Reimagining Bucharest's Central Station: PPP and Air Rights as Tools for Metropolitan Integration

PHDc. Arch.Urb. Baicu Liviu-Gabriel,
Doctoral School of Urbanism of the University of Architecture and Urbanism Ion Mincu Bucharest, Romania
Glb.stud23@uauim.ro

Abstract

This article explores how public-private partnerships (PPPs) combined with the development of air rights can unlock latent value above railways, finance modernization, and catalyze the intensification of smart mixed use. The proposed research focuses on how PPPs combined with the development of air rights can transform Bucharest's North Train Station-Basarab railway station into an intermodal hub of European importance. It argues that the development of land adjacent to railways can co-finance the modernization of the station, a high-quality public space and intensive mixed use, promoting decarbonization and metropolitan competitiveness. The study is based on node-site and TOD frameworks, international rail plus property models, and recent SCRD themes on urban regeneration and infrastructure governance. It extends these concepts to the context of Central and Eastern Europe, where integrated PPP/air rights applications remain under-explored. Methods combine GIS spatial analysis, scenario design for a covered "urban slab" operational modeling for a two-terminal concept, PPP/air rights financial structuring and value capture testing, plus stakeholder contributions/surveys on housing-work-study patterns and station use. Results show that selective coverage can unlock substantial buildable areas while connecting the urban fabric across rail barriers; value capture can co-finance rail and intermodal upgrades; an operational two-terminal model improves frequency, orientation, and transfer times; and intensified mixed use driven by stations supports polycentric growth and better public domain performance. The contribution is an integrated framework, adapted at the local level - spatially, operationally, and financially - that demonstrates how PPP + air rights can transform an old railway hub into a resilient metropolitan center, providing a scalable model for Romanian and European stations.

Keywords: Sustainable Mobility Architecture for Railway and Technology (SMART)

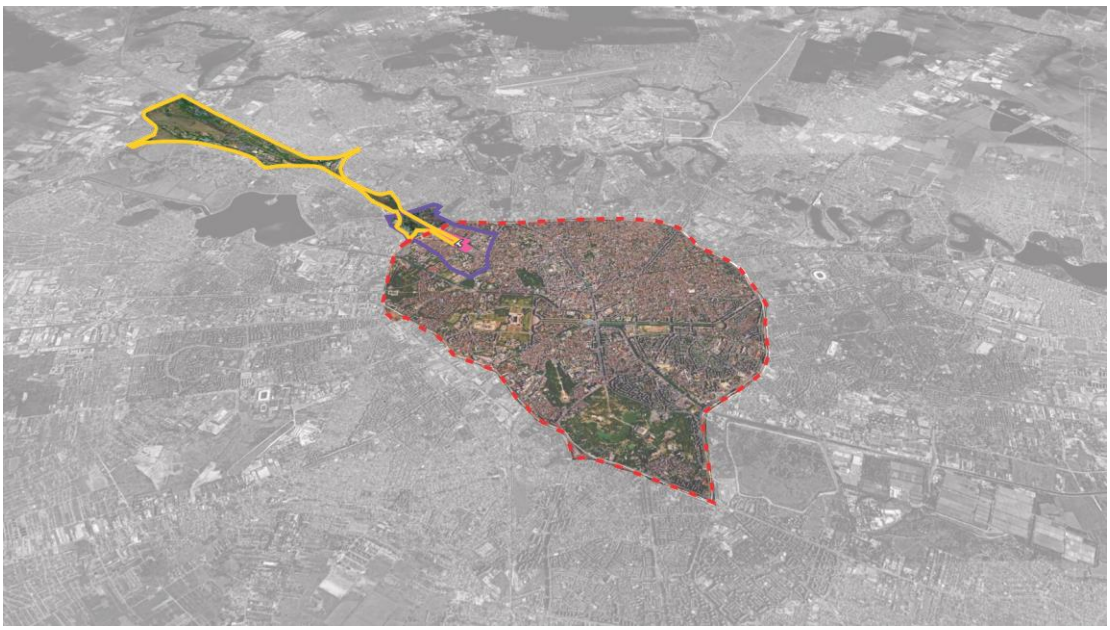

Figure 1: Railway area (yellow), North Train Station district (purple) and urban core of Bucharest (red dotted line)
Source: L.G.Baicu 2025 [1]

