail (the national railway company (CFR), could upgrade services). The Ministry of Development often funds local transit projects through programs- their buy-ins and technical help are

valuable. Additionally, the central government can help to frame the narrative (for example, Romania's Climate Change Department could highlight Bucharest's efforts as part of national climate commitments).

However, coordination between ministries and the municipality has often been reactive rather than strategic. For example, Metrorex and STB remain under separate governance with different planning cycles, hindering system integration. Political turnover and a lack of inter-institutional agreements exacerbate delays in infrastructure delivery and digital systems harmonization (e.g., unified ticketing).

Transport operators, like STB and Metrorex, are responsible for project implementation and service delivery. STB operates under City Hall guidance, executing tasks like expanding networks, purchasing vehicles, and managing services. Metrorex, funded and overseen by the national government, manages the metro infrastructure.

Their mandates are not aligned; STB is managed locally and Metrorex is managed centrally. However, both serve overlapping catchments in the city. This fragmented oversight limits joint planning for schedules, fare integration, and last-mile connectivity.

There are also smaller operators: for regional routes, including companies such as Serviciul Transport Voluntari S.A. (Voluntari City's transport); Ecotrans STCM (for Chitila and Mogoșoaia to București); and Regio Serv Transport (Chitila and Buftea to Bucharest). Other concessions also run some buses—TPBI coordinates these; thus, they are stakeholders in offering consistent service.

All transport operators need to train drivers to follow set priorities (e.g., bus lanes only work if buses use them properly and don't block intersections) and provide better maintenance for their vehicles.

The residents of Bucharest and Ilfov are the beneficiaries of the public transport system; they are also agents of change through their travel choices. Public buy-in can make or break initiatives. For instance, if residents widely flout a traffic rule or protest a new charge, it can be withdrawn (as with the "Oxygen Vignette" pollution charge earlier). Therefore, the institutions and administrations in Romania need to understand public sentiment. It is essential to tailor approaches (e.g., phase in a charge gradually, or start with voluntary programs). Engaging the public via consultations for major changes (such as redesigning a bus network or creating a pedestrian zone) will improve acceptance.

Bucharest has active NGOs such as OPTAR (focused on cycling infrastructure [71]), Greenpeace Romania (which did studies on mobility), and other advocacy groups. These actors can be allies in pushing ambitious policies; they often provide expertise, promote awareness, and hold authorities accountable. However, despite their active engagement, their role in formal decision-making is minimal and participatory planning remains underdeveloped.

Several NGOs actively militate for bicycle lanes in Bucharest such as Bucureștiul Meu Drag (My Beloved Bucharest- bucurestiulmeudrag.ro); Asociatia pentru Tranzitia Urbana (ATU) (Association for Urban Transition- https://atu.org.ro/ accessed on 4 April 2025); and Asociatia Bike Works (Bike Works Association-www.bikeworks.ro accessed on 4 April 2025). Some projects, such as SkirtBike, an event dedicated to women who want to pedal through the streets of the city in a festive and friendly atmosphere, or guided tours of art in public spaces in Bucharest, Brașov and Iași, aim to promote the participatory regeneration of public spaces through art and by attracting young people to contemporary culture.

Businesses are impacted by mobility decisions, employee commutes, customer access, and delivery logistics; all these issues hinge on urban transport. Large employers can support reform by offering transit incentives, adjusting work hours to reduce peak loads, or co-investing in mobility services (e.g., bike-share sponsorships).

Public–private partnerships have been explored to build Park and Ride facilities or charging stations. Industry groups and Chambers of Commerce are valuable partners in aligning economic and mobility goals.

Although not formal implementers, media outlets and opinion leaders strongly influence public and political sentiment. Strategic communications that highlight success stories, dispel myths, and frame reforms as quality-of-life improvements, are essential. The city can invite journalists and urban influencers on "demo commutes" or host press briefings tied to key milestones. Sustaining public interest in positive changes builds the political capital needed for long-term reform.

Despite the presence of multiple actors with converging goals, the absence of a binding metropolitan authority and the lack of a shared implementation roadmap have repeatedly led to policy incoherence. This undermines continuity and credibility.

The effective implementation of Bucharest's mobility reform framework depends not only on stakeholder engagement but also on institutionalized mechanisms for coordination. Clear communication channels, formal partnerships, and strategic problem-solving structures are needed to align priorities across agencies and levels of government, and to transition from planning to execution.

