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Book of Extended Abstracts

PhD conference focused on the interaction between people, city, and transport.

The People – City – Transport conference aims at strengthening the interdisciplinary approach to studying urban mobility, including behavioural, sociological, environmental and technical perspectives. The conference will encourage knowledge transfer among the specialised disciplines and contribute to building competencies and capabilities to address current urban mobility issues.

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People – City – Transport 2025: Book of Extended Abstracts

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PREFACE

It is my great pleasure to present the Book of Abstracts for the third edition of the People – City – Transport 2025 conference. The event is organized by the Department of Spatial Planning, Faculty of Architecture, Czech Technical University in Prague, in cooperation with the Faculty of Transportation Sciences, CTU in Prague.

Urban mobility is a complex and multifaceted phenomenon. It is studied across a wide range of scientific disciplines, including urban planning, geography, economics, transportation, sociology, psychology, anthropology, and many others. Yet, no single field can fully capture or explain its complexity. This is precisely why we invite young researchers from diverse academic backgrounds—those exploring different aspects of urban mobility—to come together, exchange perspectives, and learn from one another.

People – City – Transport offers a platform for the mutual presentation of research activities and for open discussion of current research plans and preliminary findings from ongoing projects. The conference brings together young scientists from around the world who examine urban mobility from multiple viewpoints. I firmly believe that this multidisciplinary approach will contribute to a deeper understanding of today's urban mobility challenges and inspire innovative, sustainable solutions.

Jakub Vorel

Head of Department of Spatial Planning
Faculty of Architecture,
CTU in Prague

SYSTEM EFFECTIVENESS OF PUBLIC BIKE-SHARING IN INDIAN SMART CITIES: LESSONS FROM CHANDIGARH, KOCHI, AND SURAT

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1. Introduction

With the rapid growth of the world, it is expected that the number of vehicles on the road will double globally by 2050. This is a huge social and environmental challenge for the cities. A paradigm shift to more inclusive mobility systems that are cleaner, safer, connected, and autonomous is required. Around this discourse, cycling represents a sustainable mobility option for car-oriented cities. Cycling has numerous benefits in the form of health benefits as it increases physical activity, environmental benefits for its zero-carbon emission, and economic benefits as it provides an affordable means of transport for the economically low-income group of people [1, 2]. Despite the many advantages of using bicycles as a mode of transportation, the prevailing idea of modernity still recognizes cycling and pedestrian as marginal or peripheral [3].

India is the second largest producer of bicycles in the world, still there is a strong hesitancy in adopting cycling as a preferred mode for urban commuting [4]. Cycling is seen as an unsafe mode of travel and a poor man's vehicle. However, in recent years, India and many countries around the world have adopted various policy initiatives to encourage and prioritize cycling as the prime mode of urban transport, catering to all sections of society.

Under the Smart Cities Mission in India, several cities introduced public bike-sharing systems to promote cycling. This paper aims to evaluate the effectiveness of public bike-sharing system implemented under the Smart Cities Mission, in terms of its usability and modal integration. A comparative analysis of three smart cities namely, Chandigarh, Surat and Kochi have been conducted using multiple criteria frameworks to identify the reasons of success or failure of the system. The key findings of the study highlight the gaps and challenges in implementing the public bike-sharing system and provide recommendations for the same.

2. Methodology

For this study, a macro-to-micro level approach is undertaken with a mix of secondary and primary studies. The methodology for assessing public bike-sharing for this study involves a systematic approach to collecting, analyzing, and interpreting data.

A literature review was conducted to identify and assess the existing concepts, theories and best practices on PBS system around the world. To better understand the Indian context, the planning and policy framework in India was analysed. Based on the theoretical understanding, a comprehensive framework was developed to evaluate the PBS system in Indian cities.

In India 48 cities have implemented PBS system in their mobility plans. A set of questions were sent to these cities seeking specific information on the implemented systems. Out of 48, 27 cities provided the information, which facilitated the authors to select three cities for a detailed primary assessment. The selection criteria involved choosing cities with a varied socio-economic and geographical context, contributing to diverse implementation outcomes and user experiences.

Chandigarh, Surat and Kochi were chosen and evaluated using a detailed framework based on the parameters derived from the various guidebooks and manuals including CROW manual and ITDP and MoUD guidebooks [5, 6, 7, 8, 9], as mentioned below:

- Lane Infrastructure
- System Size / Coverage / Integration
- Usability
- Operation and Maintenance
- Financing Structure

The data was collected through Stakeholders Interviews; On-ground System Testing- Testing of the Mobile App, Testing of Cycles, Testing of Infrastructure, Testing of Functionality and Testing of customer complaints redressal mechanism; and User Surveys.

3. Results

A descriptive analysis was conducted for an overall evaluation of cities with Public Bike-Sharing (PBS) system, with a specific focus on understanding the extent of PBS usage and functioning across the country. It was noted, that cities with higher populations have comparatively larger PBS system sizes in terms of the number of bicycles. It was evident from the data that in most cities, PBS has been implemented as a pilot project with a limited number of bicycles and docking stations that do not fulfill the demands of the city's population.

The detail analysis of the three cities on the accessibility and usage of the system was conducted taking into consideration the capacity of the system infrastructure, coverage, location, user interface, fare structure and financial model.

3.1 Comparing the Cities

3.1.1 Lane Infrastructure

Even if there is little existing cycling infrastructure, cycle sharing can be implemented, but integrating the cycle tracks with the PBS system can add to public acceptance and enhance safety for users of the new system. This was evident in the cities of Chandigarh, Kochi, and Surat. As Chandigarh has built upon its existing bike lane infrastructure, the user acceptance of cycling was visible in the city. Surat, on the other hand, has introduced lanes in specific areas of the city, limiting the usage of the cycles. Kochi, however, fell short of providing a good network of bike lanes.

3.1.2 System Size / Coverage

System Coverage plays an important role in the success of the PBS system as it increases the accessibility of the people to use the system. All three cities launched the system coverage depending upon their local needs to maximize the ridership. Chandigarh prioritized system coverage across the entire city, focusing on tourist areas and Central Business Districts (CBDs). Kochi prioritized the coverage near the metro stations and tourist areas, while Surat focused on zonal areas, again with limited station density.

3.1.3. Integration with the Public Transport Network

As a PBS system is part of the city's larger transport system, integration with existing public transport modes is essential to ensure seamless connectivity. Although, in the case studies, stations have been placed along the transportation modes, fewer or no integration was seen at the spatial or policy level.

3.1.4 Usability

Chandigarh, Kochi, and Surat launched the PBS systems tailored to the local needs and developed their own system design generating widespread public interest resulting in initial success and usage. Over the years, the PBS system of these cities has seen a decline in terms of ridership and infrastructure. One of the reasons is the user interface. There is a huge dependency on the internet to unlock and lock the bikes through the Mobile App.

3.1.5 Financial Structure

The investment models are different in all three cities. In Chandigarh, the agencies responsible for the investment in lane infrastructure, bike stands and bikes are different, reducing the financial burden on any agency. In Kochi, two agencies are responsible for the investment in the PBS system. Surat has opted for a convergence model where AMRUT funds have been utilized for the PBS system apart from the Surat Municipal Corporation investment.

The financial data showed that while significant investments have been made in the PBS system in Chandigarh, the project is currently operating at a loss, mostly due to theft and vandalism. Due to the lack of data on Profit/ Loss for Kochi and Surat, this cannot be determined.

4. Conclusion

The study examined the experiences and models implemented by Chandigarh, Kochi, and Surat in India, on sustainable mobility. Based on the case studies, it was inferred that to ensure the long-term success and effectiveness of public bike-sharing systems, it is essential to move beyond pilot projects and piecemeal initiatives at the city level. Instead, there should be a concerted effort to develop an ecosystem that cultivates a cycling culture and promotes sustainable modes of transportation. The focus should be on creating an interconnected and integrated system that encourages the widespread adoption of cycling as a primary mode of transport. This involves:

To summarize, cycling as a modal shift in India still needs acceptance from the people. The study revealed gaps in the usage of the public bike-sharing system in all three cities. While this paper is useful in understanding the complexity of cycling-specific to Public Bike-Sharing in India. Still, additional theoretical and empirical research on user behavior specific to the context is required.

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TOWARDS A TRANSFERABLE FRAMEWORK FOR URBAN DATA INTEGRATION: LESSONS FROM PRAGUE

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1. Introduction and theoretical framework

In an urban environment, a variety of data types are generated. In Prague there are several categories: Mobility and public space, Environment, Energy and buildings [1]. Effectively integrating these categories can provide new information and knowledge in the context of urban mobility, emissions [2]. However, there are several challenges for analytics in the combination of data from different categories for purposes such as the Climate Plan. [3] This paper presents insights from data integration efforts in Prague using two main data sources: the Golemio data platform [4] and the Czech Hydrometeorological Institute (CHMI) [5]. Despite the increasing availability of urban datasets, there is still a lack of practical frameworks that can bridge the gaps between meteorological conditions, traffic flow, air pollution, and urban morphology in a way that supports decision-making. This paper seeks to answer the following research question: How can heterogeneous urban datasets from weather, traffic, emissions, and urban morphology be methodologically harmonized to create a transferable and explainable framework for urban air quality assessment and prediction?

In Flanders, social housing functions as a safety net for the lowest income deciles, which means that social renters are less likely to own a car. As a result, social renters are on average more dependent on public transport and nearby amenities such as shops, schools, and healthcare to meet their daily and occasional needs. Their satisfaction is therefore strongly influenced by the location and accessibility of their housing [4]. Since social tenants are allocated to housing and thus have very little control over where they are going to live, the location of social housing is crucial for the well-being of social tenants.

2. Key Challenges and Methodology

2.1. Data Sources and Semantic inconsistency

The data sets came from different institutions (Golemio [4] and CHMI [5]), each of which used its own naming conventions [7], units, and data formats. Weather data was reported using meteorological terminology, traffic data used transport-specific metrics, and emissions were often inconsistently labeled across sensors.

In each paper [6], [8], a semantic harmonization layer was developed by manually mapping terms to categories based on each domain and measured values. This process revealed the absence of shared urban ontologies for operational data.

2.2. Temporal Inconsistencies and Irregular Sampling

The temporal resolution varied from 5-minute-based traffic data to hourly or irregular emissions readings. Some sensors recorded missing or duplicate timestamps, while others lacked consistent temporal metadata [8].

Therefore, all data sets were resampled at an hourly resolution. Where appropriate, the gaps were interpolated while respecting domain-specific dynamics (e.g., traffic peaks versus weather stability). We defined this hourly granularity as the minimum unit for cross-domain reasoning [8].

2.3. Spatial Dislocation and Sensor Incompatibility

Sensors in different domains are not spatially aligned. Weather stations, traffic detectors, and emission sensors (such as NOx, CO2, PMs) were rarely located in the same place. The other aspect is spatial itself (urban morphology), which influences the direction of the wind and the behavior of emissions in the air [2].

A spatial matching procedure using proximity buffers and weighted interpolation was necessary for the following steps. Morphological features were aggregated into discrete urban zones based on cadastral or planning layers to allow integration with dynamic sensor inputs [8].

2.4. Missing Data and Quality Gaps

In general, all datasets contained missing values that varied in cause and treatment. Some gaps were due to sensor outages and others were due to pre-processing errors. Inconsistent encoding of missing values (e.g., NA or blank spaces) further complicates automated workflows.

To address this, a unified cleaning pipeline was created to standardize the representation of missing data, supported by metadata inspection. The emphasis was on identifying systematic gaps rather than random noise [8].

3. Results and Data Recommendations

Based on methodological reflection, we propose a structured set of recommendations for minimum viable data requirements that are applicable in various urban contexts. These recommendations aim to support cross-domain integration between weather, traffic, emissions, and urban morphology data sets.

Domain	**Required Structure**	**Data Type**	**Temporal Resolution**	**Categorization**
Weather	Geo-referenced time series	Temperature, Precipitation, Wind Speed and Direction	Dynamic – Hourly	Meteorological classifications (e.g., synoptic scale)
Traffic	Segment-based sensor data or traffic flow models	Traffic flow, speed of traffic flow	Dynamic – Hourly	Level of Service (LOS), congestion metrics
Emissions	Monitoring stations or modeled data	NO_x, PM_s, CO_2, CO	Dynamic – Hourly	Regulatory thresholds, health impact levels [7]
Urban Morphology	Spatial zoning or gridded form data	Built-up density, green cover, road surface, ...	Static (annual or less frequent)	Urban structure typology

Table 1: Proposed data requirements and domain harmonization recommendations

Ideally, sensor locations across domains should overlap to allow for direct relational analysis. However, due to spatial discrepancies in sensor placement, spatial interpolation and map matching techniques are required to harmonize the datasets. The table above outlines the minimal structural and temporal criteria to support interoperability and analytical integration, regardless of the size of the city or the maturity of the data infrastructure. It can lead to making maps of how much pollution is in the air in cities, along with other data sets, such as FCD (floating car data). This allows municipalities to make more informed policy decisions.[9]

4. Discussion

Integrating heterogeneous urban datasets is a challenging task that requires careful management of temporal, spatial, and semantic inconsistencies. The challenges identified in this paper are not unique to Prague, but reflect the broader issues that cities face when trying to use open data for research and decision-making purposes. By documenting and systematizing these challenges, we contribute to the growing methodological toolkit for not only smart city analytics. Previous research has shown that urban morphology is an important factor in urban knowledge. The structure of the city, its streets, and surrounding environments play a key role in airflow behavior (including emissions and weather). Temporal resolution is usually measured in months or years [8]. The research question posed in the introduction has been addressed through the identification of key integration challenges and the proposal of transferable data recommendations.

5. Conclusion

This paper emphasizes the complexities of merging traffic flow, emissions, urban morphology, and weather data sets. Based on our practical experience in Prague, we identified several challenges, ranging from temporal misalignment to semantic inconsistencies, and proposed a structured preprocessing approach to address these issues. This paper presents systematic reflections on practical challenges in data interoperability in the context of Prague's urban data platform and provides minimal transferable data requirements applicable to other cities. As cities increasingly rely on data-driven planning, transparent and reusable data workflows will be essential to ensure the credibility and utility of urban analytics. For example, this framework could support early warning systems for emission peaks during heat waves or suggest traffic rerouting during poor dispersion conditions. This work provides practical implications for urban data management and planning. The proposed minimum viable data set helps cities identify which data is essential for cross-domain analysis of air quality. It can support urban planners in targeting interventions, improving sensor deployment, and aligning data infrastructures. For researchers, the data requirements offer a transferable baseline for building explainable and interoperable models in other urban contexts.

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EDUCATIONAL ACCESSIBILITY AND PARENTAL MOBILITY: CORRELATIONS BETWEEN SCHOOL PROXIMITY AND TRAVEL BEHAVIOUR IN THE PRAGUE METROPOLITAN AREA

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1. Introduction

Car dependency has been widely recognised in the international literature as a key driver of urban development, shaping settlement patterns, land use, and transport systems throughout much of the twentieth and twenty-first centuries [1,2]. Yet, empirical evidence on how these dynamics unfold within Central European metropolitan regions remains limited. Fragmented settlement structures and dispersed amenities often constrain modal choice and perpetuate car-oriented mobility.

To address car dependency, contemporary planning paradigms, most notably the 15-Minute City concept [3], advocate proximity-based urban design that seeks to situate essential amenities within short walking or cycling distances [2]. Among these amenities, schools and kindergartens play a particularly pivotal role, as they structure daily trip patterns and are strongly associated with parental mode choice.

This study focuses on parents in the Prague Metropolitan Area, exploring how accessibility to relevant educational facilities—kindergartens for households with children aged 0–5 and primary schools for those with children aged 6 and above—correlates with the frequency of car and public transport use. The research contributes an evidence-based perspective on family travel behaviour within a Central European context, while acknowledging that all identified relationships are correlational rather than causal.

2. Methodology

The analysis is based on the Prague Metropolitan Travel Survey (2021), comprising approximately 1,000 respondents, from which a parental subsample (N = 352) was extracted. The study employs an ordinal Structural Equation Model (SEM). The SEM approach allows simultaneous estimation of multiple interrelated equations, incorporating both direct and indirect (mediated) correlations between variables. This modelling framework captures how socio-economic attributes, built environment characteristics, and amenities accessibility jointly co-vary with mobility behaviour.

The model includes three main groups of independent variables: (i) socio-economic characteristics, (ii) built environment characteristics, and (iii) relevant education facility accessibility.

Two mediating variables—driving licence possession and number of cars in the household—represent individual and household-level mobility resources that link transport mode availability.
The model includes two dependent variables: (1) frequency of car use and (2) frequency of public transport use, both measured on ordinal scales. The structural relationships are estimated as

correlations rather than causal pathways. Model estimation was conducted using the R package 'lavaan', with fit indices indicating satisfactory adequacy (CFI = 0.91, RMSEA = 0.056).

3. Results

Independent variable	**hh_cars**	**r_driving licence**	**r_car_use freq**	**r_pt_use freq**
r_gender			-0.905 ***	
r_econ_active		0.093 *	0.336 '	
r_grad_master				0.428 **
r_driving_licence	0.428 ***	×	2.284 ***	-0.924 ***
hh_single_adult	-0.970 ***			
hh_income_per_breadwinner	0.019 ***			
hh_cars	×		0.544 ***	-0.223 ***
ho_detached	0.390 **			
population_density		−0.001 **		
rel_education_in_15			-0.626 *	
reg_ctrs_hi_pt_car_ratio_f			0.210 *	-0.227 ***
reg_ctrs_lo_pt_car_ratio_f			0.178 '	

***p<0.001; **p<0.010; *p<0.050; 'p<0.100

Table 1: Summarization table—estimates

Categorical dependent var.	**Never**	**<1 time**	**<1–3 times**	**1–3 times**	**>3 times**
r_pt_use_freq	-1.86 ***	-0.77 **	-0.20 *	0.17	—
r_car_use_freq	0.62 '	0.97 **	1.29 ***	2.09 ***	

***p<0.001; **p<0.010; *p<0.050; 'p<0.100

Table 2: Summarization table—thresholds

Accessibility of a relevant educational facility (kindergarten for children aged 0–5, primary school for children aged 6+) stands out as a key correlate of modal choice. Parents with a school within a 15-minute walking distance report less frequent car use ($b = -0.626$; $\beta = -0.19$). The magnitude of this association is comparable to the effect of car ownership, underlining the central role of educational accessibility in structuring family mobility routines.