1. Introduction

Over the past three decades, urban regeneration projects and Transit-Oriented Development (TOD) have become essential pillars of global strategies for sustainable urbanism. These initiatives have been driven by the need to combat uncontrolled urban sprawl, reduce carbon emissions, and improve quality of life in large urban agglomerations. Urban regeneration has focused on revitalizing degraded or underutilized areas, transforming them into attractive, mixed-use, and functional spaces, while TODs have promoted compact, dense development that is well connected to public transport networks. In the context of rapid urbanization and climate change, these concepts have been widely adopted in cities around the world, becoming benchmarks for integrated and sustainable urban planning.

Urban regeneration brings a number of significant benefits, both socially and economically and environmentally. Among the most important are:

- Revitalization of degraded areas - Transforming abandoned or underutilized spaces into attractive, functional, and safe neighborhoods, contributing to increased property values and attracting investment;
- Improving quality of life - By creating green spaces, modernized infrastructure, quality housing, and accessible public services, urban regeneration contributes to a healthier and more pleasant urban environment;
- Reducing social inequalities - Well-designed projects can promote social inclusion by providing affordable housing, jobs, and access to education and healthcare for marginalized communities;
- Stimulating the local economy - By attracting businesses, tourism, and cultural initiatives, urban regeneration can revitalize the local economy and create new employment opportunities.
- Sustainability and resilience - Integrating sustainable development principles (energy efficiency, green mobility, smart resource management) helps reduce environmental impact and adapt cities to climate change.
- Strengthening urban identity - By preserving architectural heritage and promoting local culture, urban regeneration can strengthen a sense of community belonging and pride.

In the European context, TOD has been adopted as a key strategy for promoting sustainable mobility and urban cohesion, particularly in cities that are modernizing their transport infrastructure. Unlike the Chinese model, where urban development and subway network expansion occur simultaneously, in Europe, many cities benefit from well-established transport networks, which allows for more effective integration of TOD principles.

Recent studies propose advanced methods, such as combining node-site analysis with geographic information systems and statistical algorithms developed with the help of artificial intelligence, to identify urban areas with high transformation potential. Thus, Europe can benefit from a more precise and locally adapted approach to urban regeneration projects with the help of transport infrastructure.

Applied in the context of Bucharest's North Train Station railway station, this research proposes the adaptation of a TOD-type method to identify and optimize the urban potential of the area. The aim is to select the metro stations and adjacent areas that can benefit most from

integrated urban interventions, based on public transport connectivity and the spatial and functional characteristics of the area.

Starting from the node-site model, the methodology can be extended to include indicators specific to the local context, such as population density, spatial-functional mix, pedestrian accessibility, and urban attractiveness.

2. Context

Romania's railway stations occupy prime urban land yet remain underutilized beyond their transport function. With growing urbanization, sustainability imperatives, and EU-backed modernization programs, the concept of air rights - the ability to use or sell the space above a property for development - offers a transformative solution. This article explores how air rights can be applied to Romanian railway stations, drawing on global best practices, legal frameworks, and Romania's strategic development goals.

For urban transport planning, numerous solutions based on smart mobility technologies have been promoted, allowing sustainability criteria (such as network efficiency, territorial cohesion, and environmental protection) to be integrated into the formulation of sustainable transport policies. Multimodal transport planning must ensure the functional integration of institutions, networks, stations, user information systems, and pricing mechanisms.