To support collaboration, the city can establish multi-level and cross-sector platforms such as a mobility advisory council, project-specific working groups, and intergovernmental agreements.

A permanent, city-led forum will bring together representatives from public agencies, transport operators, NGOs, academia, and civil society. It should meet regularly to review progress, resolve conflicts, and provide strategic guidance.

For targeted initiatives (such as the implementation of bus lanes or integration of fare systems) multi-stakeholder task forces (e.g., STB, TPBI, traffic police, and cycling NGOs) can offer technical and operational input, ensuring on-the-ground feasibility and public acceptability.

A formal cooperation mechanism, such as a memorandum of understanding (MoU) between the Bucharest General Council and relevant ministries, can institutionalize alignment, particularly for interjurisdictional projects like Park and Ride facilities, which require joint planning between the city and entities like CFR (Romanian Railways).

By clarifying roles, with the city as the driver of local policy, the national government as the enabler and financier, operators as service providers, and citizens and NGOs as both validators and co-creators, Bucharest can move from fragmented initiatives to coordinated, systemic change.

4. Discussion—Anticipating Framework Implementation Difficulties

The proposed framework outlines strategic interventions to reform and transform Bucharest's urban mobility system toward sustainability, efficiency, and equity. The complexity of coordination in a multi-level governance setting, coupled with political and financial uncertainties, make this endeavor challenging but achievable.

The framework draws on international best practices, while adapting to Bucharest's specific governance context and legacy of transport policy inertia.

Our findings reinforce a central insight from the literature on sustainable urban transport: institutional coordination and political commitment are as important as technical solutions in realizing the sustainable mobility paradigm. Several studies emphasize a necessary shift from traditional, infrastructure-focused planning to more holistic approaches that integrate environmental, social and economic dimensions [72]. Further exploring how integrated transport strategies can be operationalized [73], the authors stress the importance of bridging policy design and real-world implementation.

The stakeholder typology presented in this study resembles patterns observed in other post-socialist cities, such as Budapest and Sofia, where civil society and the private sector have historically been sidelined, but are now increasingly essential for building legitimacy and driving user-oriented solutions. In Bucharest, similar dynamics can be observed, particularly in the growing role of NGOs and citizen-led mobility advocacy.

Moreover, governance fragmentation remains a significant barrier. Cities with dispersed jurisdiction over transport (e.g., Warsaw, Barcelona) struggled to implement coherent strategies until they established empowered metropolitan institutions [74]. In this context, the strengthening of TPBI is not only an operational necessity but also a potential governance innovation critical to aligning policies and ensuring implementation.

The implications of this proposed framework extend beyond the mobility sector. A shift toward integrated, multimodal transport affects urban land use, social equity, public health, and economic competitiveness. Key benefits include reduced environmental impact, greater social inclusion, and increased economic productivity.

Reducing car dependence supports Romania's national climate targets and the EU Green Deal. Additionally, introducing low-emissions zones and reallocating road space can significantly lower urban air pollution. Moreover, congestion costs Bucharest billions of euros annually in lost time and fuel. More efficient, reliable public transport networks enhance economic performance and urban attractiveness [75].

Improving public transport and expanding pedestrian and cyclist infrastructure benefit those without car access, aligning with equity-oriented mobility models.

The proposed framework is ambitious and faces a range of implementation barriers, including financial constraints, technical issues, lack of political support, coordination issues, and resistance to change, just to name a few.

First, the modernization of infrastructure and fleets is capital-intensive. Multiple sources of financing need to be optimized, such as the EU funds (ROP, NRRP, etc.), the issuing of municipal bonds, access to loans for long-term projects, and revenues from parking fees or congestion charges to reinvest in transport.

Different administrations often prioritize different agendas. Bucharest has a history of discontinuity, with initiatives launched under one mayor being cancelled by the next. Long-term strategies [3,15,58,59] and their associated implementation plans can help to ensure continuity, especially if public support grows and pressures future leaders to maintain course. If residents witness tangible improvements, they are more likely to demand continued progress, regardless of political leadership.