At the regional scale, the accessibility of higher-tier regional centres by public transport (relative to car) also shows a clear pattern. Poorer public transport competitiveness correlates with higher car use ($b = 0.210$; $\beta = 0.13$) and lower public transport frequency ($b = -0.227$; $\beta = -0.19$). Accessibility to lower-tier regional centres has weaker significance ($b = 0.178$; $\beta \approx 0.10$), suggesting that these destinations play a minor role in parents' daily travel structure.

Regarding the built environment, living in a detached house correlates positively with car ownership ($b = 0.390$; $\beta = 0.22$) and indirectly with higher car use, reflecting the spatial separation typical of suburban housing forms. Population density does not correlate significantly with modal frequencies, though it shows a negative association with driving licence possession ($b = -0.001$; $\beta = -0.14$), implying that denser environments may slightly reduce car-oriented tendencies. Dwelling size (house area) shows no significant effects, likely due to low variance among respondents.

Within socio-economic characteristics, gender remains one of the strongest correlates: women report lower car use frequency ($b = -0.905$; $\beta = -0.29$). Economic activity ($b = 0.336$; $\beta = 0.10$) is associated with more frequent car use, consistent with the travel demands of employed parents. Higher education attainment correlates with more frequent public transport use ($b = 0.428$; $\beta = 0.18$), potentially reflecting value orientations or workplace locations more compatible with collective transport.

Two mediating variables—driving licence possession and car ownership—show the strongest statistical associations across the model. Licence holders report both higher car use ($b = 2.284$; $\beta = 0.41$) and lower PT use ($b = -0.924$; $\beta = -0.23$), underscoring the enabling function of licence possession. Each additional household car correlates with higher car use ($b = 0.544$; $\beta = 0.31$) and lower public transport use ($b = -0.223$; $\beta = -0.18$), reflecting how household motorisation conditions everyday mobility flexibility.

Overall, the model shows that among parents in the Prague Metropolitan Area, car use is systematically correlated with local accessibility and built environment attributes. Walkable access to schools is associated with reduced car reliance. These relationships highlight the interdependence between spatial structure and household resources, without implying direct causal effects.

4 Discussion

The observed relationships align with international studies emphasising the role of proximity and density in shaping mobility correlations [1,4]. For parents, escorting children to educational facilities structures daily travel routines and often determines subsequent mode choices. In the Prague metropolitan context, long walking distances to schools coincide with more frequent car use. The SEM framework highlights that accessibility, built environment, and socio-economic characteristics act as interlinked correlates rather than isolated determinants of behaviour. These findings underline the need for planning policies that integrate school siting, neighbourhood density, and multimodal accessibility—without presuming direct causality between the built environment and travel choices.

5 Conclusions

The model demonstrates that the accessibility of relevant educational facilities is an important correlate of parental mobility in the Prague Metropolitan Area. Parents residing within 15 minutes of a kindergarten or primary school tend to use cars less frequently. Population density, regional accessibility, and dwelling type further co-vary with modal choice, mediated by household-level mobility resources. The structural equation approach provides a robust way to observe these interconnected relationships while maintaining a correlational interpretation. For spatial planning, the results suggest that improving accessibility and spatial compactness may align with more sustainable mobility outcomes for family households, though no causal inference is made.

Overall, the activities highlighted how mobility is perceived not only as a functional necessity but also as a right and an opportunity to activate new centralities and strengthen the relationship between communities, landscape and heritage.

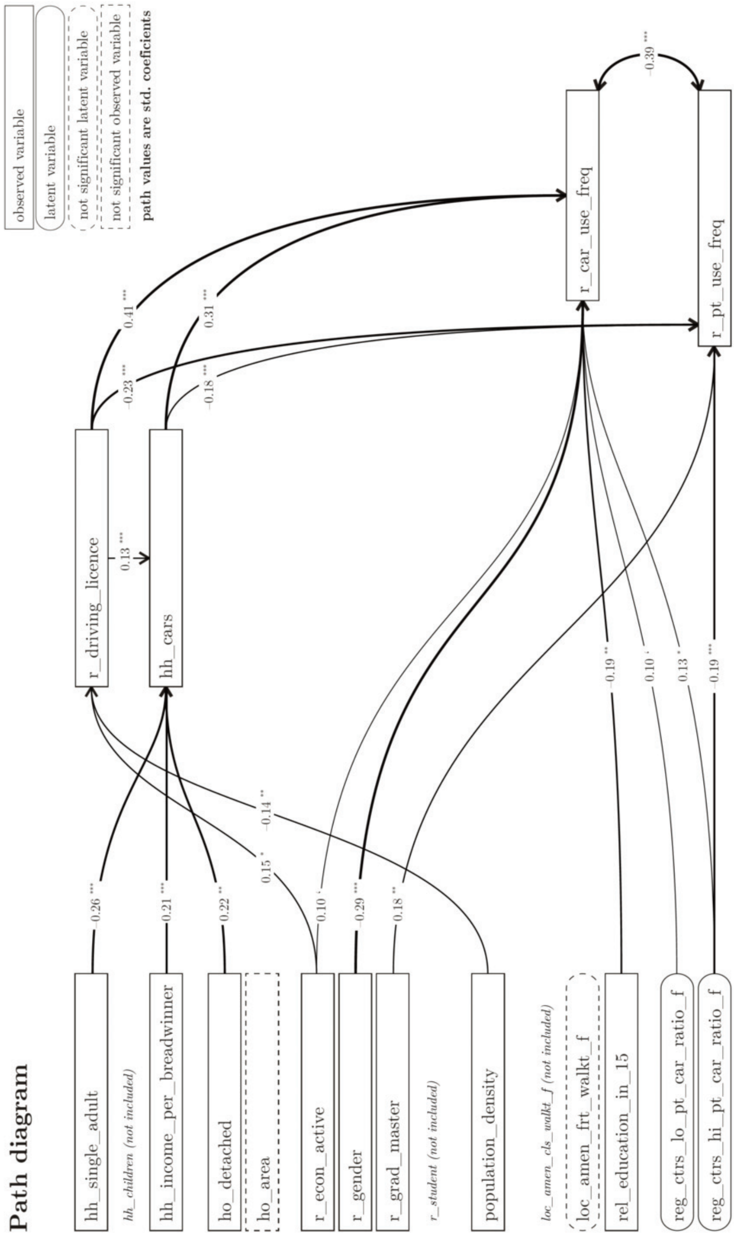

Figure 1: SEM path diagram

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CROSSING CULTURAL LANDSCAPE: LAND-SEA INTERMODALITY FOR ACCESSIBILITY AND RESILIENCE IN CAMPI FLEGREI

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1. Introduction

This contribution reflects on the regenerative potential of everyday mobility services and infrastructures for urban welfare activation and heritage enhancement. It focuses on the case study of the everyday mobility network – by land and by sea – in Campi Flegrei, a territory strongly characterized by its cultural and landscape values, but also by accessibility issues and social and geological vulnerability.

This contribution, therefore, brings into dialogue the theme of mobility with that of heritage fruition, through the concept of *crossing*, understood not only as functional movement but also as an aesthetic and cultural experience that enables territory to be lived and valued. From this perspective, everyday mobility becomes a privileged observatory for studying the interplay between people, cities and transport systems[1].

The work adopts as its theoretical premise a critical reading of the concept of heritage: in line with the definition of cultural landscape proposed by UNESCO [1], heritage is understood "as the historical product of long-term co-evolutionary processes between human settlement and the environment, between nature and culture" [2],encompassing not only places of historical or environmental significance but also "ordinary" landscapes, shaped by processes of sedimentation and accumulation [3]. Therefore, the concept of heritage extends to the territory as a whole [Figure 1]. Thus, mobility infrastructures stand out in the landscape as traces of urbanization processes, and can be understood as spatial capital [4], assuming heritage value above all in relation to the quality of the context they traverse.

The experience of *crossing*, enhanced within everyday mobility practices, assumes a social value: not only responding to the mobility needs of the resident population, but also contributing to the reactivation of relationships between places and communities, and by defining new centralities, new modes of territorial access and new public spaces. The social and environmental dimension is grounded in the idea of a diffuse urban welfare, in which public mobility is accessible, sustainable,

[1]The contribution develops within two research projects carried out by DiARC (Department of Architecture of University of Naples Federico II): CHANGES (Cultural Heritage active innovation for Next Gen Sustainable Society) – aimed at developing strategies for the protection and enhancement of historical landscapes in vulnerable contexts; and MERCIE (Eco-sustainable Models for Collaborative, Integrated and Inclusive Urban Regeneration of the Land–Sea System) – focusing on outlining sustainable mobility scenarios oriented towards the protection and enhancement of coastal and inland landscape resources» [5].

inclusive and sensitive to the territorial context, placing public interest at the centre. The aim is to (re)construct a collective and landscape imaginary that can provide renewed centrality even to marginal areas, since «people not only observe the city whilst moving through it, rather they constitute the city by practising mobility» [5].

Figure 1: *Tempio di Venere*, Bacoli. Interplay between land and sea resources

The objective is therefore to reflect on the possible synergies between heritage accessibility and territorial mobility, so that the mobility transition does not become yet another instrument of *touristification* [6], but rather a catalyst for the mobility needs of the resident population, contributing to the reactivation of relationships between places and communities. The aim is to overcome the logic of scarcity and the resulting need for *austerity* often embedded in mobility transition processes, instead emphasising the value of movement itself also through a *spectacularization* of everyday mobility networks [7] [Figure 2].
The research addresses mobility as a theme that intertwines sociological (needs and practices of local communities), environmental (volcanic risk and sustainability of transport systems), and technical (intermodal networks, accessibility and connections) dimensions. «This means rethinking the role of mobility as what keeps communities both connected and diverse. Mobilities may be the means through which we interact with each other and with the environment around us» [7].

By proposing an interpretation of infrastructures not only as physical devices but also as spaces mediating between accessibility needs, social demands and heritage enhancement, the research is guided by the following questions:

RQ1. How can everyday mobility networks and services (land–sea and cycling–pedestrian) improve accessibility for residents and occasional users through the experience of crossing the territory?

RQ2. How does improved accessibility to the territory generate social benefits (inclusion, new centralities, public spaces, heritage enhancement) and operational benefits (reduction of congestion, support for emergency plans)?

RQ3. What role do communities and stakeholders play in co-designing routes and services that better respond to local needs?

Figure 2: *Castello di Baia* from Vie del mare maritime route, Bacoli

2. Methodology

From a methodological perspective, the work relies on a case study: the everyday mobility network – by land and by sea – in Campi Flegrei. This vast area – a still active volcanic caldera west of Naples – concentrates one of the highest densities of cultural and landscape resources in Italy, but at the same time suffers from serious accessibility problems, due to the territory's morphology and its vulnerability to volcanic, seismic and bradyseism risk. It is precisely within this framework that we see the possibility of studying mobility as a regenerative resource, capable of generating new centralities and public spaces and of enhancing cultural heritage. The research adopts an integrated approach that combines analytical tools (GIS mapping of cultural and landscape assets, risk conditions, settlement dynamics, urban policies) with exploratory and participatory practices (co-mapping, walking interviews, photographic surveys). The aim is to construct a multidimensional knowledge framework that captures the interactions between heritage, risk and urban dynamics, and to generate strategic guidelines for socio-spatial regeneration.

3. Case study

The analysis reveals that the widespread presence of archaeological remains within a highly urbanized landscape produces a complex interaction between heritage conservation, heritage use, and territorial vulnerabilities. The outcome is a fragmented landscape in which historical and contemporary layers often collide [Figure 3].

Figure 3: *Parco Archeologico delle Terme di Baia*, Bacoli. Archaeological remains emerging within urban fabric

From the perspective of infrastructures and mobility services, Campi Flegrei area, although connected to Naples by major road and rail networks, suffers from severe local accessibility issues, caused by disorderly urban growth and complex orography. In this context, the need to intervene on the infrastructural system can become an opportunity to enhance the accessibility and enjoyment of archaeological and landscape heritage: everyday mobility practices may foster crossings capable of reactivating relationships between places and communities, creating new centralities, new modes of access to the territory, and new forms of public space. This approach counters a narrative that frames heritage valorization merely as a tool for extractive tourist economies, which tend to limit its use by residents in their daily practices.

Currently, Campi Flegrei are the focus of new projects aiming to promote slow and intermodal mobility, with the dual objective of reducing road congestion and supporting strategies for managing bradyseism risk. Within this framework, disused or transforming infrastructures play a significant role: a former railway station converted into a cultural center, abandoned railway tracks redeveloped into cycling and pedestrian paths, and the system of maritime connections – the *Vie del Mare* – linking coastal ports with the islands [Figure 4]. These initiatives may represent valid alternatives to traditional transport systems, fostering symbolic connections with the territory and with its archaeological and landscape heritage.

Figure 4: Pier of Torregaveta, landing point for maritime connections towards the Islands

4. Field Activities

The fieldwork research and engagement activities were structured through participatory practices and on-site observations, aimed at exploring how mobility is perceived and experienced by local communities. Exploratory walks, living labs and thematic workshops enable the collection of qualitative data on crossings, barriers, and potentials, highlighting how everyday mobility is closely intertwined with heritage enhancement and local productive dynamics. In parallel, the analysis of seasonal mobility policies and related citizen responses – gathered through targeted meetings and social media monitoring – revealed a widespread demand for more stable services focused on residents' needs rather than solely on tourist flows. These findings were further explored through interviews with operators and users, aimed at reconstructing different mobility profiles (residents, occasional users, tourists [Figure 5]) and evaluating the potential for extending or adapting existing mobility services. The stakeholders involved – local administrations, cycling and cultural associations, environmental organizations and private operators – expressed a shared need to improve accessibility as a condition for enhancing the liveability of the territory.

Overall, the activities highlighted how mobility is perceived not only as a functional necessity but also as a right and an opportunity to activate new centralities and strengthen the relationship between communities, landscape and heritage.

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Figure 5: Field activities on the *Capitan Morgan* maritime line.

5. Conclusion and preliminary findings

The activities carried out reveal that transformative capability lies in the willingness of communities to cross and inhabit the landscape. Everyday mobility thus emerges a cultural, social and environmental practice which goes beyond mere functional movement, offering opportunities to enhance the territory and to recognize its qualities.

Infrastructures – whether functioning, disused or in transformation – are not merely technical devices but also material networks and cultural experiences, capable of reinterpreting and re-signifying landscapes. Their value resides in the immersive and relational dimension of crossing contexts dense with memory and stratification.

Thus, this process cannot overlook the role of local communities, who are not passive spectators but fundamental actors in recognizing and activating transformations and in orienting future choices. Mobility therefore becomes a lens trough which reinterpreting cultural landscapes and promoting new forms of public space and diffuse urban welfare, capable of generating new centralities and strengthen relations in marginal territories.

In this perspective, Campi Flegrei represent an emblematic laboratory for experimenting with how mobility, integrated with heritage enhancement and territorial resilience, can contribute to rethinking the relationships between people, cities and transport.

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FRAMING CHANGE IN SUSTAINABLE URBAN MOBILITY PLANS: DISTINGUISHING TRANSITION FROM TRANSFORMATION FOR URBAN DECARBONIZATION

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1. Introduction

The transformation of car-based mobility systems represents one of the most pressing challenges for achieving sustainable, climate-neutral urban transport [1,2]. Despite numerous technological innovations and policy initiatives, progress in urban mobility remains limited, and even when cities adopt Sustainable Urban Mobility Plans (SUMPs), planning often focuses on incremental adjustments rather than systemic change [3, 4, 5]. This raises a critical research question: does the SUMP guideline itself facilitate deep systemic transformation, or does it primarily reinforce slow, incremental transition? Addressing this question requires analyzing how SUMPs conceptually frame transition and transformation, as these framings directly shape the practical outcomes achievable by cities implementing these plans.

2. Conceptual Background

SUMPs have been recognized as a significant advancement over traditional transport planning by operationalizing sustainability through criteria such as accessibility, economic viability, social equity, health, environmental quality, and effective use of urban space [6,7]. The European Commission frames SUMPs as central instruments for achieving climate-neutral and sustainable mobility systems, emphasizing the need to move from incremental change to fundamental transformation in line with the European Green Deal [7,8]. Nevertheless, questions persist regarding the sufficiency of SUMPs in enabling the profound systemic transformations envisioned by European policy [7].

Some scholars distinguish between transition and *transformation* in the context of socio-technical change. In transition research, Geels and Schot (2007) treat transformation as one possible pathway within broader transition processes, whereas other researchers emphasize that transformation involves more radical, large-scale, and long-term changes [9,10]. Transformation has been widely positioned as a solution to societal and planetary crises, including climate change and biodiversity loss; yet its conceptualization remains ambiguous, often framed either incrementally or radically depending on the problem definition [11].

Canıtez (2025) highlights that mobility systems are undergoing systemic change through technological innovations, policy interventions, and societal shifts, but he employs *transition* and *transformation* interchangeably, reflecting the conceptual ambiguity that persists in contem–

porary mobility research [1]. Manderscheid (2020), in contrast, differentiates three hierarchical perspectives on change: propulsion engine transition, focusing on technological decarbonization; transport transition, emphasizing modal shifts and shared mobility services; and mobility transition, prioritizing travel demand reduction and sufficiency, representing deep systemic change [12]. This framework clarifies the depth of change; however, its main focus lies on transitions. While both concepts refer to change within complex adaptive systems, they are applied to different system scales and foci[10].

Urban mobility transitions are inherently complex, involving technological and infrastructural changes as well as shifts in governance, policies, socio-cultural norms, and travel behavior [1,13,14]. These transitions unfold over long time frames and are influenced by unpredictable events, global crises, and local contextual factors [1,14]. Although SUMP engages on how change can be influenced, it does not articulate an explicit theory of change, leaving the distinction between incremental adjustments and deep systemic change unresolved [7]. Critically, the way the SUMP guideline frames *transition* and *transformation* shapes the normative and practical boundaries of urban mobility interventions, influencing the outcomes cities can achieve when implementing these plans.

Focusing on *transformation* rather than *transition* in urban mobility planning has significant implications for both the ambition and effectiveness of interventions. Transformation-oriented approaches encourage systemic reconfiguration, addressing root causes of unsustainable mobility, including car-dependence, inequitable access, and fragmented infrastructure. Conceptual clarity in framing transformation may therefore expand the potential for meaningful societal, environmental, and technological outcomes.