The interdependence between land use patterns and transport systems is well documented in the literature and recognized as an essential factor in shaping urban dynamics. The functional and spatial separation of human activities generates demand for mobility, both for people and goods, and influences the travel behavior of key urban actors. The reverse impact - namely, the influence of transport infrastructure and services on land use decisions - remains relatively unexplored and poorly understood [2, 8, 13].

Although the accessibility provided by transport infrastructure determines the attractiveness of certain locations, the mechanisms by which changes in transport networks influence the location behaviour of investors, developers, firms and households are often difficult to quantify. There has been growing interest in the concept of transport planning based on multimodality, node typologies, interchanges, etc.

In this context, the concept of "transport-land use feedback cycle" is frequently used to describe the bidirectional and dynamic relationship between the development of mobility infrastructure and the spatial evolution of cities. The integration of land use and transport planning is key to sustainable transport planning [4, 6, 12]. As Litman [9] mentions, transport planners have begun to apply service level assessments for walking, cycling, and public transport and to consider demand management strategies as alternatives to road capacity expansion. Regarding the link between multimodal exchanges and their impact on land use, [3] mentioned that this is not a direct link if there is no strong, integrated development plan associated with politically involved decision-makers. Some cities have a good PPP-based business model for developing transport exchanges. For example, Cervero [6] discusses an interesting example applied in Hong Kong: using land sales to develop an intermodal transit hub.

3. Programatic developement

Redeveloping North Train Station into a modern, intermodal hub requires innovative financing and urban planning strategies. Two key mechanisms - Public-Private Partnerships (PPPs) and air rights - offer Romania the opportunity to transform this historic station without overburdening public budgets. PPPs enable the state to leverage private capital and expertise while retaining strategic control, as outlined in Government Emergency Ordinance No. 39/2018. Through structures such as Design-Build-Finance-Operate (DBFO) or Build-Operate-Transfer (BOT), private partners can manage the full lifecycle of redevelopment under concession agreements, ensuring compliance with EU procurement and state aid rules [7]. Joint ventures further allow shared governance and equity participation, fostering transparency and risk-sharing.

Air rights, defined as a separable property interest, unlock vertical development above existing rail infrastructure. By enabling Transferable Development Rights (TDRs) and amending zoning laws, Romania can permit construction above transport corridors, creating mixed-use towers integrated with station concourses. This approach aligns with Transit-Oriented Development (TOD**)** principles, promoting urban densification, reducing car dependency, and enhancing connectivity. Architectural concepts could include retail and cultural spaces at concourse level, green decks bridging neighborhoods, and hospitality or office towers above platforms. Such interventions not only modernize the station but also create vibrant urban hubs that attract investment and improve passenger experience.

Revenue streams from air rights development are diverse: retail leases, office rentals, hospitality services, and advertising rights can generate sustainable income for the Romanian Railway Company (CFR) and its partners. These funds can be reinvested in infrastructure upgrades, accessibility improvements, and digital systems, ensuring long-term operational efficiency. Moreover, integrating commercial and cultural functions within the station precinct transforms North Train Station into a destination rather than a mere transit point, stimulating local economic activity.

The economic and social benefits are significant. Monetizing air rights provides capital for modernization without relying solely on public funds. Vertical development curbs, urban sprawl, optimizes land use, and supports climate goals by encouraging public transport over private cars. Socially, the project fosters inclusivity through improved accessibility, enhanced safety, and better passenger amenities. It also creates jobs during construction and operation phases, contributing to Bucharest's economic resilience.

Challenges remain, including ownership ambiguity of airspace, restrictive zoning under current urban regulations, and potential public opposition. These can be mitigated through legal reforms, transparent consultations, and design competitions that prioritize architectural quality and community engagement. Engineering complexities - such as vibration isolation, fire safety, and lightweight structural systems - require advanced solutions but are manageable with global best practices.