Restricting private car use may provoke backlash (as seen globally with fuel price increases or parking reform). To avoid this, high-quality alternatives must be introduced in advance, accompanied by clear public communication and trial phases. For instance, a low-emissions zone could initially target only the most polluting vehicles, gradually expanding over time. Transparent communication, especially about public health impacts, can bolster support; studies link traffic pollution in Bucharest to elevated rates of respiratory and cardiovascular disease [76].

Inter-agency coordination remains a bureaucratic challenge. Aligning the efforts of City Hall and the six district authorities, or coordinating between surface and metro schedules, can be difficult. A solution could be to legally empower TPBI to override local sectoral interests in transport-related matters and appoint a dedicated deputy mayor for mobility to regularly convene relevant actors and maintain alignment.

Technological upgrades (e.g., traffic signal priority, integrated IT systems) are prone to technical setbacks such as bugs or delays. Likewise, major infrastructure works, like metro expansion, can disrupt daily life. Mitigation strategies include phased rollouts, strong

public communication about timelines, and the use of international best practices and peer learning (e.g., city-twinning via EU programs).

Despite these challenges, the potential benefits are substantial. The successful reform of Bucharest's public transport would bring environmental, health, economic, and social gains. It could reduce emissions (advancing national and EU climate goals), improve air quality (and public health), save commuters time (less time in traffic means more productive or leisure time), provide economic gains (attractiveness for investors/tourists increases with better infrastructure), and enhance urban quality of life. These gains will only materialize if urban mobility reform is approached as an integrated economic, social, and environmental challenge, in line with sustainable development principles.

Nonetheless, unlocking these benefits requires overcoming entrenched path dependencies and short-term political cycles. As highlighted in the stakeholder analysis, success hinges on building coalitions that span local, regional and national governments, supported by transparent evaluation, sustained civic engagement, and shared accountability mechanisms.

Although rooted in Bucharest's unique institutional and political context, the proposed framework provides relevant insights for other Central and Eastern European (CEE) cities. Many of these cities face similar constraints, an aging infrastructure, fragmented governance, and the need to rapidly absorb EU funds to modernize their transport systems.

Limitations and Future Research

This study is based on secondary data, expert reports, and comparative policy analysis, which provide a robust yet indirect perspective on Bucharest's mobility challenges and decarbonization potential. A key limitation is the absence of original empirical data (e.g., user surveys, traffic measurements, stakeholder interviews) to validate behavioral trends, institutional bottlenecks, or public sentiment shifts. Moreover, while the paper draws parallels with leading European cities, it does not offer a fully quantitative benchmarking or scenario modelling approach that could refine policy forecasting.

Future research could address these gaps by conducting longitudinal studies on the impact of specific interventions, such as the expansion of bus lanes or the introduction of low-emissions zones, on mode shift, emissions, and user satisfaction. Another promising direction would be to assess the equity impacts of sustainable mobility reforms across demographic groups, using tools like social impact assessment or transport justice frameworks. Finally, as institutional reform is a critical factor in policy success, further studies could explore how governance structures, like TPBI, evolve over time and which mechanisms enhance their accountability, coordination, and adaptability in the face of political change.

5. Conclusions

Decarbonizing urban transport remains a central pillar in achieving Europe's climate goals; however, its implementation varies widely across cities. This paper has examined the case of Bucharest to highlight how high-level EU strategies (i.e., Green Deal, Fit for 55, and the Sustainable and Smart Mobility Strategy) are translated into local mobility reforms. The analysis reveals both the structural challenges and the latent opportunities of a post-socialist metropolis with strong transit traditions but increasing car dependency.

While Bucharest's conditions are specific, its experience offers broadly relevant insights into cities across Central and Eastern Europe (CEE), many of which share similar governance structures, legacy infrastructure, and EU-funding dependence. Based on this case study, we highlight five transferable recommendations regarding establishing coordinated metropolitan governance; engaging stakeholders early and continuously; balancing investment between public transport and active mobility; phasing in car restrictions

alongside service improvements; and fostering long-term vision through integrated policy and funding.

The fragmentation of transport responsibilities across municipal, district, and national bodies hampers coherent planning. Strengthening a single coordinating authority, such as Bucharest's TPBI, is essential for aligning public transport operations, infrastructure investments, and regulatory reforms. This institutional model can be replicated in other metropolitan areas to improve execution capacity.