3. Methodology

To investigate how the SUMP guideline frames transition and transformation, this study employs a qualitative document analysis of both the first and second editions of the SUMP guidelines (2013 and 2019), as well as relevant European Commission policy documents that reference the EU framework for urban mobility, covering the period from 2013 to 2023. Planning and policy documents are treated as discursive artifacts that structure what is considered feasible and legitimate in urban governance, making them particularly suitable for examining the assumptions, normative orientations, and linguistic choices that shape urban mobility planning.

According to Graf and Kantel, different ideas of transformation are brought together under the label of ‘sustainable mobility’, making the analysis of sustainability essential to understanding the framing of change [15]. Therefore, the analysis begins with a systematic identification of key terms, including transition, transformation, and sustainability, to capture how these concepts are invoked and interrelated within the texts. Coding focuses primarily on temporal orientation and the implied depth of change, while policy instruments referenced in the guidelines are also considered to understand how they contribute to the framing of change. The thematic categories for organizing the findings are informed by Manderscheid’s hierarchical framework of propulsion engine, transport, and mobility transitions, with additional categories added where necessary to capture emerging patterns.

The identified themes are then subjected to critical discourse analysis (CDA) to examine how language choices reproduce, challenge, or legitimize existing power relations, particularly in relation to the entrenched automobile regime. This approach integrates descriptive mapping with critical insight, linking textual evidence from the SUMP guidelines and EU policy documents to broader debates on sustainability, socio-technical transitions, and systemic transformation. By analyzing both the explicit and implicit framing of change, the methodology enables an assessment of whether the guidelines conceptually support incremental adjustments or deeper systemic transformation in urban mobility.

4. Expected Contributions and Conclusions

The study is expected to clarify how the SUMP guideline frames change and whether it conceptually supports incremental adjustments or deep systemic transformation. The analysis is anticipated to reveal areas in which the guideline conflates transition and transformation, potentially predisposing cities to pursue incremental measures rather than the radical interventions required to achieve European decarbonization and sustainability targets. By contrasting the guideline's framing with Manderscheid's hierarchical framework, the research will provide a heuristic to assess the anticipated depth of change associated with SUMP adoption.

The findings will also illustrate the normative influence of sustainability framing within the guideline, emphasizing conceptual clarity in policy guidance. How transformation is defined and operationalized within SUMPs, may function as a key determinant of whether future urban mobility planning can achieve the systemic change envisioned in European sustainability agendas.

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ADDRESSING THE ACCURACY-INTERPRETABILITY TRADE-OFF IN CHOICE MODELING WITH EXPLAINABLE AI

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1. Introduction

Modeling travel mode choice is fundamental for understanding travel behavior and forecasting transportation demand. Accurate mode choice prediction models are essential for effective transportation planning, policy decision-making, and route recommendations [5]. Traditionally, this domain has been dominated by theory-driven frameworks based on the Random Utility Maximization (RUM) paradigm [3]. RUM-based Discrete Choice Models (DCMs), such as the Multinomial Logit (MNL), not only predict travel behavior but also provide valuable *behavioral insight*—revealing how explanatory variables like cost or time influence decision-making through interpretable parameters (e.g., marginal utilities). This transparency and theoretical grounding make RUM models indispensable for policy formulation and infrastructure planning.

The recent rise of data-driven modeling, particularly through Artificial Neural Networks (ANNs) and Deep Neural Networks (DNNs), has introduced an alternative paradigm that prioritizes *predictive performance* over structural transparency. These models can flexibly capture complex nonlinearities and interactions among variables, often outperforming traditional models in empirical accuracy [8]. However, this gain in predictive capability comes at the expense of interpretability. DNNs are typically opaque "black boxes" that reproduce observed behavior but provide limited insight into the underlying causal mechanisms driving such behavior.

This tension between *prediction accuracy* and *behavioral understanding* represents a fundamental methodological dilemma in moder choice modeling. Theory-driven models offer high *structural transparency* but may oversimplify behavioral complexity, whereas datadriven models achieve a strong empirical fit but lack inherent interpretability. Addressing this dichotomy requires techniques capable of bridging empirical prediction with causal explanation. Figure 1 illustrates how applying post-hoc explanation techniques to high performance models can bridge this dichotomy, which is visually formalized as the accuracy-interpretability trade-off across four quadrants. To address this, our research selects the most common and influential models to predict travel mode choice: DNN, XGBoost, and Random Forest (black-box) versus Multinomial Logit, Mixed Logit, and Nested Logit (inherently interpretable). Crucially, the figure highlights the objective of Explainable AI (XAI): applying post-hoc explanations to black-box models effectively moves them into the high-performance, higher-transparency space.

Explainable Artificial Intelligence (XAI) has emerged as a response to this challenge. Rather than being inherently transparent, XAI provides *post-hoc explanation* methods, such as Shapley Additive Explanations (SHAP) or Local Interpretable Model-Agnostic Explanations (LIME), that approximate the internal logic of complex models after training [2, 4]. To ensure conceptual rigor, it is essential to distinguish three related but distinct concepts: (1) *Transparency*, referring to full traceability of how model outputs arise from inputs; (2) *Inherent Interpretability*, where the model structure itself is understandable (as in RUM-based DCMs); and (3) *Post-hoc Explanation*, where interpretability is reconstructed externally using tools like SHAP.

Within this study, XAI techniques are applied to DNN-based mode choice models to explore whether post-hoc explanations can provide mode choice insight comparable to that of inherently interpretable, theory-based models. By systematically analyzing the relationship between predictive accuracy and structural transparency, this work aims to contribute to resolving the enduring trade-off between performance and interpretability in transportation choice modeling.

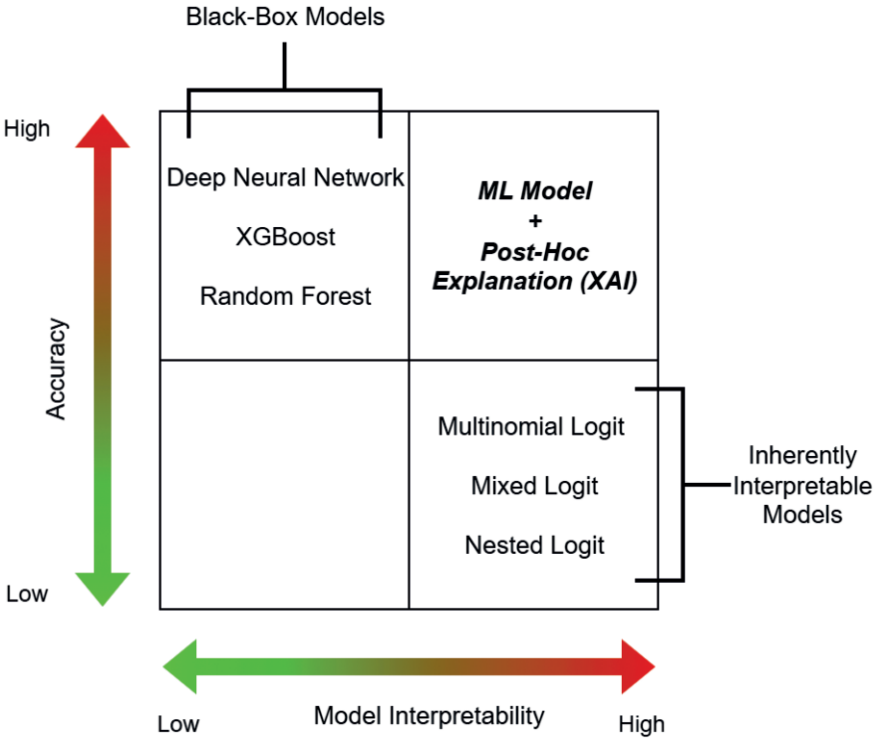

Figure 1: Accuracy vs. Interpretability Trade-Off in Choice Modeling.

The central question is not merely how well AI can predict choices, but whether it can also *explain* them in a manner consistent with behavioral and causal reasoning.

2. Methodology

Establishing a rigorous analytical framework is essential and requires the selection of appropriate evaluation metrics for reliable comparisons across diverse model architectures. The research is explicitly framed as navigating the accuracy-interpretability trade-off, comparing models that prioritize high predictive performance with those that ensure transparency.

The methodology described in this study is conducted in the broader research on travel mode choice modeling. In our ongoing work, a travel survey dataset is utilized that captures discrete mode choices across several transport options, including driving, public transit, walking, and biking. For the task of high-accuracy prediction, Deep Neural Networks (DNNs) are trained to achieve high prediction accuracy. To interpret their complex decision-making, the SHAP (SHapley Additive exPlanations) methodology is employed; it is a unified framework that interprets model predictions by assigning an importance value to each feature and quantifying its contribution to a particular prediction [2]. This provides critical insight into the black-box model's behavior.

For comparative evaluation, the established econometric models serve as the standard of model transparency. The analysis focuses on Random Utility Maximization (RUM)-based Discrete Choice Models (DCMs), specifically the Multinomial Logit (MNL) and the Mixed Logit models. These DCMs represent high inherent interpretability because their parameters directly represent marginal utilities rooted in economic theory.

Finally, the research moves to a direct assessment of the structures learned by the models. This involves investigating the stability of the DNN's learned feature relationships, derived from the SHAP output, against the coefficients from the established RUM models. This comparative approach positions the research within the paradigm shift toward Explainable AI (XAI), directly providing the robust insights for understanding travel mode choice behavior.

3. Discussion and Conclusion

This study discusses how Machine Learning (ML) models, when combined with Explainable AI, can provide interpretable and actionable mode choice insights, specifically addressing the trade-off between predictive performance and interpretability. By systematically comparing black-box models, such as DNNs, with theory-driven DCMs, this study highlights how post-hoc explanation methods, including SHAP, can reveal the behavioral factors that influence mode choice decisions. This approach reconciles high predictive accuracy with interpretable behavioral understanding and demonstrates that Explainable AI can effectively bridge the gap between predictive performance and transparency.

Several challenges remain in the field of travel mode choice modeling. Evaluating models based on a single criterion, such as predictive accuracy or interpretability, is insufficient, and there is no consensus on the best approach to predict mode choice [6]. Neural networks are promising due to their predictive power and flexibility across diverse scenarios. However, the use of ML in choice modeling is still in its early stages, with no established methods or standards [7]. There is a need to balance the strengths of theory-driven modeling with the potential of machine learning.

While this research focuses on addressing the accuracy–interpretability trade-off, it is important to note some general limitations of current XAI techniques. The reliability of post-hoc explanations can be influenced by factors such as small or unrepresentative background datasets and unbalanced input data. Although Explainable AI can enhance transparency it does not fully replace the inherent interpretability of theorydriven models; therefore, careful evaluation is necessary when applying these methods in practice.

Furthermore, the extent to which XAI techniques can truly improve transparency in mode choice modeling remains uncertain and warrants further investigation [7]. Finally, future work must address the broader methodological challenge of maintaining decision quality while increasing model interpretability [1].

4. Author Contributions

Halil Çevik: Conceptualization, Methodology, Writing – Original Draft, Writing - Review & Editing.
Ondřej Přibyl: Supervision, Writing - Review & Editing.

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15-MINUTES CITIES CATEGORIES AND FACILITIES FROM THE PERSPECTIVE OF DIFFERENT CONTINENTS

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1. Introduction

In 2016 Carlos Moreno wrote his first article regarding the 15-minute city. The concrete definition of this concept comes from the year 2021: "The term covers an urban theory and an urban model that cities can use to ensure that all residents are able to access their daily needs (work, housing, food, health, education, and culture and leisure) within the distance of a 15-minute walk or bike ride"[1]. In other words, categories considered normative are living, working, commerce, healthcare, education and entertainment [2].

However, the core of this concept is not based on a totally new idea [3, 4]. This fact is confirmed by the author of the definition of the 15-minute city concept himself [1] and also allows for the possibility of adapting the concept to individual cities and their morphology and specific needs [5].

Due to the number and type of services in the concept of 15-minute cities is not uniform, the different studies use different types, but also there are different categories of these types of services [6, 7].

On the other hand, are there no examples of similar studies that prove otherwise? Is it not possible to trace similarities in research that would be determined, for example, by the location in which the research is conducted? This contribution will aim to create a closer idea of the similarities of the research in relation to the 15-minute cities model with regard to the location of the research areas.

2. Materials and methods

The research is based on monitoring terminological, but also substantive, similarities in research works monitoring the fulfilment of the principles of the 15-minute city. The research procedure is illustrated in the diagram below. Firstly, they were searched in the ScienceDirect database using the term "15-minute city" in the title (n = 75). Only research that examined the availability of categories within specific cities was then selected (n = 36). The research selected in this way was then further classified according to membership within the continent and the given country. Within these interconnected units, the categories assessed were based on the basic and above-mentioned definition of 15-minute cities and basic human needs through a two-level monitoring system.

The first monitoring included an assessment of the similarities and differences between category names according to the basic definition of a 15-minute city and the category names of selected research. The output of the first monitoring is the identification of the degree of respect for the declared categories regardless of the monitored equipment included.

The second monitoring involved research into the devices under consideration regarding their inclusion within a superior category. The output of the first monitoring, supplemented by the results of the second monitoring, will provide a closer and more basic idea of the similarities and differences of the research with regard to the geographical areas of their implementation.

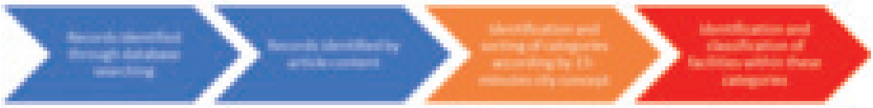

Figure 1: Graphical representation of the methodology

3. Results

When the frequency of representation of each category is taken into account, the outputs of a first monitoring can be divided into three groups. The first group of the most observed categories according to the 15-minute concept represent the category of education (n=20) and health/healthcare (n=23). Both categories constitute 12 works which respect category names by Carlos Moreno without any modification of this title (without words services or facilities). The second group is made up of less frequently monitored categories, namely culture and entertainment. Both categories constitute 10 works which respect category names by Carlos Moreno. However, in this case, the ratio of category name edits is different. While the name of the entertainment category was changed only twice, the name of the culture category was modified eight times. The last group of the less observed category according to the 15-minute concept represent the rest of the categories, specifically food (n=3), commerce (n=4) and leisure (n=3). On the other hand, this group is represented by categories with minimal changes to their names. This group also includes the category of work (n=2). The most followed research outside the 15-minute cities category includes especially the transport area (n=11).

The groups of categories from the first monitoring also points to facilities´ stability within the identified research. The first group represents facilities whose categorical device is unambiguous. However, the second and third groups contain facilities whose categorical facility is not so conclusive.

As can be seen from the table, although most of these devices are considered in the entertainment category, other categories also include the same example of facilities. Even the most respected facilities (outside the education and health/healthcare categories), Grocery Stores, is not a representative example of any of the categories under the 15-minutes city concept.

Category/facility by research	Restaurants	Grocery stores	Parks	Cafés	Cinemas	Gyms	Libraries	Theatres	Museums	Shopping malls/centres
Without category	6	9	7	2		1				1
Entertrainement	3		5	3	6	4	2	3	4	
Leisure			1	1	1	1		2		
Learning							2	2	2	
Commerce	2			2						1
Recreation			2					1	1	1
Food	1	1		1						
Culture							2		1	
Education							2			
Supllying		2								
Community centre							1	1		1
Other	3	4	1	1		2		1	1	1

Table 1: Categorization of considered categories for facilities from a second and third group

The results of the second monitoring show that research that followed the same categories (or with minor modifications) further varied across the facilities monitored. This fact is evident from the overview of the most watched facilities and their projection into graphs. The sum of studies that track the availability of the most frequent example of a facility in a given category is always lower than the total sum of all studies tracking the same category.

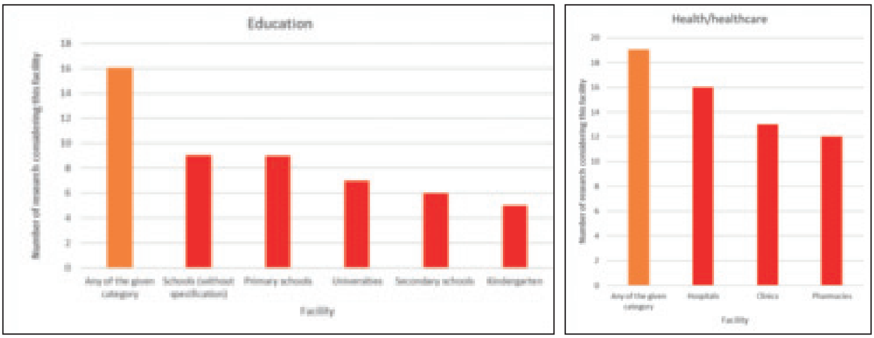

Figure 2: Graphs of facilities from a first group by given categories

The monitored records, especialy their size and frequency of geographical localities is not sutaible for identification of characteristic facilities. The tracked records of the articles, particularly their size and frequency of available geographic locations, do not provide support for unambiguous identification of their characteristic facilities. However, it is possible to point out selected intercontinental differences.

Within Europe, the continent from which the 15-minute city concept originated, the largest proportion of selected articles is evident, as well as probably the greatest agreement on the monitored facilities. The results of the monitored cities in Asia achieve very similar, but logically lower, agreement values. The most different picture is found in research looking at cities in America. On the other hand, there are examples of facilities whose monitoring results show greater agreement outside the European continent. These are hospitals where a more obvious consensus was found in Asia, and universities where there is an obvious consensus from research both in Asia and America. These are mainly facilities whose presence within the scope of 15-minute city units is questioned [8]. In this context, it is necessary to mention that, for example, in the case of university facilities, pedestrian accessibility is still monitored and considered. Within America, there is a slight increase in the values of facilities whose availability will clearly be more significant in American cities, specifically hospitals, public schools, universities, grocery stores, and parks.

Continent	Restaurants	Grocery stores	Parks	Cafés	Cinemas	Gyms	Libraries	Theatres	Museums	Shopping malls/centres	Work
Europe	6	8	5	5	5	4	5	6	4	1	0
Asia	7	4	7	5	1	4	5	4	4	4	1
America	1	4	4	0	1	0	0	0	0	0	1

Table 2: Facilities from a first group by continents

Continent	Hospitals	Clinics	Pharmacies	Schools (without specification)	Primary schools	Universities	Secondary schools	Kindegartens
Europe	4	6	6	4	4	1	5	3
Asia	9	6	5	2	3	3	1	2
America	3	1	1	3	2	3	0	0

Table 3: Facilities from a second and third group by continents

4. Conclusion

The results of this research clearly show a justified claim about the ambiguity of the framework of categories and facilities of 15-minute city concept, about which there should be a consensus among experts. The first monitoring pointed out the possible redundancy of the food, commerce, culture and leisure categories, which most research replaces with the Entertainment category. The monitoring results further confirmed the general disagreement over the monitored facilities, as well as possible geographical differences. However, based on both monitoring methods, it is possible to distinguish between more and less included facilities in the research. Facilities such as elementary schools, grocery stores, and parks tend to be monitored generally, even across selected continents. On the other hand, less monitored facilities include, for example, the aforementioned universities or workplaces. Further research could focus on separate and deeper monitoring of individual continents to identify obvious disparities and their causes..