A strategic roadmap should begin with a **pilot project at North Train Station**, supported by a clear PPP framework and air rights legislation. Success here can scale to other major stations like Cluj-Napoca, Iași, and Constanța, aligning with TEN-T corridor upgrades and Romania's broader mobility objectives. By combining PPP financing with air rights

development, Bucharest can transform its central station into a world-class intermodal hub, catalyzing urban regeneration and setting a benchmark for sustainable infrastructure modernization.

4. The case for North Train Station Station

North Train Station, located at the edge of Bucharest's central zone, is the city's primary railway hub and a terminus station occupying approximately 600 hectares - around 10% of Sector 1's area. Its accessibility profile is high, offering a comprehensive range of transport options aligned with international standards. As a terminus station, it consolidates all major railway lines in Romania through 14 passenger tracks and 8 platforms, serving both national and international routes, including Vienna, Budapest, Thessaloniki, Istanbul, and Chișinău (via Ungheni).

The northern railway system of Bucharest, encompassing eight secondary stations, depots, and sorting yards, totals over 600km of tracks. Intermodality is enhanced by the recent rail link to Henri Coandă International Airport (Otopeni), creating a strategic connection between two major transport hubs. Additional integration with Metro lines M1 and M4, as well as tram and bus services, strengthens the area's NOD index - a measure of intermodal connectivity.

North Train Station handles over 2,200km of railway routes and functions as a terminus for Metro M4 and a transit station for M1, attracting approximately 6,000 daily passengers at North Train Station and 10,000 at Basarab. The complex serves as a major transfer point for tram lines 1, 10, 44, and 45, alongside multiple bus and trolleybus stops on Dinicu Golescu and Calea Griviței. However, passenger orientation remains challenging due to poor signage and the absence of modern wayfinding systems.

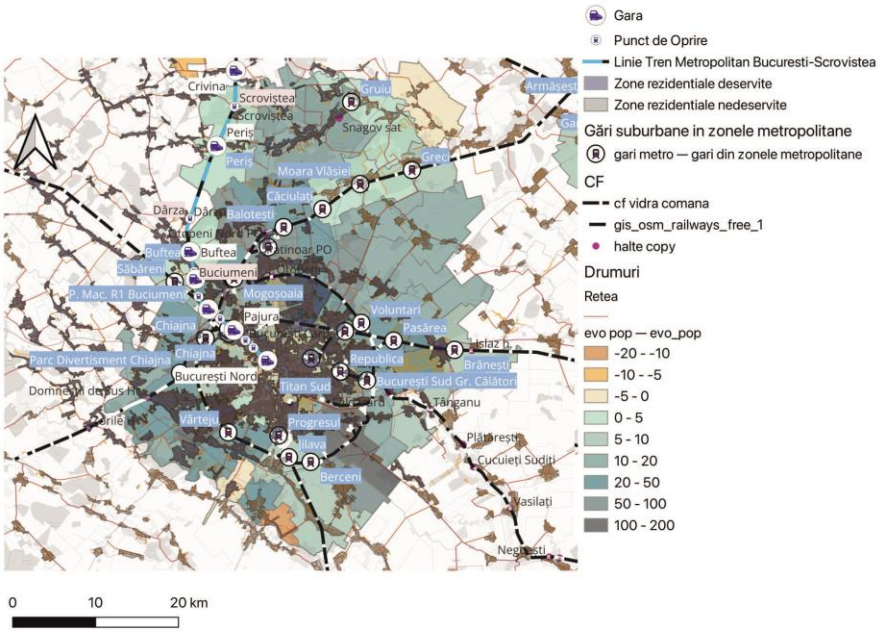

Figure 2: GIS Model for Bucharest-Ilfov Metropolitan Area corelated with railway and population evolution.
Source: L.G.Baicu 2025 [1]

Cycling infrastructure is minimal, limited to legally mandated bike racks (HG 250/2020) and a single dedicated lane on Buzești Street, with no direct connections to central or peripheral areas. Pedestrian infrastructure is present and adapted for individuals with mobility impairments, but only within the North Train Station zone. Modern mobility solutions such as bike-sharing, carpooling, and on-demand services are absent, making the area a hotspot for taxis with inflated fares.