Reform efforts, like low-emissions zones or bike lane expansion, often face resistance when public engagement is reactive rather than proactive. Early and transparent consultation with residents, civil society, and business stakeholders builds legitimacy and identifies barriers to implementation. In Bucharest, recent improvements in civic dialogue suggest a pathway for broader public acceptance and the co-ownership of reforms.

While public transport modernization is critical, active modes, like walking and cycling, offer cost-effective, low-carbon alternatives for short trips. Bucharest's underutilized potential for cycling highlights the need to develop protected infrastructure and bike-parking facilities in tandem with bus and metro improvements. CEE cities should avoid over-focusing on heavy transport infrastructure while neglecting walkability and micromobility.

The experiences of Amsterdam and Copenhagen highlight that cities cannot rely on public transport alone; walking and cycling must be safe and appealing for short trips, and car use must be actively managed through policies. Bucharest has significant room to grow in cycling and walking mode shares. By building bike lanes and pedestrian zones, and simultaneously implementing policies, like parking reform and low-emissions zones, Bucharest can start to tame its car congestion and pollution. These measures are initially contentious but ultimately beneficial, as seen in other cities, where residents now enjoy cleaner, quieter, and more accessible urban environments.

The failed 2020 "Oxygen" vignette [10,11] in Bucharest underscores the political risk of restricting car use without first improving alternatives. A phased approach, where vehicle restrictions are introduced gradually and coupled with visible improvements in transit speed, reliability, and coverage, can build trust and reduce opposition. Cities with similar car-oriented patterns should align incentives and disincentives more carefully.

The EU has set a clear direction with the Green Deal, Sustainable and Smart Mobility Strategy, and Fit for 55 packages. These frameworks call for sweeping changes: phasing out combustion vehicles; greening public transport; and shifting mobility habits by 2030 and 2050. Romania has aligned its national plans, especially via the NRRP and forthcoming mobility strategies, to contribute to these goals. Bucharest, as Romania's largest city, is on the front line where these high-level policies must translate into real-world transformation.

EU funding can be a catalyst for sustainable mobility; however, its effectiveness depends on coherent long-term planning. The integration of transport goals with land-use, air-quality, and climate strategies allows for synergies and more impactful interventions. CEE cities should also focus on developing local capacity for monitoring, evaluation, and adaptive policy management.

A recurring theme is that no single intervention will solve Bucharest's transport woes; a combination of infrastructure, incentives, disincentives, technological upgrades, and societal shifts is required. This demands coordination among all stakeholders. The stakeholder analysis underscores that a common vision must be shared by city officials, national agencies, transit operators, businesses, and the community. Each has a role, whether it is funding, executing, or adapting to new policies. Inclusivity is also vital—the needs of different groups (students, elderly, people with disabilities, suburban commuters, etc.) should be considered so that the new transport paradigm is equitable. For example,

ensuring barrier-free access in transit and keeping fares low for low-income riders align sustainability with social inclusion.

In summary, Bucharest exemplifies the challenges of transitioning from car-centric urban mobility toward a sustainable, multimodal system. Despite institutional fragmentation and political constraints, the city's experience demonstrates that meaningful progress is possible through integrated governance, inclusive planning, and sustained investment. These lessons are not only relevant for Bucharest's future trajectory but also for other cities in the region seeking to meet EU climate obligations while improving urban quality of life.

Bucharest stands at a crossroads: it can continue the car-dependent trajectory with mounting costs, or it can choose a sustainable mobility path leading to a greener, healthier, and more competitive city. The analysis and recommendations in this article aim to inform and inspire the latter choice.

Abbreviations

The following abbreviations are used in this manuscript:

AFIR	Fuels Infrastructure Regulation
EU	European Union
CFR	Caile Ferate Romane [National Railway Company]
CNG	Compressed Natural Gas
DRPCIV	Romanian Driving License and Vehicle Registration Directorate
EV	Electric Vehicle
GHG	Greenhouse gases
INS	Institutul Național de Statistică [National Institute of Statistics]
NGO	Non-governmental organization
NRRP	National Recovery and Resilience Plan
SSMS	Sustainable and Smart Mobility Strategy
STB	Societatea de Transport București [Bucharest Transport Company]
SUMP	Sustainable Urban Mobility Plan
TPBI	Asociația de Dezvoltare Intercomunitară pentru Transport Public București-Ilfov [Intercommunity Development Association for Public Transport Bucharest]

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