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THE ACCESSIBILITY OF SOCIAL HOUSING UNITS: AN ANALYSIS OF LOCATION AND POLICY IN FLANDERS

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1. Introduction and theoretical framework

1.1. The importance of accessibility for social housing

Social housing is a crucial lever for breaking the cycle of structural poverty, although its effectiveness can vary depending on the location. Nevertheless, the accessibility of social housing, essential for reducing mobility-related exclusion, is an underexplored topic and thus far, its relationship with such exclusion is poorly understood.

In this contribution, we analyse the accessibility of the current social housing stock in Flanders (Belgium) in relation to amenities, the labour market and public transport. Accessibility in this context refers to the extent to which residents have access to various destinations such as jobs, schools, shops and other amenities. It encompasses both the proximity of such amenities - the spatial context - and the presence of transportation services and infrastructure - the mobility context. The spatial and mobility context of rural and suburban areas means that residents are more likely to depend on a car to reach destinations. Residents of urban areas may depend on a car to access their jobs in suburban areas, or to visit relatives living in rural areas. Thus, having access to a car has a major impact on the range of destinations a person can reach. Car ownership, however, is highly correlated with income - the higher the income, the more likely a household is to own one or more cars [1]. As social tenants typically belong to the lowest income groups, they are generally more dependent on nearby amenities and public transport. As such, a lack of accessibility could partly cancel out the material benefits of social housing for social tenants.

At worst, limited accessibility can even lead to mobility-related social exclusion. This refers to "the process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities, services and social networks, due in whole or in part to insufficient mobility in a society and environment built around the assumption of high mobility" [2]. Therefore, ensuring good accessibility to public transport, services, and employment is essential to foster social inclusion and reduce spatial inequalities [3].

1.2. The case of Flanders: social housing in a fragmented region

The spatial context of the region of Flanders (Belgium) is strongly characterized by urban sprawl and fragmentation: a proliferation of housing along ribbons and in scattered parcels of land, and an unstructured patchwork quilt of industrial areas, offices and other activities between which agriculture and nature are squeezed. Beyond its aesthetic implications, this spatial patchwork has far-reaching consequences for accessibility.

In Flanders, social housing functions as a safety net for the lowest income deciles, which means that social renters are less likely to own a car. As a result, social renters are on average more dependent on public transport and nearby amenities such as shops, schools, and healthcare to meet their daily and occasional needs. Their satisfaction is therefore strongly influenced by the location and accessibility of their housing [4]. Since social tenants are allocated to housing and thus have very little control over where they are going to live, the location of social housing is crucial for the well-being of social tenants.

2. Methodology: measuring accessibility

Using Flanders as a case study, we employ a set of proximity indicators to analyse the accessibility of the current social housing stock in relation to public transport, amenities, and employment. In addition, through interviews with key stakeholders, we examine how accessibility is currently addressed within social housing policy.

To measure accessibility, we conduct a spatial analysis of the existing social housing stock, based on the Mobiscore and job accessibility. The Mobiscore, developed on behalf of the Department of the Environment and Planning of the regional government, reflects how easily residents can reach schools, shops, public transport stops, and other amenities by sustainable modes of transport [5]. A high Mobiscore (e.g., 8.5 or above) indicates a neighbourhood with a wide range of easily accessible amenities, whereas a low score reflects limited accessibility.

The second indicator, job accessibility, measures the extent to which the location of a dwelling provides access to the labour market. For this, we rely on recent research by [6] commissioned by the Department of Employment and Social Economy. This indicator provides insight into how well jobs can be reached by different modes of transport, broken down by income groups. We focus specifically on the lowest income group, as social renters predominantly belong to this category.

3. Results of the spatial analysis and policy interviews

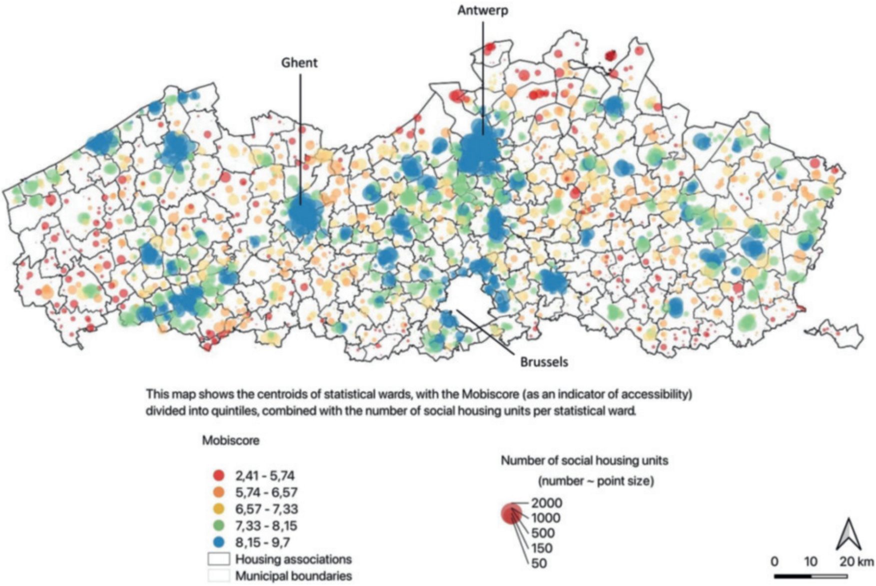

Figure 1: Social housing locations, combined with accessibility
Source: Provinces in Figures and Department of Environment and Planning, own editing.

This map combines social housing locations with the Mobiscore. The size of the circles reflects the amount of social housing within a statistical ward, and the colour shows the Mobiscore. Red indicates poor access, blue indicates good access to amenities and public transport.

Our key findings show that most social housing units are well located near jobs, amenities, and public transport, particularly in urban areas. At the same time, the spatial pattern is uneven: some social housing is concentrated in remote, car-dependent zones with poor access, while in several suburban and central urban areas with excellent accessibility scores, social housing is largely absent. The latter areas represent important opportunities for future development, as they are well connected but remain inaccessible to lower-income households.

Exploratory discussions with the Flemish administration 'Wonen in Vlaanderen' (the regional government's housing agency) and several housing associations (who provide and manage social housing) indicate that the scarcity and high cost of land in urban centres, and increasingly also in rural municipalities, severely restrict the ability of housing associations to build in highly accessible locations. Additional barriers include local regulations and resident opposition, making the construction of new homes a complex puzzle [7]. As a result, housing associations face the challenge of securing suitable land in a context of rising competition with private developers for scarce, well-located sites. Their reliance on third parties, primarily local authorities, is compounded by an ever-lengthening waiting list. Together, these factors risk pushing housing associations toward less accessible locations. In both scenarios, (prospective) social tenants bear the brunt, either through housing projects in difficult-to-reach areas or through delays and postponements in the delivery of much-needed homes.

4. Conclusion

We conclude that systematically mapping the accessibility of social housing can generate valuable insights into the opportunities and constraints associated with its location. We therefore recommend a more structural integration of accessibility in social housing policy, taking the needs and preferences of social tenants as a starting point.

Finally, the study raises a deeper question: what is the purpose of social housing? Is it just about providing a roof over someone's head, or should it serve as a home and a lever for accessing work, education, healthcare, and social networks? The latter, more holistic perspective on social housing puts the question of location centre stage.

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CRIPPING ACTIVE TRAVEL FUTURES

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1. Introduction

There has been a significant expansion in active travel research with some encouraging policy developments. Alongside this is a growing recognition that inclusive action to account for different needs is necessary when planning for change [1], [2]. Such policy, however, does not necessarily translate to planning and funding in 'everyday' practice. Active travel affords many personal and societal benefits, but opportunities to walk, wheel, and cycle are not equitable, with barriers to participation playing a significant role in the disabling process for people with 'impairments [3]. Similarly, disabled people often find that the impetus is upon themselves to highlight and resolve accessibility problems or framed as hindrances to collective sustainability goals [4]. There is an immediate need to substantially improve walking, wheeling, and cycling environments to enable participation of those most marginalized, towards sustainable and just transport futures.

This research centralizes disabled bodyminds[1] [5], [6] and underpinned by feminist, queer, crip, and critical disability theory. Critical Access Studies in particular offers theories of accessibility grounded in contestation, interrogating who gets access and under what terms, enabling more intersectional analyses. Interrogating assumptions of who is 'active' in active travel, and by what means, through critical disability analyses can help unpick normate standards in active travel planning and policy [7].

2. Context

Research has grown in recent years that uncovers the multiplicity of experiences of the built environment and how disabled people might be disadvantaged [8], [9]. Research has also shown that practitioners, often unconsciously, replicate standard ideas of who they plan for, such as "Reference Man" [10] or the 'prototypical disabled body' which maintain the normate template of an idealised, productive, non-disabled citizen [11]. In the UK, such planning processes often lead to decisions based around a societal preference for, and privileging of, able-bodiedness/mindedness resulting in the designing out of disabled people in active travel infrastructure [12].

Such imaginaries are significant as they shape policy and become materialised in the design of the built environment, framing who is more or less likely to benefit. As such, there is an urgent need to centre disabled people's expertise in active travel planning as well as for Critical Disability Studies to engage across disciplines, notably with transport research, which does not centre normative or ableist conceptions of health and healthiness [13].

[1] Disability scholars use the term bodymind to emphasize the interdependence and inseparability of the body and mind.

3. Methodology

This study is informed by post-positivist, interpretivist forms of policy analysis and the practice turn and sees practices as central to understanding [15]. This study uses ethnographic methods to creative 'thick' descriptive case studies of active travel planning practice [16] to explore whether, and how, disabled people are represented and included in active travel planning processes and how they are subsequently represented in policy and funding schemes. To observe and shed light on decisions and policy as they emerge in the arenas of everyday practice, practitioners are followed through meetings, site visits, and practitioner fora. Work shadowing, and participant observation, alongside participant listening [17] through conversations with actors in the planning process, help triangulate and interpret findings in the field. Interviews with practitioners in the flow of their everyday work will help see the wider forces they are interpreting as they move planning processes along.

Through following active travel practitioners in North East England this project assess potential to reshape practices through an exploration of rhetoric-reality deficits in planning. Through prolonged engagement with active travel practitioners the research will contribute to understandings of how to achieve more equitable active travel futures and question whether thinking differently about dis/ability might enable innovative critical practices that lead to better outcomes for all [18].

4. Expected Outcomes

Centralizing disability to make transport more sustainable, as a precondition for creating a more equitable and socially just system, is multi-faceted [19], [20]. Accessibility and inclusion are reliant on practitioners reflecting on and adapting practices as mediations of power and normativity. It is anticipated that both access and inclusion are narratives added on at the end of decisions-already-made, with disabled people's inclusion in consultation exercises already fraught with barriers to accessibility themselves [21], [22].

Disability justice frames accessibility not as a technical fix or universal standard, but as a complex, relational, and political process shaped by power, difference, and context. In turn, this critiques compliance standards in favor of justice-oriented understandings which are always partial, negotiated, and embedded in social relations [23]. Findings of this study might therefore highlight ways in which planning for sustainable and just futures for disabled people in active travel is currently limited. Likewise, it is likely to show that planners in this field have limited understandings of accessibility and disability, confirming the need for planning bodies to advance more just practices and the need for better understandings of disability theory [24].

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TRANSIT-ORIENTED DEVELOPMENT IN MEDIUM-SIZED EUROPEAN CITIES: COMPARATIVE CASE STUDIES OF POZNAŃ, BRNO AND FREIBURG

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1. Introduction

This extended abstract presents the research design and methodological assumptions of an ongoing doctoral dissertation focused on the spatial and functional integration of public transport and housing development within the framework of Transit Oriented Development (TOD). As the project is still in progress, the contribution does not yet report empirical results but outlines the research concept, methodological approach, and expected outcomes.

Transit-Oriented Development (TOD) has become a central concept in the discourse on sustainable urban development. It advocates compact, mixed-use neighbourhoods centred around high-capacity public transport nodes, thereby reducing automobile dependency and encouraging sustainable mobility patterns [1]. The efficiency of TOD implementation, however, varies significantly across spatial contexts. While numerous studies have focused on large metropolitan areas in North America [2], the European experience—particularly in medium-sized cities—remains underexplored.

Recent works emphasize that functional accessibility, and not just spatial proximity, is key for evaluating the effectiveness of TOD [3]. Studies from European cities such as Amsterdam, Naples and Stockholm demonstrate that rail-based accessibility strongly correlates with the concentration of residents and workplaces near stations [4], [5]. In Poland and Central Europe, TOD research is relatively limited, with some exceptions focusing on the Poznań Fast Tram [6] or the role of suburban rail systems [7].

This work aims to contribute to this discussion by examining the implementation of TOD in different contexts using three medium-sized European cities: Poznań (Poland), Brno (Czech Republic), and Freiburg im Breisgau (Germany). These cities provide a unique comparative framework, representing different institutional, cultural, and planning traditions while facing common challenges of suburbanisation, housing demand, and sustainable transport integration.

2. Research Objectives

The study pursues three main objectives:
1. Empirical objective – to measure and compare accessibility to public transport systems in three cities, using spatial and temporal models.

2. Methodological objective – to develop a mixed-methods framework integrating spatial-statistical modelling, qualitative interviews, and planning document analysis, with a strong emphasis on methodological triangulation and case study design.
3. Practical objective – to formulate recommendations for urban policies enhancing integration between housing development and public transport infrastructure in medium-sized European cities.

3. Methodology

3.1. Mixed-methods approach
The research employs a mixed-methods strategy, combining quantitative (indicator-based measures, GIS-based accessibility models) and qualitative (in-depth interviews, planning document analysis) techniques. This methodological triangulation ensures that both measurable patterns and institutional/social contexts are addressed.

3.2. Case study design
Three case studies are analysed:
- Poznań (Poland) – the district of Naramowice, where a new tram line triggered large-scale housing development.
- Brno (Czech Republic) – the Bystrc/Kamechy district, illustrating integration of new housing estates with the public transport system.
- Freiburg (Germany) – the Vauban district, a widely cited example of European TOD implementation, recognised for its compact, car-reduced planning.

3.3. Data sources
- Poznań: data from the Statistics Poland, municipal open data, and the Transport Authority (GTFS).
- Brno: municipal geoportal (geoportal.brno.cz), Czech Statistical Office, and open transport data (data.brno.cz).
- Freiburg: geoportal (geoportal.freiburg.de), Statistical Office of Baden-Württemberg, and planning documents.

3.4. Analytical tools
Three complementary accessibility models are applied:
1. Raster-based accessibility model (Juliao 1999; Gadziński 2013) for walking time distances.
2. Network-based model (OpenRouteService) capturing topological constraints.
3. Multimodal GTFS-based model (OpenTripPlanner, R5) integrating waiting times, transfers, and service frequencies.

These models are supported by statistical indicators (density, housing concentration, transport service levels) and GIS-based visualisations.

3.5. Qualitative analysis
- In-depth interviews (IDIs) with stakeholders (planners, local authorities, residents).
- Content analysis of planning documents (e.g., local plans, mobility strategies).

4. Related Research

4.1. TOD in international literature

Global research indicates an exponential growth in TOD studies over the past two decades, with annual publications increasing from 25 to nearly 50 between 2013–2018 [8]. In the US, Portland is a flagship case of TOD integration [9], while European approaches emphasize coupling transport policies with local spatial planning [4], [5].

4.2. Polish and Central European context

In Poland, TOD-related research is relatively scarce. Bul examined the potential of suburban railway integration in the Poznań metropolitan area [6], while Radzimski and Gadziński investigated the influence of the Poznań Fast Tram on housing prices and relocation behaviour [7]. A more systematic contribution has been developed by Jurkowski, who analysed the integration of suburban housing with railway stations in various metropolitan areas of Poland [10], [11], [12]. However, compared with the broader European context, where TOD research frequently links accessibility with urban form — for example in Italy, Sweden, and the Netherlands [4], [5], [13]— the Polish debate remains underdeveloped. Studies by Papa and Bertolini demonstrated the correlation between rail-based accessibility and the concentration of housing and jobs around stations [4], [5]while Geurs et al. highlighted institutional and infrastructural barriers in medium-sized European cities [14]. This suggests that integrating the Polish perspective into the European discourse is essential for understanding both the potential and limitations of TOD in diverse planning systems.

4.3. Recent methodological developments

Recent research stresses the importance of cumulative accessibility measures [4], temporal segmentation of accessibility analyses [15], and the growing use of GTFS datasets for dynamic modelling [16], [17]. These methods support more realistic assessments of accessibility, identifying so-called "white transport gaps" and enabling scenario-based urban planning [13,14].

5. Results (Preliminary)

Initial comparative analysis shows:

- Poznań (Naramowice): the new tram line significantly improved accessibility within a 15-minute walking radius, yet housing development outpaces service provision.
- Brno (Bystrc/Kamechy): accessibility is relatively high, but integration with regional transport is weaker compared to local tram services.
- Freiburg (Vauban): demonstrates the highest level of TOD integration, with balanced accessibility, mixed land use, and strong community acceptance.

Preliminary results confirm the hypothesis that TOD effectiveness in medium-sized cities depends not only on transport infrastructure, but also on institutional frameworks, planning consistency, and housing policy coordination.

6. Conclusions

The study highlights the value of applying a comparative case study and triangulated mixed-methods approach to TOD research. It shows that while medium-sized European cities pursue TOD principles, their implementation varies significantly. Freiburg provides a best-practice model, while Poznań and Brno reveal both potential and barriers in adapting TOD principles under transitional institutional conditions.

Future work will deepen the analysis with longitudinal data (2004–2024), stakeholder interviews, and GTFS-based temporal modelling. The results aim to inform evidence-based urban policies supporting sustainable mobility and housing development.