Parking facilities are scarce, with no park-and-ride options. Recently developed platforms near Basarab Bridge and Titulescu Boulevard provide limited capacity, supplemented by three official parking lots and paid street parking managed by the municipality. The Carrefour Orhideea parking remains the most utilized. Logistically, the presence of the GN sorting yard, IDM warehouses, and proximity to the Postal Center and industrial halls in Grivița-Basarab enhances the area's attractiveness for freight operations. The metropolitan ticket system theoretically offers integrated access to train, metro, and bus services within 30km, but operator resistance has limited its adoption.

The Basarab area exemplifies advanced intermodal design, featuring three vertical levels: metro lines underground, rail and bus at ground level, and tram on the Basarab overpass - similar to Tokyo's Shinjuku node. This compact hub, within a 100-meter radius, combines regional rail links and diverse commercial functions.

Land use analysis shows 30% dedicated to railway infrastructure, 20% to transport-related buildings, 20% to streets, 5% to green spaces, and 25% to other constructions. Despite its strategic role, the area has low residential density and limited educational facilities, reflecting its historic urban fabric and lack of recent real estate pressure.

4.1 Node – Site analysis.

For a preliminary analysis, we performed an analysis on the Node-Site Model introduced by Bertolini. [5] The Node-Site Model was applied to railway stations in the Bucharest-Ilfov Metropolitan Area by the author in this paper. Using the model, we identified the upward or downward development processes of each railway station in the selected area. The dimensions of the node and the site are quantified using composite indices obtained through multi-criteria analysis.

The node index reflects the degree of accessibility of the station, being influenced by:

- Rail transport: the number of directions served, the daily frequency of trains, connectivity within a 45-minute radius (e.g. Scroviștea, Buftea, Periș);
- Urban public transport: connections with buses, trolleybuses, or trams (where available);
- Road access: proximity to motorways or national roads, parking capacity;
- Alternative mobility: bicycle infrastructure and dedicated parking facilities.

The site index measures the intensity and diversity of activities in the station area, defined as a 700m walking radius from the main entrance. Variables include:

- Number of residents and employees in the area;
- Economic sectors represented (commerce, services, education, industry);

- Spatial and functional mix and potential for urban regeneration (e.g., Pajura-Dămăroaia, Ion Creangă - Dobroești).

Table 2. Node-Place values for Bucharest-Ilfov Metropolitan area train 27 stations

Station name	Graphic code	Site	Node	Station name	Graphic code	Site	Node	Station name	Graphic code	Site	Node
North	GN	0.91	0.98	Otopeni	AIHCB	0.50	0.90	Balotesti	Ba	0.20	0.20
Basarab	GBs	0.90	0.92	Bucuresti Titan	GBST	0.70	0.10	Buftea	Bf	0.70	0.50
Baneasa	GBSa	0.80	0.40	Bucuresti Sud	GBSS	0.50	0.10	Sabareni	BfS	0.40	0.30
Obor	GO	0.83	0.55	Progresul	GP	0.50	0.40	Periș	Pe	0.50	0.45
Bucurestii Noi	GBSN	0.34	0.30	Varteju	Va	0.20	0.20	Caciulati	Ca	0.10	0.07
Bucuresti Triaj	GBST	0.30	0.40	Jilava	Ji	0.30	0.26	Moara Vlăsiei	MV	0.50	0.20
Chiajna	Chi	0.50	0.44	Berceni	GBSB	0.40	0.34	Gruiu	Gr	0.05	0.05
Chiajna Parc	Chp	0.30	0.45	Pasarea	Pa	0.01	0.48	Snagov Sat	SS	0.01	0.05
Chtila	Cta	0.60	0.5	Branesti	Br	0.20	0.50	Mogoșoaia	Mo	0.10	0.10

Source: L.G. Baicu 2025 [1]

To reduce subjective influences in the analysis, we used AINO (an artificial intelligence-based tool with applications in urban planning, architecture, and construction), specifically the AINO-15 minutes cities method, an objective multi-criteria analysis variant for identifying site-related scores. The generated rating reflects both the current level of development of the area around each station and the potential for improvement.

The following figure shows these indicators on a Bertolini diagram:

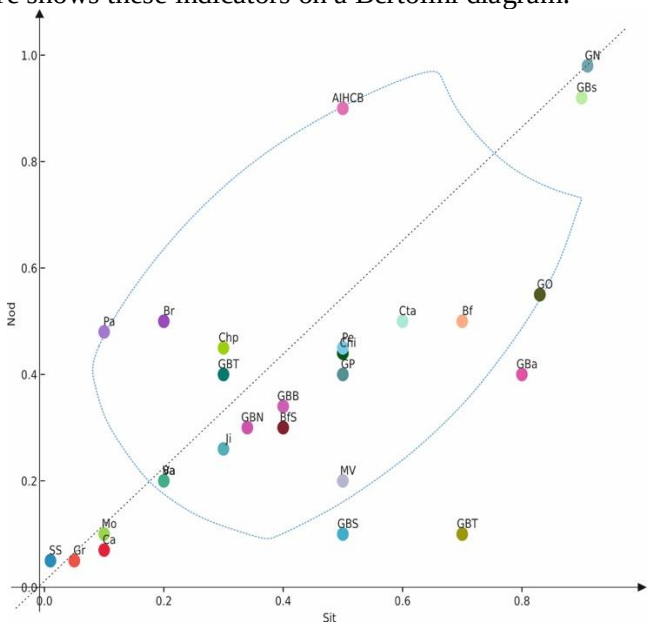

Figure 3: Node-site model applied to the Bucharest-Ilfov metropolitan area.
Source: L.G.Baicu 2025 [1]

It can be seen that there are several types of stations in the Bucharest-Ilfov area:

- Growing stations: e.g. Scroviștea, which benefits from network expansion and high intermodal potential;
- Unbalanced stations: such as Periș, with limited access and poor infrastructure;
- Balanced stations: such as Buftea, which combines rail accessibility with local urban development;
- Stressed stations: such as GN and GBS. In these areas, there is an insufficient variety of functions and connections, and the system is vulnerable to functional stress. They have the potential to achieve balance if both node and site indicators are improved. They can become a regenerated urban pole and an integrated intermodal hub in a smart city through a holistic approach that combines sustainable mobility, urban regeneration, and community involvement.

4.2 Development framework

For the GN-GBs area, a multi-criteria analysis (MCA) was performed based on the documentation for the modernization of the North Railway Station, currently available (Bucharest Railway Belt, Metropolitan Train, Sustainable Urban Mobility Plan, Modernization of North Train Station, part of the project to modernize 47 stations in Romania), correspondence related to ongoing projects, interviews with specialists from MT, CN CFR SA, SRCF Bucharest, PMB. It is necessary to take into account the projects in the set of interventions for the GN–GBs area (diagonals, 4B–GN connections, simultaneities) and the objects of the Metropolitan Train (TM) scenarios, the situation of the Basarab intermodal hub (decommissioned) and the need for replacement, as well as the PMUD 2016–2030 framework and limitations of the Bucharest Railway Complex, elements from SF GN – stage 1 for halls/squares.