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TOPOGRAPHY OF THE GARGANTUAN WAREHOUSES

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1. Introduction

This essay explores the spatiality of logistics centres through a postcolonial research lens and reflective practice in urban studies. The spatial form and scale of global supply chain infrastructures are being reconfigured, accelerated by the rise of online shopping. While online consumption habits shape today's trade flows, this process is largely embodied in the massive warehouse structures located on the peripheries of cities. The following text aims to make visible the process in which the city is reproduced according to trade flows and warehouses enter the system as commodities. Its purpose is to initiate a discussion on the ethical dimensions of these invisible infrastructures outside the city, logistics centers, and their complicity in global systems.

Methodologically, the study uses essay films to explore logistics centres in cities and adopts creative, practice based methods such as walking, filming, and annotating to engage with rhythms, scales, and frictions that escape conventional datasets. Within a postcolonial research framework, methods are not *neutral tools* but world making practices; the researcher's positionality, modes of representation, and prevailing hierarchies of knowledge are therefore continuously questioned. This stance challenges modernity's claim to detached objectivity and calls for a continuous reflection on where research speaks from, on whose behalf it speaks, and with whom it engages [1–3].
Donna Haraway's notion of situated knowledge is instructive here. In *Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective* [4], Haraway questions scientific objectivity, which is identified with the myth of the 'godlike gaze' that can see from everywhere. She argues that knowledge is always produced from a specific place, body, and network of relationships. Situatedness is not merely a limit but a ground for accountability: it compels us to take responsibility for *the things we learn to see* (Haraway, 1988). In this context, the research presented here determines its own perspective rather than looking down from above; it places the researcher within the research itself.

This study combines essay film practice with postcolonial methodologies to situated and accountable knowledge, treating logistics centres not only as technical nodes but also as instruments of corporate accumulation. These centres are strategic spaces where companies commodify land, labour, and circulation to secure their profitability. In this sense, colonisation continues today not through states but through companies: this is the corporate form of colonisation in the present day.

2. Methods: Essay Film as Postcolonial Spatial Research

Situated knowledge invites methodological plurality, bringing together discourse and text analysis, historical comparison, ethnography, and site specific work to reveal the spatial and institutional traces of power. The aim is not merely to collect data, but to reflect systematically on which knowledges are legitimized and which voices are silenced. This also calls for emergent research modes, such as decolonial research. Postcolonial research aims to disrupt knowledge systems that produce inequality at both theoretical and practical levels [5]. For these approaches to matter in practice, method itself must be handled critically and reflexively. Donald Schön's, notion of *action reflection* underscores this move: the act of making becomes the direct object of inquiry [6]. In this framework, every representation produced in research is positioned not merely as an outcome, but as the research itself.

Within this framework, the essay film functions as a creative–reflective tool for research. It short-circuits institutional constraints of written theory and counters objectification by loosening rigid protocols of data collection and representation. As a form, it opens room for the subjective, the playful, even the amateur, the irrational, or the sublime [7]. Borrowing from Adorno's conception of the essay as a form of oddity and heresy, which enables transgressive thought, resists the systematic, and operates as an inbetween state defined by the critical position it provokes, the essay film makes visible the everyday and subjective experiences that methodological crises tend to obscure [7, 8]. In this sense, film is not merely an outcome but a postcolonial research method: methods are approached not as neutral instruments but as world making practices in which positionality and regimes of representation are continuously interrogated.

Placed within this framework, the essay film structure of Topography of the Gargantuan Warehouses reveals the invisible logistics center and the entanglements of online consumption, labor, and ecology through a poetic montage. The narrative is deliberately fragmented, mirroring the discontinuous experience of encountering these hidden spaces. Inspired by Lewis Carroll's *Alice's Adventures in Wonderland* [9], the film guides the viewer through a surreal landscape, where scale and perception continuously shift: as Alice struggles to orient herself in a world that distorts reality and measure, the viewer navigates vast, labyrinthine interiors and edge landscapes.

Here the warehouse is not merely infrastructure, but a spatial knot where the colonial past persists in the present through firm-led extraction and commodification. The essay film is thus both method and argument: it retrains how we look and what we deem to be evidence, and it invites a stance on complicity, ethics, and spatial inequality.

3. Following the Receipt: Topography of the Gargantuan Warehouses

For some time I have been thinking about the logistical landscapes behind the excitement of online shopping, including warehouses, ramps, and queues. The essay film opens on a simple text: I scroll, I click; three days later, the item I ordered online is at my door. A simple, persistent question follows: Where did it come from? Which bodies, which infrastructures, which notes and silences brought this package here?

The receipt becomes a trace that leads toward a logistics centre in the Marmara region, somewhere between Istanbul and Kocaeli, and I follow its path down the rabbit hole (see Figure 1). Along the periphery, faceless façades line up: corrugated metal, cast concrete. Dock doors gape; trucks inhale and exhale; barcodes crackle; hydraulic brakes leave a metallic breath.

Figure 1: Topography of the Gargantuan Warehouses: Following the Receipt[rabbit].
Film Stills. Begüm Eser, 2023.

Outside the warehouses there is a thin line of trees and a patch of water with birds and insects. The sound momentarily softens, then the engines return: the sigh of asphalt, a low mechanical tremor. Nature and industry touch; there is no clean edge. The ecology of the periphery keeps time with just in time delivery.

A bridge appears before me. Feet, decks, spans... The trucks shrink; they become toys. Near and far, human and nonhuman, center and periphery all shift their scales. Scale becomes the subject of the film: how does consumption reconfigure distance?

Figure 2: Topography of the Gargantuan Warehouses. Film Stills. Begüm Eser, 2023.

This film is not a report; it is a research itself (see Figure 3). An essay film that short circuits the rigid expectations of written theory, opening space for subjective, playful, and speculative gestures. With Adorno's notion of the essay as an *inbetwee*n mode of thought, it brings into the field the everyday and embodied experiences that conventional method overlooks, exposing the position of the camera body. The warehouse is not merely infrastructure; it is the spatial crystallization of invisible labor and ecological burden behind the smooth surface of consumption.

Figure 3: Topography of the Gargantuan Warehouses. Film Stills. Begüm Eser, 2023.

The film retraces the receipt and asks the viewer to do so with me, to witness the costs folded into online shopping's excitement. Ultimately, Topography of the Gargantuan Warehouses confronts the hidden infrastructures that shape our world. The work asks uncomfortable questions about our complicity in this global system and invites reflection on the ethical and environmental consequences of our consumption habits. By making visible what is usually hidden, it invites a more accountable way of seeing and encourages a deeper engagement with the spaces we inhabit and the systems we sustain.

4. Discussion and Conclusion

This study, as postcolonial research suggests, reads space not merely as a technical infrastructure or a neutral ground, but as the continuations of colonial pasts and global inequalities in the present. Within this framework, the warehouse is not merely a technical node organising the circulation of goods; it is a tool for capital accumulation that reconfigures the city's periphery for capital, renders labour invisible, and externalises environmental costs. The receipt we trace in the essay film makes the warehouses audible and visible.

This reading aligns with Haraway's understanding of situated knowledge: Research is carried out not with *a god like gaze from nowhere*, but with a partial and accountable perspective that discloses the camera's position and embodiment.Thus, what becomes visible and what remains invisible in the film are themselves part of the argument, as evidence is produced together with position and relationship.The essay film here is not a report, but the method itself: through decisions of montage, sound, and distance, it tests interpretations and opens the study's findings to the viewer's counter-interpretation.

The findings point to a shift from state-centered colonialism to a firm-centered regime of accumulation. Warehouses are not reducible to their use value (storage/distribution) but are large scale investment assets shaped by exchange value; land, labor, and circulation capacity are commodified and profitability is secured. Thus, colonization today proceeds primarily through corporations, as the colonization of logistical capacity and environmental carrying power.

This picture is not ahistorical. As Mumford emphasizes, the storage of surplus is an ancient technique of power: controlling excess produces domination over others' lives, and scarcity is constituted from within abundance itself [10]. *The person who managed to control the annual agricultural surplus also wielded power over the lives and deaths of their neighbours. The creation of artificial scarcity amidst increasing natural wealth was one of the characteristic triumphs of the new economy of civilised exploitation; this economy was diametrically opposed to the customs of the village* [10]. Today, however, this logic is updated through time regimes and financialized warehouse investments that render environmental and social costs invisible in the name of *uninterrupted flow*. The warehouse thus becomes the crystallized form of capitalism's process of commodifying space.

The study focuses on a specific logistics corridor on the Marmara route; labour regimes and ecological impacts may vary in different corridors. The essay film is a selective representation; the scope of the screening and feedback sessions is limited. Ultimately, Topography of the Gargantuan Warehouses aims for more than an aesthetic revelation of invisible infrastructures: it invites us to spatially trace the question of whose profit, whose cost. It proposes viewing the warehouse not merely as an 'infrastructure' but as a spatial node of corporate-centred colonisation; thus, the labour and ecological debt behind the smooth surface of consumption is opened up for debate in terms of both research and planning ethics.

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ASSESSING PUBLIC TRANSPORT STOP COVERAGE AND ACCESSIBILITY: A GIS-BASED APPROACH TO PEOPLE'S PERCEPTION

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1. Introduction and research aim

Public transport plays a crucial role in urban mobility, influencing the efficiency, sustainability, and inclusiveness of cities. Several methods have been developed to evaluate the quality of public transport, focusing on factors such as service reliability, operational efficiency, and environmental impact. Among these, accessibility stands out as a key aspect that integrates urban and transport planning aspects [1]. Its relevance becomes amplified when analysed from the user's perspective, as the perception of accessibility can vary considerably between individuals [2]. Therefore, this research moves beyond the existing literature, focusing not on objective determinants but on the elements that shape people's perceptions. Since public transport is accessible through stops [3], it focuses specifically on accessibility to existing or future stops/stations. More precisely, the aim is to develop a method that maps the factors influencing the perception of public transport accessibility, enabling the easy identification of potential weaknesses in areas requiring intervention. Therefore, this research aims to provide services that efficiently respond to users' needs.

2. Literature review

Measuring accessibility is a crucial issue. Traditional assessment methods rely on mathematical models and tools known as accessibility instruments, which face some limitations, including political, organizational, and institutional barriers [4]. Moreover, these tools often treat people as homogeneous, without considering individual capabilities, experiences, and perceptions [5]. These considerations have led to a growing interest in how individuals perceive the surrounding environment and evaluate accessibility [6]. This concept has been expressed in several ways [7], e.g., "experienced accessibility" [8], "self-reported accessibility"[9], "subjective accessibility" [10], and "perceived accessibility" (PA) [11]. The latter is the most commonly used term [7] and, when applied to public transportation, can be defined as "how easy it is to live a fulfilling life using the transportation system" [11]. A broader definition of PA, untied to public transport, is "how individuals or groups of individuals understand or experience their own accessibility" [12].

Several studies have analysed the topic of PA to public transportation, with particular attention to the elderly population and other disadvantaged groups [13]. Other studies have analysed the factors that influence PA and use of public transportation, highlighting the role of individual attitudes, service quality, and characteristics of the built environment [11]. Some studies focus specifically on the relationship between the built environment and accessibility to public transportation [14], highlighting how place of residence and urban characteristics contribute to shaping this perception [10].

From this research emerged seventy-two elements that can influence the perception of accessibility, divided into three criteria (node, place, people), each with two dimensions (objective and subjective). Compared to the existing literature, this research does investigate the role that some factors can have in PA but rather develops a planning support tool that incorporates PA aspects.

3. Methodology

The research method comprises five phases. In the first phase, the existing literature on perceived accessibility is identified using a snowball review method and investigated to determine criteria and attributes that can influence accessibility perception. In the second phase, objective attributes are selected, i.e., attributes that are quantitatively measurable and easily calculated within a GIS environment. In fact, GIS tools facilitate data visualisation of results on maps, simplifying their comprehension. Additionally, data accessibility is a key aspect, ensuring that the required input data could be easily available from local authorities or open-source databases. In the third phase, the attributes were categorised into three criteria: people, place, node. These were used to compute three composite indices: (i) the people index, (ii) the place index, (iii) and the node index. Respectively, the three indices describe: (i) the ability of residents near the stop to adapt and benefit from the service, (ii) the vitality of the stop surrounding area, and (iii) the attractiveness of the stop itself. Composite indices are adopted since they are useful in represent synthetically multidimensional phenomena [15]. Before to computate the indices, however, it is necessary to weight the attributes that compose them. Thus, in the fourth phase, a questionnaire was developed to obtain the needed weights. The questionnaire involved public administrators and local stakeholders, introducing a qualitative element to research that would otherwise be purely quantitative. Therefore, it collects individual perceptions and experiences from people living in the context. The weighting is computed with the Best-Worst Method (BWM), a recent Multi-Criteria Decision-Making (MCDM) method. Compared to other MCDM methods, e.g., the Analytic Hierarchy Process, the BWM requires less comparison data and generates more consistent and reliable results [16]. Finally, the indices were computed. The analysed area was di discretized with a hexagonal grid - commonly used in accessibility studies [17] - and the indices were calculated for each cell, using the weights obtained from the BWM. The output of the method is a cartography for each index.

4. Case study

The method was applied to the city of Brescia, Italy. The research is part of a PhD scholarship co-funded by the Italian National Recovery and Resilience Plan (PNRR) and Brescia Mobilità S.p.A., the company that manages public transport and mobility services in the urban area of the city. Brescia is a medium-size city in northern Italy with 200,000 inhabitants in the urban core and 500,000 inhabitants in its functional urban area [18]. It is strongly committed to improving the quality of life of its citizens, including through the improvement of public transport. Brescia has undertaken a planning process for implementing a mass rapid transit network, based on the existing light metro line (opened in 2013), which is the backbone of the entire public transport network. Specifically, the current SUMP (2018) includes the implementation of an ambitious rail-based public transit system, comprising the existing metro, two tram lines and suburban trains.

5. Results

Based on data availability, the three indices were composed of attributes listed in Table 1. The analysis resulted in three maps, each representing one of the indices for each hexagonal cell (Figure 1). While the first two maps cover all the municipality, the latter covers only the cells inside the service area of the existing metro station and future tram stop. The areas with higher people index values represent an urban context with greater social resilience, where the residents are more adaptable and therefore able to exploit the coverage provided by public transport. Similarly, higher place index values represent an urban context more favourable to the perception of accessibility. While the areas with lower place index values show the opposite situation. The combination of these three indexes can provide useful insights for planning.

Variable	**Attributee**	**Needed data**	**Source**	**Alternative source**
People	Age	Residents under 65 (%)	Census tracks	Municipal registry
People	Gender	Residents of male gender (%)	Census tracks	Municipal registry
People	Citizenship	Residents with local citizenship (%)	Census tracks	Municipal registry
People	Income	Average income (€/y)	Census tracks	Municipal registry
Place	Connectivity	Location of roads connections	Topographic database	Open Transport Map
Place	Density	Built volume	Topographic database	Open Street Map
Place	Land use mix	Land use data	Topographic database	Open Street Map
Place	Activities	Locations of points of interests	Topographic database	Open Street Map
Node	Frequency	Trips/hours of service	Public Transport	Google Maps
Node	Interchange	Number PT lines crossing the node	Company Public Transport	Google Maps
Node	Crowding	Number of stop users	Company Public Transport	Google Maps
Node	Comfor	Presence (1) or absence (0) of roof, benches, real time information	Company Local survey	Google Earth

Table 1: List of attributes used to computed the three indices in the case study

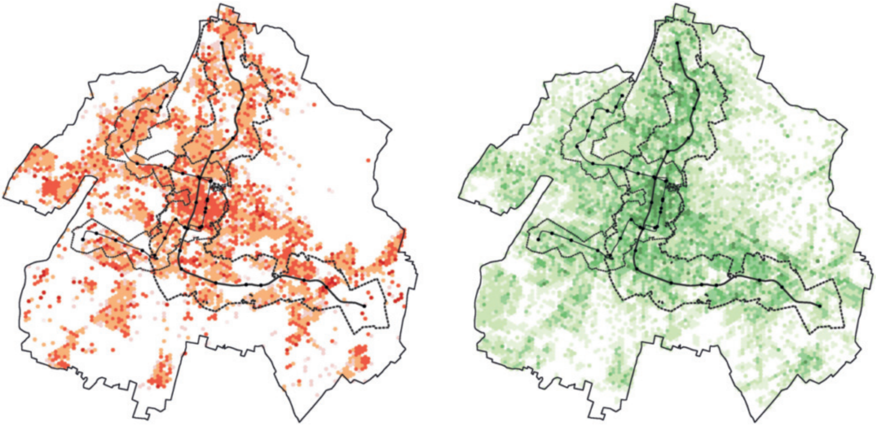

Figure 1: Cartographies for the people index (left) and the place index (right). The darker the colour, the higher the index. Overlapping, the metro line (thick line) and the future tram line (thin line) with their respective service areas (dotted lines).

6. Conclusion and future improvements

The proposed method constitutes a practical analysis tool capable of providing useful planning insights into public transportation and its context. This assessment method has potential, as it allows both an ex-post and ex-ante analysis, i.e., in planning and monitoring phases. More precisely, it can be applied to existing infrastructure to evaluate possible improvement interventions, as well as during the planning and project phases, to better understand where to locate and how to design the specific stop. Consequently, urban and transport planners can adopt it as a decision-support method based on people's needs. In the future, the method could be enriched with a survey that captures people's actual perceived level of accessibility to compare it with the results of the quantitative method.

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THE OBSERVABLE DEVELOPMENT PATTERNS OF RAPID AND UNREGULATED EMERGING TRANSIT-ORIENTED DEVELOPMENTS ALONG THE LIGHT RAIL TRANSIT 2 STATIONS IN METRO MANILA

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1. Introduction

Transit-Oriented Development (TOD) is a proven strategy for helping cities grow over time. However, it can only work if certain conditions are in place, such as high density, easy access, pedestrian-friendliness, good connections, livable public spaces, mixed-use design, and affordable housing. The study examines the aspects of affordable housing and accessible living, analyzing fluctuations in land prices and demographic trends that arise from the emergence of TOD practices. The study employs paired t-tests to examine changes in communities located along the Light Rail Transit (LRT-2) corridor in Metro Manila, assessing the statistical significance of fluctuations in land prices and demographic trends. The results will indicate which station areas are experiencing questionable growth, helping planners make informed choices to level the playing field and consider the needs of all parties involved. Railway infrastructure is essential for city development, as it affects the economy, transportation, and the environment. The LRT-1, MRT, and LRT-2 alignments work together to link up various parts of Metro Manila, making it easier for businesses and services to expand into areas on the outskirts of the metropolis. Of all the alignments, LRT-2 is the only line that extends its function outside Metro Manila and offers the broadest range of transportation options and transfers, which makes it a viable model for future TODs. However, unregulated growth and development may render these hopes impossible. To address these issues, the Philippine government has incorporated TOD into its "Build! Build! Build!" program. Both the Asian Development Bank and JICA have promised to help with the entire design and feasibility studies. There is also a national TOD Policy Framework that emphasizes the importance of integrating land use and transportation planning to strengthen communities, reduce traffic congestion, and conserve energy. If transportation investments are tied to fair housing rules, TODs could be very useful for achieving social, economic, and environmental goals in Metro Manila and beyond [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15]

2. Methodology

2.1. Argument and Research Question

Many urban planning, development, and economic theories support the argument and results of this study. The Access Node Theory claims that limiting access nodes contributes to urbanization rather than alleviating vehicular congestion, which is a prerequisite for initiating research. Metro

Manila and the Philippines have a limited number of serviceable railway nodes and transportation means compared to other Southeast Asian countries. Consequently, rapid and uncontrolled urbanization is likely to occur, rather than alleviating vehicular congestion, which is exacerbated by increasing built-up areas and reduced open spaces, in line with the theory of Rail Infrastructure Development. The accessible and strategic location of the limited transit nodes created an imbalance between built and open areas, where built-up areas started consuming supposed open and public spaces to maximize and optimize properties and developments in the district, consistent with Bid-rent Theory, which states that different land uses have different spatial requirements and are willing to be paid different amounts These ideas argue that the unregulated urban growth, enabled and significantly altered land prices, and population trends in affected areas. This research utilizes these theories to assess how selected rail stations impact land values and population patterns within their respective stations [16, 17]

2.2. Conceptual Framework and Research Objective

This study will focus on the TOD Station Areas of selected LRT-2 Stations. The Station Area is the neighborhood within 400 meters of a key transportation node, such as an LRT-2 rail station. This research examines land prices and population growth within a 400-meter radius of selected LRT-2 stations, and their impact on stations constructed before 2004, as illustrated in Figure 1. Two hypotheses emerge from comparing land values and population before and after the introduction of rail stops. The factors show that land values and population in the TOD station area either stayed the same or changed after the train station opened. These significant, visible changes are then assessed for their pros and cons. The public and commercial sectors should prevent and handle new TODs' possible adverse effects, as this research will show [4]

Figure 1: Conceptual Framework of the Study

2.3. Selection of Stations for the Study

The researcher used the 11 stations and their relevant information to find the median ridership, which is presented in Table 1. Hence, this study will only investigate Recto, Santolan, Legarda, Katipunan, Cubao, and Pureza Stations, since higher ridership is associated with successful TODs [8, 18].

Station	Ridership	City	Primary Land Use	Secondary Land Use
Recto	29,877.00	Manila City	Commercial	Institutional
Santolan	22,787.00	Marikina City	Commercial	Residential
Legarda	19,473.00	Manila City	Institutional	Residential
Katipunan	17,445.00	Quezon City	Institutional	Residential
Cubao	14,291.00	Quezon City	Commercial	Residential
Pureza	10,210.00	Manila City	Residential	Institutional

Table 1: Inventory of LRT-2 Stations and Supporting Information

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TFigure 2: LRT-2 Railway Alignment showing the location of stations [19]

2.4. Data Gathering and Processing

This research derived primary data from secondary data for analysis. Comparison Land Values are based on the current Bureau of Internal Revenue Zonal Value Data, which includes past Zonal Value Appraisals, and the Philippine Statistics Authority's population census, which incorporates older census data. The Paired Sample T-Test, run using IBM-SPSS software, was used to observe the change between two similar nature samples (e.g., Land Value and Population), which differed only byyear and were compared before and after the train station was introduced in their respective areas. This variable was crucial for the study to analyze observable changes and trends between land values and population, as well as the impact of the train station on them [20, 21, 22].

3. Results

Figure 3: Population Trend from 2000-2020 w/in 400 meters of Selected Stations [22]

		Paired Differences					t	df	Significance	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				One-Sided p	Two-Sided p
					Lower	Upper				
Legarda	Land Values 2004-2019	-55922.13	22250.07	5104.52	-66646.32	-45197.94	-10.96	18	0.00	0.00
	Population 2000-2010	321.00	663.25	152.16	1.33	640.67	2.11	18	0.02	0.05
Cubao	Land Values 2004-2019	-28141.09	9288.69	2077.02	-32488.33	-23793.84	-13.6	19	0.000	0.000
	Population 2000-2010	-1028.22	1798.44	402.14	-1869.91	-186.52	-2.56	19	0.010	0.019
Katipunan	Land Values 2004-2019	-20070.76	7199.98	3219.93	-29010.72	-11130.81	-6.23	4	0.002	0.003
	Population 2000-2010	-1356.40	1147.70	513.27	-2781.46	68.66	-2.64	4	0.029	0.057
Recto	Land Values 2004-2019	-29194.99	10323.48	1674.69	-32588.23	-25801.75	-17.43	37	0.00	0.00
	Population 2000-2010	73.68	500.07	81.12	-90.68	238.05	0.91	37	0.18	0.37
Pureza	Land Values 2004-2019	-51696.33	8772.23	2127.57	-56206.60	-47186.07	-24.30	16	0.000	0.000
	Population 2000-2010	-122.23	1113.45	270.050	-694.716	450.246	-0.453	16	0.328	0.657
Santolan	Land Values 2004-2019	5049.64	6378.29	4510.14	-52257.06	62356.33	1.12	1	0.232	0.464
	Population 2000-2010	-8137.50	3291.58	2327.50	-37711.19	21436.19	-3.50	1	0.089	0.177

Table 2: Paired Sample Test Result for all Station Areas

After the Legarda, Cubao, and Katipunan Stations were built, the land values and populations in the barangays where they were constructed changed significantly, as shown in Table 2. All the barangays had land values that were higher than the average for their respective zones. From 2000 to 2010, the population at Legarda Station decreased, and it has fluctuated in the years since then. This could be a sign of gentrification. The number of people living in Cubao Terminal initially increased, but then it declined around 2020. The number of people living in Katipunan grew. Counterurbanization and high land prices at Legarda Station make it harder to secure affordable housing, essential for promoting social inclusion in TODs. After the Recto and Pureza stations were built, an analysis of land values revealed that they increased significantly in both barangays, as shown in Table 2. In fact, 81.58% of Recto's land values and 88.24% of Pureza's land values were higher than their average zonal land values. The number of people living in the Recto Station Area decreased from 2000 to 2010 and then increased again, which could be a sign of gentrification. The Pureza Station Area, on the other hand, saw its population steadily rise as land prices rose. However, it's challenging to secure affordable housing in Recto and Legarda Stations due to high land prices and possible gentrification, which is crucial for successful TODs to be inclusive. Table 2 presents the observable changes in land value and population for Santolan Station and its two barangays after the train station was built. However, the p-value of >0.05, or 5%, is insignificant according to the Normal Distribution. Despite the insignificant paired sample t-test results, an abrupt increase in land values of 1 barangay in Santolan TOD Station Area, which exceeded 100% of the computed mean Land Value in Table 4. Figure 3 shows stable population growth. Santolan TOD Station Area does not show significant changes in land values or population, but there are still changes that must be sustained and managed to achieve Affordable Housing and Accessible Living as an indicator for emerging TODs.

4. Discussions

Station Areas	Residential Land Uses?	Commercial Land Uses?	Institutional Land Uses?	Intermodal Activities	Population Condition?	Possibly Gentrifying?	Land Value Increase
Recto	No	Yes	Yes	Yes	Increasing	Yes	High
Legarda	Yes	No	Yes	Yes	Decreasing	Yes	Very High
Pureza	Yes	No	Yes	Proposed	Increasing	No	High
Cubao	Yes	Yes	No	Yes	Increasing	No	Very High
Santolan	Yes	Yes	No	No	Increasing	No	Very High
Katipunan	Yes	No	Yes	No	Increasing	No	Moderate

Table 3: Comparative Analyses of Land Uses with Land Value and Population Behavior

In the context of Table 3, Legarda and Recto TOD Station Areas are exhibiting possible gentrification, indicating potential challenges for developing effective TODs. Table 4, on the other hand, shows significant changes in land value and population in the Legarda area, as indicated by the t-test results. Notably, land value increases at an alarming rate in Legarda, Cubao, and Katipunan Station Areas. Pureza and Recto should also monitor their land values, as more than 80% of their barangays are measured above the Mean Land Values. This is especially important since Zonal Values are only benchmarks for land value determination and may result in higher values using Fair Market Values.

TOD Station Areas	Sig. Observable Change ($p < 0.05$)		Barangay Mean Land Value		Population Trend and Behavior			Degree of Priority Needed
	Land Value	Population	Above	Below	Significantly Increasing	Significantly Decreasing	Possibly Gentrifying	
Recto	X		81.58%	18.42%			X	2
Santolan			50%	50.00%	X			4
Legarda	X	X	100%	0.00%			X	1
Katipunan	X	X	100%	0.00%	X			2
Cubao	X	X	100%	0.00%		X		2
Pureza	X		88.24%	11.76%	X			3

Table 4: Summary of Findings

The Access Node Theory suggests that limited access nodes in Metro Manila facilitate urban growth, but they don't alleviate traffic congestion. The area is experiencing trouble with rising property prices due to rapid, unregulated development in the vicinity of station areas. To solve the problem of not enough rail stations and make TODs more decentralized, we need to plan on a macro level. Adding different types of public transportation can help keep urban growth stable, and a corridor-level analysis is suggested to make TOD typologies work better. The World Bank lists seven types of efficient urban development, one of which is affordable housing, aimed at preventing gentrification. Land Value Capture is also mentioned to promote sustainable development. Additionally, for TOD to function effectively, there must be local and national frameworks and policies, as well as efforts to educate everyone on their meaning. The study finds that significant changes have occurred in land values and population trends in TOD station areas. This means that urban policies need to have more rules to keep pace with the rapid growth of cities, especially since the UN has predicted that urban populations will continue to grow in the future [4, 17, 23, 24, 25]

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DAILY MOBILITY OF WORKING STUDENTS: A RHYTHMANALYSIS APPROACH

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1. Introduction

Combining university studies with paid work has become increasingly common across Europe [1]. While flexible jobs expand opportunities [6], students often face time pressures and trade-offs between work, study, and leisure [8]. It is interesting to look at how this tension manifests itself in terms of mobility.

Mobility is more than physical movement; it involves social and emotional dimensions [10] and is staged both "from above" by institutional timetables and "from below" through everyday practices [13]. Existing research has focused on international migration [14], commuting to school [16], or transport modes [17], but rarely on students who must commute to both university and work. This study, therefore, asks how the different temporalities of studying and working shape the daily mobility strategies of working students, applying concepts from time geography and rhythmanalysis.

This contribution is based on rhythmanalysis. At the outset, it is important to lay down a question: What is rhythm? Rhythm can be understood as a structured repetition of movements and energies in time and space [19]. It emerges through pacemakers such as timetables or work schedules [21]. Scholars distinguish natural rhythms like circadian cycles [24], social and socio-temporal rhythms [25], cultural rhythms [27], and individual rhythms of the body [25]. For Lefebvre (2013), the body itself is a metronome [28], capturing tensions between harmony and disruption [29]. He identifies polyrhythmia as the coexistence of multiple rhythms, which may align in eurhythmia—states of health and everyday balance—or clash in arrhythmia, when rhythms diverge and synchronisation breaks down. Building on this, Rongna and Sun (2020) propose the dynamic process of arrhythmia–recuperation–eurhythmia, where individuals develop temporal strategies to restore equilibrium.

This perspective provides a framework for analysing how work and study rhythms intersect in the mobility of students. More concretely, this contribution aims to address the following question: How do the different temporalities of studying at university and working affect the mobility behaviour of working students? The main aim of this paper is also to demonstrate how the mobility behaviour of working students can be studied using Lefebvre's rhythmanalysis while contributing empirical research to the discussion of the arrhythmia-recuperation-eurhythmia process.

2. Methodology

This study examines the daily mobility of university students who combine study and paid work within the Brno Metropolitan Area. Empirical material was collected through 17 semi-structured interviews conducted between May and July 2024. Participants were recruited mainly via posts in student groups on social media, with care taken to include students from all local universities. Most conversations were held face-to-face in informal settings such as cafés and libraries, while three interviews took place online. The final sample consisted of eleven women and six men, with data saturation guiding the decision to stop recruitment. Informed consent was obtained from all participants, who were briefed on the scope of the study and their right to withdraw at any point. The interviews, averaging 54 minutes, were audio-recorded, transcribed, and analysed in Atlas.ti. Following the principles of open, axial, and selective coding [30], a coding structure was developed to identify patterns and interrelations across the data [31]. Analytical tools such as code co-occurrence tables, network diagrams, and causal maps supported a deeper exploration of empirical material.

3. Main results and concluding discussion

The analysis shows that student employment is marked by flexible but irregular working hours, frequent job changes, and non-standard shifts, often in the evenings or weekends. This creates a work rhythm that students can partly manage themselves. In contrast, university schedules act as a rigid institutional rhythm with limited autonomy, fixed timetables, and predictable changes during semesters, exam periods, and holidays. The interaction of these two rhythms structures students' daily mobility: some combine both within a single day, while others separate them across different days or periods. Mobility practices vary—from direct commuting to transitional stops at home, mindful walking, or chaining activities to save time. When rhythms align, students experience eurhythmia, but when they clash, commuting is perceived as burdensome or inefficient, leading to stress and adaptation. Strategies such as teleworking, weekend shifts, or seasonal work illustrate how students continually adjust, reflecting the dynamic movement between eurhythmic and arrhythmic states.

This study applied rhythmanalysis to the daily mobility of students combining study and work. University schedules and working hours act as two central pacemakers, producing distinct rhythms: the relatively flexible work rhythm and the more rigid student rhythm. Their coexistence generates both eurhythmic states, when activities are harmonised, and arrhythmic states, when they clash. Students respond through diverse mobility strategies—direct commuting, transitional pauses, chaining of activities, or separating study and work across different days. These strategies are dynamic, as changing academic timetables or employment conditions continually shift students between eurhythmia and arrhythmia, confirming the arrhythmia–recuperation–eurhythmia process [25]. While some students can integrate both roles smoothly, others experience conflicts, fatigue, and inefficiency, leading to adaptations such as weekend work, teleworking, or job changes. Findings highlight that student work mobility is highly variable, context-dependent, and sensitive to institutional temporalities, suggesting broader implications for university scheduling, labour flexibility, and future research on telework, field-specific differences, and financial pressures.

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CRITICAL POINTS OF CYCLING INFRASTRUCTURE IN PRAGUE THROUGH BIG DATA ANALYSIS

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1. Introduction

In the context of climate change and the urgent need to reduce urban CO_2 emissions, cities around the world are increasingly turning to non-motorized modes of transport as a cornerstone of sustainable urban mobility. Prague, the capital of the Czech Republic, faces mounting challenges related to traffic congestion, air pollution, and the overuse of public space by individual automobile traffic (IAT). Despite growing interest in cycling among residents, the city's cycling infrastructure remains fragmented and often unsafe, discouraging widespread adoption of bicycles as a primary mode of transport.

This case study builds upon the methodology developed by Jan Haruda [1], which utilizes big data analytics to identify critical points in cycling infrastructure. Haruda's research demonstrates how Volunteered Geographic Information (VGI) from sports applications such as Strava and Cyclers can be harnessed to reveal patterns in cyclist movement and pinpoint locations with high accident rates (data from Policie ČR). These insights are crucial for urban planners seeking to design resilient and sustainable transport networks that cater to all age groups and abilities.

The Prague case study applies this data-driven approach to the city's unique urban landscape. With its historical core, hilly terrain, and dense traffic network, Prague presents a complex environment for cyclists. The study integrates anonymized movement data from cycling apps, police accident statistics, and open data on existing infrastructure to map cyclist behavior and identify hazardous locations. This triangulation of data sources enables a comprehensive analysis of where infrastructure improvements are most needed.

As Haruda notes, the proliferation of smartphones has led to the unconscious and conscious generation of geolocation data by users [2]. This data, when properly anonymized and aggregated, offers a powerful tool for understanding urban mobility patterns. In Prague, the use of Strava and the Bike to Work initiative provides a rich dataset of daily commuting routes, which are contrasted with accident hotspots recorded by the Czech Police [3].

The methodology involves hotspot analysis, identifying clusters of accidents and evaluating their proximity to existing cycling infrastructure. In Haruda's study of Hradec Králové, this approach revealed that many accidents occurred at intersections and transitions between protected and unprotected cycling paths [1]. Applying the same technique to Prague allows planners to assess the effectiveness of current infrastructure and prioritize interventions in areas with the highest risk.

One of the key findings from Haruda's research is that the linear routing of cycle lanes is less problematic than the design of crossings and ramps where cyclists merge with vehicular traffic [1]. This insight is particularly relevant for Prague, where many cycle paths abruptly end or fail to guide users safely through complex intersections. By identifying these critical points, the city can implement targeted improvements that enhance safety and encourage cycling.

Moreover, the study highlights the importance of demographic factors in cycling behavior. Cities with younger or more environmentally conscious populations tend to have higher rates of cycling [4]. Prague's growing population of young professionals and students presents an opportunity to promote cycling as a viable alternative to IAT. However, this requires infrastructure that is not only safe but also continuous and intuitive.

The integration of big data into urban planning aligns with the principles of smart city development, where data is used to optimize services and infrastructure [5]. In Prague, this means leveraging cyclist movement data to inform decisions about where to build new cycle paths, improve existing ones, and implement safety measures. It also supports the Sustainable Development Goals (SDG), particularly Goal 11 (Sustainable Cities and Communities) and Goal 12 (Responsible Consumption and Production) [6].

In conclusion, the Prague case study demonstrates how the methodology pioneered by Haruda can be adapted to larger urban environments. By combining VGI, accident data, and infrastructure mapping, the city gains a powerful analytical tool for enhancing cycling safety and promoting sustainable transport. This approach not only addresses immediate concerns of traffic safety but also contributes to long-term goals of reducing emissions and improving urban livability.