Six intervention scenarios were considered:

- S0 – Do nothing: no interventions (minimum maintenance).
- S1– GN restoration: interventions currently being implemented on the building/platforms/halls (stage 1 SF GN).
- S2 – Projects in progress: Metropolitan Train (Scenario 3 GN-Chitila-Scroviștea), works on the Bucharest Railway Complex (CFB) and doubling of the airport connection, related modernizations.
- S3 – "Urban deck" over lines: selective covering (deck) of lines to create public space/urban functionalities, with rail operation maintained underneath.
- S4 – Tram Train Basarab-Obor-Progresu stations: orbital connection on dedicated rail/trans rail, integrated with the urban network (light/hybrid rapid line), in line with the PMUD.
- S5 – Urban deck + underground LMV: functional-urban stratification + underground high-speed line (LMV) with station in the central area. (Requires correlation with Master Plan/TEN T, phased approach).
- S5+ – Common underground terminal (LMV + regional/metropolitan) GN-Basarab: common underground node for LMV and the regional/metropolitan network, with the release/reorganisation of ground space.

For the analysis, we used the following evaluation criteria with different weights:

- C1 Architecture & heritage (15%) – quality of rehabilitation, compatibility with monument status, experience in halls/platforms.
- C2 Urban planning & placemaking (15%) – squares, pedestrian links, active fronts, and TOD.
- C3 Mobility & capacity (25%) – simultaneity, GN–GBS intermodality, TM cadences, PMR/B+R access.
- C4 Technology & services (10%) – ITS, PIS, e-ticketing, operation.
- C5 Environment & energy (10%) – NBS, energy efficiency, resilience.
- C6 Feasibility & risk/cost (15%) – complexity, CAPEX/OPEX, institutional risks.
- C7 Strategic alignment & financing (10%) – consistency with TM/CFB/PMUD and financing windows.

The MCA table shows that:

- S1 has the lowest value, being the scenario without interventions;
- S2 allows for a systemic benefit (mobility + alignment), is ongoing, and can realistically be phased in by 2030–2035;
- S3 creates urban space and a new image, but with the risk of complexity (ventilation/evacuation, phasing) and potential impact on operation;
- S4 offers real connectivity benefits, but requires technical clarification (interfaces, track sections, gauges), being only at the PMUD stage;
- S5 and S5+ have the highest strategic value (urban potential + mobility), but lose heavily on Criterion 6 – feasibility/cost, which requires PPP-type financing alternatives.

Scores from 1 to 5 were awarded for each criterion (1=minimum, 5=maximum), and the score for each criterion was calculated.The table below summarises the results of the analysis.

- Table 2. MCA (Multi-Criteria Analysis)

Scenario	C1 15%	C2 15%	C3 25%	C4 10%	C5 10%	C6 15%	C7 10%	Score
S0	1	1	1	1	5	5	1	**2**
S1	4	3	2	2	3	3	4	**2.9**
S2	2	3	3	3	3	4	5	**3.2**
S3	4	5	3	3	4	3	3	**3.55**
S4	3	4	4	3	3	2	4	**3.35**
S5	5	5	5	4	4	2	3	**4.15**
S5+	5	5	5	5	4	1	4	**4.2**

- *Source: L.G. Baicu 2025*

4.3 Disscussions

The correlative analysis between the spatial distribution of urban functions, built densities, and the organization of the mobility network at the urban level allows for the development of integrated development strategies, similar to those successfully applied in the Japanese context [10]. The Japanese model, characterized by a constant commitment to the principles

of sustainable urban development, provides a valuable reference framework for adapting these practices to the Bucharest context.

In this sense, the potential to consolidate the node index and capitalize on the site index in the GN-GBs area can generate structural effects on its transformation into a Transit-Oriented Development (TOD) and Central Business District (CBD) urban hub.

The North Train Station – Basarab hub should be treated simultaneously as a "mobility hub" and an "urban place." The transformation from "non-place" to "anchor place" is achieved by seamlessly integrating intermodality with place-making (public spaces, identity, social programming) and by anchoring it in the existing railway heritage. In the TOD logic, the station becomes a generator of centrality and urban quality, not just transit flows.