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PROMOTING INTEGRATED MOBILITY SYSTEMS IN EMERGING CITIES: A MAAS-INSPIRED FRAMEWORK FOR INTEGRATED, SUSTAINABLE AND INCLUSIVE MOBILITY

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1. Introduction

Many emerging cities across Africa, Asia, and Latin America are experiencing rapid demographic and economic growth that is reshaping their mobility landscapes. Their transport systems are characterised by a mix of formal public transport modes such as bus rapid transit (BRT), metro lines, and tramways, alongside active mobility options and a wide range of informal services including minibuses, tuk-tuks, and motorcycle taxis. Despite this diversity, most emerging cities struggle to deliver accessible, affordable, and sustainable door-to-door mobility for their citizens. Persistent challenges include fragmented services, limited accessibility for vulnerable groups, rising congestion and car ownership, as well as environmental pressures such as air and noise pollution, coupled with significant safety and security risks [1,2].

The fragmented nature of the existing mobility systems is challenging and is limiting the ability of authorities to implement integrated, inclusive, and sustainable mobility strategies. Urban mobility systems in cities like Cairo, Lagos, Delhi, Bogotá, and other emerging cities often evolve independently, with little coordination between operators, agencies, and service levels. As a result, travel patterns require high cognitive efforts from users and lead to increasing car-dependent mindsets for people who can afford private vehicle ownership [3,4].

In recent years, the concept of Mobility as a Service (MaaS) has been widely explored in Europe and other high-income contexts as a framework for integrating diverse mobility modes and services into a seamless user-oriented system. MaaS aims to combine Public Transport, Shared Mobility solutions such as taxi and ride-hailing services, as well as active mobility into a digital platform that offers a door-to-door solution as an alternative and strong competitor to private vehicles. [5,6,11]

MaaS is a user-centric approach that should prioritize the user's individual preferences and allow them to plan, book, and pay for their door-to-door trip in an integrated manner, across diverse mobility modes. [7,8,11]. However, most MaaS research and implementation efforts remain Eurocentric, often overlooking the distinct needs, conditions, opportunities and mobility challenges of emerging cities.

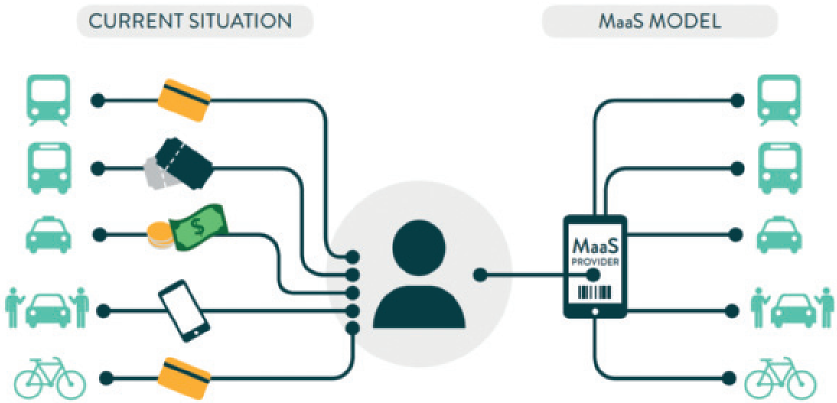

Figure 1: MaaS Model in a nutshell (Source: UITP 2019)

This research builds on the logic of MaaS as a valuable foundation; however, the emerging cities require a more comprehensive integrated mobility framework that extends beyond MaaS's digital solutions to capture the full range of integration pillars. The aim of this research is therefore to highlight the gap in current approaches and to demonstrate the need for a context-sensitive integrated mobility framework for emerging cities. This framework builds on five pillars of integration: (1) physical infrastructure, (2) digital infrastructure, (3) governance & capacities, (4) business models & operations, and (5) passenger information and inclusive systems.

This extended abstract presents the first phase of an ongoing PhD project, focusing on literature review and consultation-based findings for identifying the relevance of MaaS in the Emerging Cities context, and the potential impacts of integrated mobility developments in such contexts, as well as highlighting the main pillars for an integrated mobility approach. The next phases will include co-developing a comprehensive indicator list for each mobility pillar and validating them with stakeholders both internationally and in the local case study of the Greater Cairo Region.

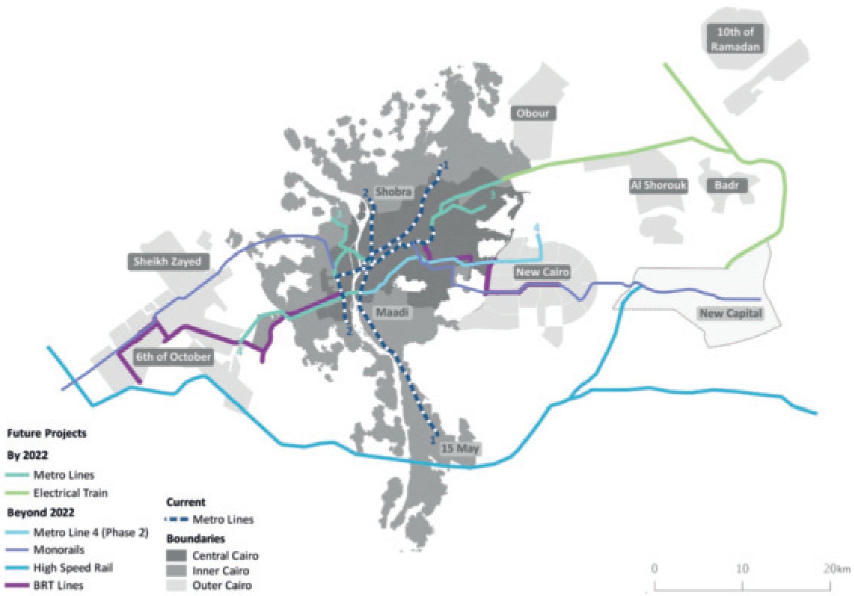

Figure 2: Major Public Transport Project in the Greater Cairo Region (Source: Transport for Cairo, 2018)

2. Methodology

The methodology of this research combines an extensive literature review with empirical insights gathered through consultation events and academic discussions.

Literature review:
The review focused on mobility conditions, challenges, gaps, and opportunities across selected emerging cities in Africa, Asia, and Latin America. Cities included Cairo and Alexandria (Egypt), Lagos (Nigeria), Delhi (India), Hanoi and Hue (Vietnam), Bogotá (Colombia), and Mexico City (Mexico). These cities were selected for their challenging, diverse yet representative mobility contexts, which include both formal mass transit investments (e.g., metro and bus rapid transit systems) and extensive informal mobility services [9,10]. The literature review included peer-reviewed journal articles, international reports, and policy documents addressing accessibility, integration, travel experiences, and climate-sensitive transport in these regions.

Consultation events:
The literature review was complemented by first-hand insights from a series of consultation events in which the author actively participated. These included stakeholder meetings, conferences and workshop interactions in Cairo, Hanoi, and Istanbul, as well as discussions within international academic classes at the Technical University of Berlin. Participants included local transport

authorities, urban planners, users, and scientific researchers. These sessions provided valuable qualitative evidence of local perspectives on accessibility gaps, integration challenges, and the need for comprehensive frameworks that move beyond fragmented interventions.

Analytical approach:
The analysis triangulated findings from the literature with stakeholder insights to identify recurring patterns and challenges across cities. This synthesis was then used to articulate the core components of an integrated mobility framework, framed as five pillars that collectively enable integrated, inclusive, and sustainable mobility development in emerging cities.

3. Preliminary Findings

The findings reveal several recurring challenges across the case study cities:
1. Fragmented service provision: Formal & Informal public transport systems mostly operate independently in terms of routes, schedules, or fare systems, resulting in gaps in coverage, inefficiencies in network design and requiring high-cognitive efforts from commuters.

2. Weak physical integration: In many cities, mobility stops and stations are poorly designed, with limited accessibility features and inadequate intermodal connections between different transport modes. This discourages multimodal journeys, especially for vulnerable or first-time users.

3. Governance challenges: Institutional fragmentation between national, regional, and municipal authorities and the public and private sectors, undermines coordinated planning and regulation. Monitoring, Evaluation and Regulatory frameworks are missing/outdated, and Informal transport providers are often excluded from formal decision-making processes.

4. Unsustainable business models: Public transport systems frequently operate under financial stress, while private informal operators prioritise short-term profit over service reliability or integration.

5. Limited digital infrastructure: While mobile technology penetration is growing rapidly, digital integration of mobility services (real-time passenger information, integrated ticketing, integrated payment) remains underdeveloped.

6. Accessibility gaps for vulnerable groups: Lack of inclusive infrastructure and passenger information disproportionately affects vulnerable users including first time mobility users whether locals or tourists, as well as women, elderly, and people with reduced mobility, limiting their ability to access education, healthcare, and employment.

Figure 3: Hand gestures were informally invented by informal transport users in Egypt to compensate for the lack of formalized passenger information. Both commuters and drivers use specific gestures on the road to communicate vehicle direction and destinations. The gestures are innovative and efficient for fast operations; however, they are exclusive for first-time mobility users. On the left, this is the gesture of 6th of October district -by raising 6 fingers-, while on the right, this is the gesture for the Pyramids -by creating a triangular shape with two fingers-. Images Source: Robert Johnson/Business Insider)

In response to these challenges, the research proposes a five-pillar integrated mobility framework, which represents the key finding of this phase:

1. Physical Infrastructure Integration: ensuring seamless connections between modes, accessible interchanges, and supportive pedestrian and cycling networks.

2. Digital Infrastructure Integration: enabling interoperable systems for planning, booking, ticketing, and data-sharing.

3. Governance Integration: establishing institutional coordination mechanisms and regulatory frameworks that include formal and informal operators.

4. Business Model Integration: developing financing and operational models that balance public and private sector roles while ensuring sustainability.

5. Passenger Information and Inclusivity: providing accessible, real-time, and user-friendly information, while addressing the specific needs of vulnerable and diverse user groups.

This framework builds upon the principles of MaaS but adapts them to the structural realities of emerging cities, where digital platforms alone are insufficient. It highlights the need for simultaneous progress across infrastructure, governance, and inclusivity.

4. Discussion

The results underscore the critical importance of moving beyond isolated interventions towards a comprehensive framework for integrated mobility in emerging cities. While MaaS has demonstrated potential in Europe, its direct application is limited in contexts where informal services dominate, institutional capacity is weak, and basic infrastructure remains underdeveloped. A broader framework is therefore needed to capture the multiple dimensions of integration.

Developing and applying such a framework offers several benefits:

- For users: Enhanced accessibility, reduced travel times, greater reliability, and safer environments, particularly for vulnerable groups. By lowering barriers to public transport and active mobility, more people can be attracted away from private car dependency.
- For authorities: A structured tool for tracking investments, monitoring progress, and coordinating across agencies. The framework can help ensure that new projects build on existing systems rather than duplicating efforts.
- For the environment: By promoting a shift towards collective and active modes, integrated systems can contribute significantly to reducing emissions and improving air quality, aligning with climate-sensitive development goals.

This research phase thus provides the foundation for subsequent work within the PhD project. The next phase involves co-developing a detailed indicator list for each pillar of the framework, which allows operationalisation and measurement. These indicators will then be tested and verified with stakeholders and experts, both internationally and in the focus case study of Greater Cairo.

By addressing the mobility challenges of emerging cities through an integrated lens, this research contributes to filling a major gap in the current literature and practice. It highlights that sustainable and inclusive mobility cannot be achieved through technology alone, but requires systemic integration across multiple dimensions.

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MODE SHIFT VERSUS URBAN SPRAWL: A QUANTITATIVE SPATIAL MODEL FOR A RAILWAY POLICY IN BUDAPEST

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1. Introduction

This paper examines the relationship between public transport investments and urban sprawl. Investment in public transport is a frequently suggested policy aimed at reducing the adverse externalities of car use in urban areas. However, as commuting costs decrease, individuals may be more inclined to move to suburban areas that offer more affordable housing and natural amenities [1], potentially leading to urban sprawl and its associated negative effects. A key question is whether railway-induced sprawl is less harmful to society than car-induced sprawl. A possible difference is that railway infrastructure investments may encourage relocation to areas within the catchment areas of stations, resulting in higher population densities compared to car-oriented suburbs [2].

The primary objective of this paper is to assess the interplay between mode shift and urban sprawl in the context of large-scale suburban railway investments. We address this research question through the development of a quantitative spatial model (QSM) for Budapest, Hungary.

2. Methodology

QSMs are powerful tools for evaluating policy interventions in spatial general equilibrium, combining the empirical estimation of key model parameters with counterfactual policy simulations, at a high level of spatial granularity. QSMs form a subset of models within the wider class of spatial computable general equilibrium (SCGE) models, where the core distinguishing features relate to the process of calibration. In a QSM, local amenities for residential and workplace activities as well as local firm productivity can be quantified for thousands of spatial units via model inversion. In addition, the core generic parameters of the model can be causally estimated in theoretically consistent econometric exercises. [3] and [4] offer comprehensive overviews of the QSM methodology.

This paper builds on [5], which has been the first attempt to turn a traditional transport-focused SCGE model (with separate monetary and time budgets and endogenous travel time valuations as in [6]) into a quantitative spatial model. We extend their model with endogenous mode choice (based on [7]) and travel times under congestion. The model focuses on commuting trips, considering two modes: car and public transport. The theoretical model is described in greater detail in [8], an earlier version of this paper.

Model estimation involves multiple model-specific empirical tasks. Congestion parameters, crucial for modeling endogenous car travel times, are estimated using traffic flow and commuting data. The Fréchet shape parameter, governing location choice dispersion, is estimated via Poisson Pseudo Maximum Likelihood (PPML) estimation with origin, distance, and mode fixed effects, and Euclidean distance used as an instrument of spatial impedance. We also deliver causal estimates for the agglomeration elasticity of firm productivity, which, to the best of our knowledge, has not been done previously in an Eastern European context.

3. Results and discussion

The counterfactual exercise assumes the construction of a cross-city railway tunnel in Budapest, improving public transport accessibility both in the center and in the suburbs. In line with intuition, the simulation reveals that the suburban areas near the railway lines become more attractive for residents using public transport. The process of urban sprawl is clearly detected in our results: we find that the demand for residential floorspace increases in suburban locations, as well as the total number of suburban households. Meanwhile, the project leads to a decentralization of employment, which aligns well with the main findings associated with a similar railway project in Greater London in [5].

The railway tunnel alters the modal split. Public transport commuting increases by about 1.5% in outer districts, where accessibility to downtown improves most. Conversely, city center residents opt to drive more often due to reduced congestion caused by fewer commuters from outer districts.

The mean value of time (VOT) increases citywide, peaking in the areas newly connected to the city center. Improved public transport boosts productivity by enhancing access to economic mass. The increasing productivity leads to growing wages throughout the city. As wages rise, individuals supply more labor in response to the financial incentive as well as reduced commuting times. Land prices grow across the city, especially in areas at the urban fringe, reflecting enhanced connectivity.

By computing the change in indirect utility right after the intervention (before a new equilibrium emerges), we show that living in the suburbs near railway lines becomes more appealing for public transport users, while downtown living offers higher utility for car commuters due to less congestion. Despite better public transport, more car commuters move to the city center, potentially increasing air pollution and complicating efforts to establish car-free zones. This finding suggests that suburban railway improvements alone may not reduce car use in central areas. Without accompanying traffic-calming measures, car traffic could rise downtown, highlighting a trade-off between rail-based suburbanization and inner-city car use.

The model has some limitations. A four-step transport model used for route assignment is not integrated into the spatial model, reducing its theoretical coherence. Travel times for public transport are treated as fixed; a more responsive approach with endogenous frequencies and crowding could enhance validity. We aim to make progress along these lines at the final stage of this project.

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TOP 10 DIRECTIONS: THE TEMPORAL DYNAMICS OF BIKE-SHARING DEMAND IN BUDAPEST

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1. Introduction

Bike-sharing systems have emerged as a vital element of sustainable urban mobility, offering flexible and low-emission transport alternatives while generating large-scale data that provide valuable insights into travel demand and network dynamics. Previous studies have extensively examined bike-sharing systems in system-level optimization, rebalancing strategies [1], and demand forecasting [2]. Origin-Destination (OD) matrix analysis has been widely applied to capture spatial flows, identify key mobility corridors, and understand usage patterns across different urban contexts [3]. Furthermore, OD-based approaches have been used to highlight travel imbalances [4], classify station types [5], and explore user heterogeneity [6].

While these contributions provide a strong foundation for understanding system performance, relatively few studies have addressed the temporal stability of the most demanded OD directions. Existing research tends to focus on aggregated flows, optimization, or clustering, with less emphasis on whether the same dominant directions persist across months, weekdays versus weekends, or consecutive hours. This represents a gap in research, as the stability and variability of key directions directly impact operational efficiency, redistribution planning, and service reliability.

The study focuses on the Top 10 OD directions in the Bubi station-based bike-sharing system in Budapest. The analysis applies the Rank-Biased Overlap (RBO) method [7], [8], which is designed for comparing ranked lists by considering both the degree of overlap and the ordering of elements. Unlike traditional similarity indices, RBO is top-weighted and accommodates lists of unequal length, making it suitable for evaluating ranked mobility directions. By applying the RBO method to annual, monthly, day-type, and hourly temporal slices, this study aims to reveal which dominant directions remain stable or change over time – thereby contributing new evidence on the temporal dynamics of bike-sharing demand.

2. Methodology

The analysis evaluated the temporal dynamics of the most demanded bike-sharing directions. The methodological framework is summarized in Figure 1.

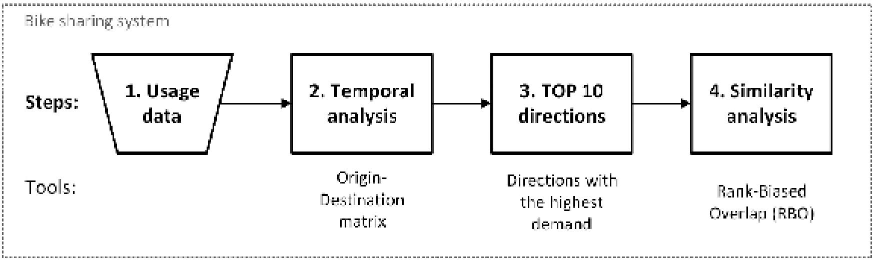

Figure 1: Methodological steps of the TOP 10 direction analysis

2.1. Step 1. Usage data

Collecting usage data, such as trip-based records including the origin station, destination station, start time, and end time. The database is to be pre-processed to remove incomplete or inconsistent records. In this study, the analysis relied on one year of bike-sharing trip records (September 2023 – August 2024). In the period, more than 200 stations and several thousand bicycles were operated, resulting in approximately 3.5 million possible OD-pairs.