The operational separation of metropolitan flows from national/regional flows is critical for regular frequencies (15–30 min) and rapid transfers between North Train Station and Basarab; the technical solution recommends dedicated lines and separate platforms for metropolitan services on the GN–Basarab section, with the reconfiguration of the line layout. The role of the hub in the Bucharest rail network is structural (TEN-T hub, convergence of main lines). The modernization of the hub must be correlated with regional projects (metropolitan train, potential east-west and north-south underground connections) and with integration with the metro, tram, bus, and P&R.

A phased vision (quick wins - medium - long) minimises risks and accelerates benefits:
In the short term: unified wayfinding, covered GN–Basarab corridors, pedestrian management, essential services (toilets, integrated ticketing), reorganisation of bus/tram stations for short transfers.
Medium term: dedicated metropolitan train platforms, reorganization of the station square, active public spaces and commercial fronts;
Long term: underground rail links (GN–GO and GN–GP) freeing up surface capacity for frequent services.

The intermodal hub can catalyze regeneration: selective densification, functional mix (housing, public services, offices, local retail), programmable civic spaces, and green-blue landscape (green corridors, green roofs). The intervention must reduce the barrier effect of the infrastructure and finely connect adjacent neighborhoods.

Capturing the value created by access (PPP, development fees, concessions on CFR domains) can finance both the operation of intermodality and public spaces and community facilities in the area of influence.

Anchoring identity (materials, public art, historical narrative) in the station building and market spaces transforms the transfer from a "weak link" into an attractive urban experience (e.g., reinterpreting historic halls as civic spaces/galleries).

The integration of Machine Learning (ML) techniques into public administration and infrastructure planning [11] introduces a transformative dimension to PPP-driven station redevelopment and air rights management. Traditionally, PPP frameworks have focused on

financing, construction, and operational efficiency, while air rights policies addressed vertical development opportunities. By incorporating ML-based image analysis and predictive modeling, these mechanisms can achieve unprecedented transparency and responsiveness in urban governance. For instance, ML algorithms can process citizen-submitted images of infrastructure issues - such as structural defects, accessibility gaps, or environmental concerns - within complex intermodal hubs like North Train Station. This capability enables PPP consortia and public authorities to prioritize maintenance and modernization tasks in real time, ensuring compliance with safety standards and enhancing user experience.

5. Conclusions

The redevelopment of Romania's railway stations - and particularly Bucharest's North Train Station - can become a landmark success story through the strategic integration of **Public-Private Partnerships (PPPs)** and a progressive policy on **air rights**. These two mechanisms offer a dual advantage: they unlock new sources of capital and expertise while enabling vertical urban growth without consuming additional land. By monetizing the space above rail infrastructure and channeling private investment into station modernization, Romania can transform underutilized transport nodes into vibrant, mixed-use hubs that drive metropolitan competitiveness.

A clear legal framework for air rights, combined with transferable development rights and zoning reforms, will allow construction above tracks and concourses, creating retail, office, hospitality, and cultural spaces integrated with transit. PPP structures such as DBFO and BOT ensure risk-sharing, lifecycle efficiency, and compliance with EU standards, while generating sustainable revenue streams through leases and concessions. This approach aligns with **Transit-Oriented Development (TOD)** principles, promoting densification, reducing car dependency, and supporting climate goals.

North Train Station, with its strategic location and high intermodal potential, is the ideal pilot for this model. Its transformation into a multi-level, interconnected hub will not only modernize Romania's most important station but also reconnect fragmented neighborhoods, improve accessibility, and catalyze urban regeneration. Success here can scale to other major stations Cluj-Napoca, Iași, Constanța - creating a national network of resilient, future-ready hubs aligned with TEN-T corridors.

Ultimately, PPPs and air rights represent more than financial tools; they are instruments of **urban innovation and social progress**. By embracing this integrated framework, Romania can turn its railway stations from functional transit points into engines of economic growth and sustainable urban development, setting a benchmark for Central and Eastern Europe.

Acknowledgements

DeepL AI software was used for translations.

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