2.2. Step 2. Temporal analysis

To capture temporal variations, the dataset was segmented into different time periods. The following breakdowns were applied:

- Annual level.
- Monthly level.
- Daytype level (weekday vs. weekend).
- Hourly level.

An OD matrix was constructed for each temporal category, where each cell represented the number of trips between a pair of stations during the given period.

2.3. Step 2. Top 10 directions

From each OD matrix, the TOP 10 directions were selected. These represent the network's strongest relations, highlighting the bike-sharing system's main travel corridors.

2.4. Step 4. Similarity analysis

A similarity metric was applied to assess the stability and variability of the Top 10 directions over time. The Rank-Biased Overlap (RBO) method was chosen, as it measures the similarity between two ranked lists while accounting for both overlap and ordering. RBO is top-weighted: higher-ranked elements contribute more strongly to the similarity score. This property makes it suitable for comparing ordered lists of the most demanded directions, where the first positions reflect the most dominant relations.

3. Results

The analysis reveals typical attributes of the dominant directions. The Top 10 trips are short-distance rides and reflect the local character of bike-sharing use. They are linked to recreational trips on

Margaret Island, a major leisure destination in Budapest, while another significant share originates from the immediate surroundings of universities, serving student mobility during weekdays. In addition, several key directions are concentrated in the inner-city area, often tied to specific locations with consistently high demand, underlining the role of central hubs in the system.

In Table 1, the month-to-month RBO matrix indicates that similarity values are higher between spring, summer and autumn, with the strongest overlaps observed between Mar-Oct and April-May. These months correspond to the peak cycling season, where user demand and station interactions are more stable. In contrast, winter months, particularly December and January, show the lowest similarity values, suggesting that usage patterns in these periods are distinct from the rest of the year.

RBO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Jan	-	0.31	0.15	0.07	0.10	0.07	0.06	0.11	0.21	0.21	0.22	0.20
Feb		-	0.29	0.17	0.21	0.17	0.19	0.24	0.37	0.33	0.25	0.13
Mar			-	0.44	0.52	0.33	0.49	0.44	0.38	0.56	0.22	0.15
Apr				-	0.54	0.49	0.42	0.52	0.31	0.41	0.07	0.03
May					-	0.43	0.46	0.51	0.33	0.47	0.12	0.06
Jun						-	0.32	0.44	0.31	0.29	0.06	0.02
Jul							-	0.41	0.31	0.45	0.10	0.07
Aug								-	0.35	0.46	0.13	0.05
Sept									-	0.44	0.21	0.14
Oct										-	0.23	0.13
Nov											-	0.28
Dec												-

Table 1: Month-to-month RBO matrix

When comparing the monthly Top 10 lists to the annual ranking, the highest similarity is found in spring and autumn (March, May, October), while winter months align poorly with the overall yearly profile (Figure 2). This indicates that the annual structure of demand is shaped mainly by the warm-season months.

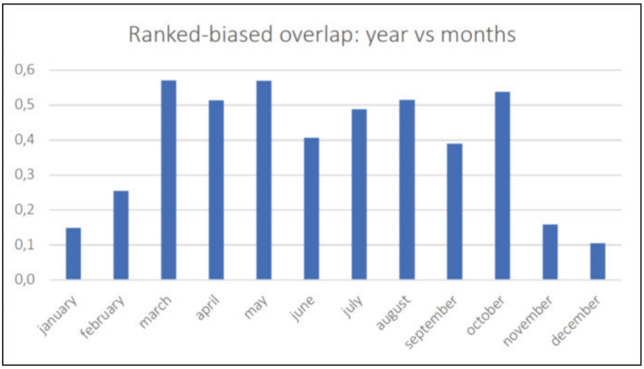

Figure 2: Ranked-biased overlap: year vs months

The comparison between weekdays and weekends reveals a relatively low RBO score (0.216). This confirms a strong structural difference: weekday travel patterns are dominated by short commuting flows, often between universities and nearby hubs, whereas weekend usage is more heterogeneous and strongly shaped by leisure-oriented rides.

The RBO analysis of adjacent hours is demonstrated in Table 2. Smooth transitions with high RBO values are visible during the late morning to afternoon period (13:00-15:00, 18:00-19:00), indicating stable directions across consecutive hours. Conversely, very low overlaps occur during the early morning (03:00-06:00) and around peak-hour boundaries (09:00-10:00), reflecting abrupt changes in usage patterns. These discontinuities capture the shift between nighttime special demand, morning commuting near universities, and later daytime leisure activities in recreational areas.

0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
0.442	0.507	0.402	0.022	0.000	0.000	0.348	0.281	0.380	0.086	0.157	0.374
12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
0.433	0.530	0.538	0.379	0.447	0.394	0.542	0.387	0.384	0.242	0.390	0.429

Table 2. Adjacent hours RBO matrix

4. Conclusion

This study demonstrated that the Rank-Biased Overlap (RBO) method provides a powerful tool for capturing the temporal stability and variability of the TOP 10 bike-sharing directions. The results provide insights into the temporal dynamics and reveal seasonal effects with similarities across the spring and summer months, contrasted by low stability in winter. Structural differences were also evident between weekdays and weekends, reflecting the divergence between commuting and leisure-oriented demand. Hourly analysis highlighted smooth transitions during daytime use and sharp shifts around commuting peaks and nighttime periods. The findings underscore that dominant bike-sharing directions are shaped by temporal dynamics and spatial-functional contexts such as recreational areas, universities, and central city hubs, offering valuable insights for planning and operational strategies.

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TRANSFORMATION OF RAILWAY STATION FUNCTIONS AND THEIR REDEVELOPMENT WITHIN THE FRAMEWORK OF SMART VILLAGES, SMART CITIES, AND SMART REGIONS

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1. Introduction

The transformation of railway stations represents one of the most significant paradigm shifts in contemporary European transport and urban development. Since the early 1990s, when the European Community initiated the institutional separation of infrastructure management from railway operations [1], the traditional role of stations has been fundamentally redefined. Originally designed as operational and economic facilities, stations are increasingly redeveloped into multifunctional hubs that combine mobility with socio-cultural, commercial, and community functions. In many documented cases [2, 3, 4, 5, 6], a multi-stakeholder approach has been adopted, resulting in the implementation of new functional and urban solutions. Consequently, railway station buildings and their surroundings undergo a comprehensive transformation.

Bertolini introduced the influential "node and place" concept [7, 8, 9], arguing that stations are both transport nodes and urban places with distinct identities. This dual perspective has become even more relevant in the context of Smart City and Smart Neighborhood frameworks, where railway stations are expected to act as catalysts for sustainability, resilience, and social inclusion [10, 11].

The Czech Republic offers a particularly illustrative case. In 2016, more than 1,000 station buildings were transferred from Czech Railways to the national infrastructure manager Správa železnic [12,13]. This restructuring provided access to European structural funds and opened the way for systematic redevelopment programmes [14,15]. However, the scientific literature still lacks a systematic evaluation of how redeveloped stations meet the evolving mobility and non-mobility needs of passengers, local communities, and new stakeholders.

2. Methodology

This research applied an empirical text analysis based on a qualitative review of user-generated content across multiple platforms, including Mapy.cz, Google Maps, Booking.com, Airbnb, as well as news portals and travel websites where visitors evaluated their experiences with selected railway stations. User comments and ratings were interpreted to identify core thematic categories such as authenticity and affective characteristics, cultural significance, comfort, location, natural environment, rating levels, and overall perception. Similar qualitative methods using online review analysis have been published in studies on restaurant evaluations [16, 17] and are widely applied in tourism research [18, 19, 20]. A critical perspective on the role and impact of online reviews has also been provided in studies [21, 22], which examine reviewer identity and the influence of credibility perceptions on consumer opinion formation.

In the pilot phase, two distinct types of redeveloped railway stations were identified, differentiated by their functional profiles: urban stations, which tend to attract a broader range of new stakeholders—primarily focused on cultural uses—and rural stations, where recreational and tourism-related functions prevail. The methodological procedure consisted of three steps: (1) data collection from the defined platforms, (2) thematic analysis of recurring review patterns focusing on the aspects listed above, and (3) synthesis through cross-platform comparison to produce a comprehensive view of how railway stations are perceived and what their defining characteristics are in aggregate.

As illustrative examples, two urban stations were selected: the newly reopened Bubeneč station in Prague and Žilina-Záriečie in Slovakia, a long-standing cultural hub with strong socio-cultural impact. For the rural category, Zbiroh—known for its established recreational services—and Jedlová—recently redeveloped—were chosen to represent contrasting trajectories of station transformation.

3. Results

The results were presented with the aim of establishing appropriate foundations for each assessed aspect, thereby enabling meaningful discussion and conclusions regarding the new functions represented by redeveloped railway stations. The findings are structured in accordance with the chosen methodological approach, focusing on the following dimensions: authenticity and affective characteristics, cultural significance, comfort and location, natural environment, rating levels, and overall perception. The presentation begins with the urban railway stations Bubeneč and Žilina-Záriečie, followed by the rural stations Zbiroh and Jedlová.

4. Discussion

The analysis of four case studies (Bubeneč, Žilina-Záriečie, Zbiroh, and Jedlová) revealed that successful railway station redevelopment depends on the interaction of several key factors. The results confirm that a universally applicable prerequisite is the presence of a strong cultural and community vision, which redefines the original transport function and adds a dimension of long-term societal value. Another decisive factor is strategic location and accessibility. Whereas urban stations benefit from integration into infrastructure networks and broader cultural settings, rural cases highlight the importance of the natural environment and tourism potential. In both contexts, locational aspects emerged as fundamental determinants of success.

Preserving authenticity and historical heritage—with elements of nostalgia—proved highly effective. The combination of new functions with the original identity enhances site attractiveness and supports positive perceptions among local residents and visitors. Expanding functions to include cultural, recreational, and accommodation services provides multifunctionality and diversification, thereby strengthening resilience and economic stability.

The discussion also confirms the irreplaceable role of local communities and leadership figures. Active involvement of residents and organizations contributes to greater acceptance and long-term sustainability. Particular attention is drawn to the personal engagement of individuals who successfully aligned their vision with community needs, thereby creating projects with broader social impact.

In conclusion, successful railway station redevelopment results from a complex synergy of cultural vision, locational prerequisites, authenticity, multifunctionality, community participation, and leadership. These factors represent not only the conditions of effective transformation but also a generally applicable framework for future projects in both urban and rural environments.

5. Conclusions

The analysis of four case studies (Bubeneč, Žilina-Záriečie, Zbiroh, and Jedlová) demonstrated that successful railway station redevelopment depends on the interplay of several key factors. The results confirm that a universally applicable prerequisite is the existence of a strong cultural and community vision, which redefines the original transport function and adds a dimension of long-term societal value. Another decisive factor is strategic location and accessibility. While urban stations benefit from integration into infrastructure networks and wider cultural milieus, rural examples highlight the significance of natural surroundings and tourism potential. In both contexts, locational aspects emerged as primary determinants of success.

Preserving authenticity and historical heritage—often with elements of nostalgia—proved particularly effective. The combination of new functions with original identity enhances place attractiveness and fosters positive perception among both local residents and visitors. The expansion of functions to include cultural, recreational, and accommodation services ensures multifunctionality and diversification, contributing to resilience and economic stability.

The discussion further underscores the indispensable role of local communities and leadership figures. Active involvement of residents and organizations fosters higher acceptance levels and long-term sustainability. Special attention is warranted for the personal engagement of individuals whose ability to align their vision with community needs enabled the creation of projects with broader societal impact.

Overall, the study concludes that successful railway station redevelopment results from a complex synergy of cultural vision, locational prerequisites, authenticity, multifunctionality, community participation, and leadership. These factors not only define the conditions for effective transformation but also provide a generalizable framework for future projects in both urban and rural environments.

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IS PROXIMITY A PRIVILEGE? THE 15-MINUTE CITY ACROSS FIVE SPANISH CITIES

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1. Introduction

After decades of prioritizing cars and functional segregation, urban planning is increasingly seeking to redesign cities in order to foster sustainable mobility and reallocate space to people [1]. One of the most prominent approaches in this field is the concept of the 15-minute city, which advocates that all essential daily facilities -such as housing, workplaces, commerce, healthcare, education and entertainment- should be reachable from home within a 15-minute walk or bicycle ride. This concept builds upon the notion of "chrono-urbanism", which links urban quality of life inversely to the time individuals spend on daily mobility [2]. In practical terms, this implies a shift from functional specialization toward mixed-use urban frabrics that integrate living, working, and leisure spaces within proximity.

However, there is an ongoing debate about the unintended effects of increased accessibility, such as the risk of gentrification [3]. Some studies suggest that improvements in accessibility and urban functions are most evident in classic gentrification contexts, emphasizing the need to balance the 15-minute city model with careful planning to mitigate socio-spatial polarization [4]. At the same time, other scholars argue that the 15-minute city falls short of addressing the deeper structural factors that sustain spatial inequality and persistent disadvantage [5].

A growing body of research has focused on the sociodemographic distribution of accessibility levels, revealing significant disparities. Proximity constitutes a critical resource for groups facing time-space constraints, such as working women or low-income residents without personal vehicles [6]. Beyond a density threshold of approximately 20,000 inhabitants per km², income and other social factors become increasingly decisive, as lower motorization in poorer areas leads to more trips remaining localized within a 10-minute walk [7].

Opportunities for living a local life and achieving accessibility via proximity differ markedly across social groups. Some studies found that low-income residents and the elderly are often located closer to facilities essential for daily life, whereas higher-income households and parents with young children may face lower accessibility, partly due to residential location choices and mobility patterns [8]. Conversely, other studies suggest that wealthier residents may benefit more from access to a broader variety of urban functions, while marginalized groups may continue to experience limited opportunities, highlighting the importance of equity-focused analyses in urban planning [9], [10]. Indeed, low accessibility levels can constrain life chances and limit participation in social, economic and cultural activities [11].

Furthermore, environmental and equity considerations are closely intertwined with accessibility. Areas with higher concentrations of local services and mobility options do not necessarily correspond to better environmental conditions. On the contrary, higher accessibility has been linked to increased exposure to air pollution [12].

The conceptual roots of the 15-minute city can be traced back to people-centered urban planning approaches and the work of scholars such as Jane Jacobs (1961), who emphasized the importance of mixed-use neighborhoods, walkability and social vitality. Nevertheless, urban vitality has also been associated with non-vulnerable urban environments, particularly in dense Mediterranean cities [13]. Despite the theoretical emphasis on accessibility and active modes, empirical research reveals persistent inequalities in walkability distribution [14].

Taken together, these findings indicate that achieving the 15-minute city vision is not merely a matter of urban design or mobility planning. It requires careful consideration of social composition, income distribution, demographic characteristics, and environmental conditions to ensure equitable access. In this context, studying the interplay between urban accessibility and sociodemographic characteristics at the neighborhood scale is essential for understanding who benefits from urban interventions and who may be left behind.

Although several studies have examined the relationship between accessibility and socio-demographic characteristics, an important research gap remains, as most focus on specific types of urban amenities and are limited to a single city or neighborhood as their study area.

2. Methodology

Building on these insights, this study examines the distribution of accessibility to essential services across sociodemographic groups in five Spanish cities: Barcelona, Palma de Mallorca, Granada, València and Madrid. The analysis uses census tracts as the unit of observation and considers key variables such as income, age structure, education, the share of touristic apartments, and the GINI coefficient, among others.

Accessibility data comes from the *Atlas de Ciudades para la Movilidad Activa en España* and was calculated as the mean travel time from home, by active modes, to 26 different facilities. These 26 facilities were further grouped into five categories: care, education, provisions, entertainment and public transport. Sociodemographic information was obtained from the Spanish National Statistical Institute (INE) and belongs to the 2021 Census.

We modeled the probability of a census tract belonging to a given accessibility category using multinomial logistic regression within a multilevel framework. The multilevel structure accounts for the hierarchical nature of the data, with census tracts nested within cities, allowing for both fixed effects of sociodemographic variables and random intercepts for each city.

It is worth noting that our study not only encompasses a broad selection of amenities, but also provides a comparative perspective across five cities of different sizes and dynamics. Three of them are Mediterranean cities with a strong touristic profile —Barcelona, Palma de Mallorca, and València—while the other two are inland urban environments, Granada and Madrid.

3. Preliminary results

Preliminary results reveal that census tracts can be grouped into distinct accessibility profiles. At one extreme, some areas are highly accessible, with all services from every category available within a 15-minute walk or bicycle ride. A second group can be described as accessible, since their overall average accessibility is below 15 minutes, although certain facilities remain uncovered. A third type corresponds to partially accessible tracts, where the overall average exceeds 15 minutes but residents still have at least one facility from each category within reach.

Beyond these, several low-accessibility profiles with specific hubs emerge: some tracts show limited general accessibility but full coverage within 15 minutes to one category of services, whether mobility, education, provision or healthcare. Finally, there are tracts characterized by low accessibility with no hub, where both overall and categorical accessibility remain limited.

In addition, statistical analysis indicates that nearly all sociodemographic variables are significant in explaining these patterns, including the share of rental apartments, the GINI coefficient, the proportion of foreign residents, unemployment rates, the share of population with secondary education, mean age, and income.

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ECOFEMINISM, SOLARPUNK, AND THE POLITICS OF URBAN MOBILITY

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1. Introduction

Mobility is defined in this research as: the ability to move from one place to another [1], to which this abstract further views urban mobility as movement within a city. Cities are hotspots for all people, and are supported by organisations such as 'Net Zero Cities' [2] to transform and reduce emissions from transport, while simultaneously fostering social inclusivity. How people move, which infrastructures are prioritised, and who is empowered to shape these transitions are central determinants of whether environmental sustainability goals can align with social sustainability. Yet, the dominant narratives of net zero often sideline questions of gender justice and community empowerment [3].

This paper integrates ecofeminist theory and solarpunk futures with urban mobility to investigate the politics of movement in two Olympic host cities. It contrasts Los Angeles (LA), which is a car-dominated, "carbon city"; with London, where the 2012 Olympics provided opportunities for rethinking public transport and green regeneration with more inclusive design. This research focuses on feminist, resilient mobility systems. Examining these trajectories offers valuable insights into how women are seen and how they are considered within urban spaces.

The central research question guiding this study is: How can urban mobility be reimagined through ecofeminism and solar punk?

After introducing Ecofeminism and Solarpunk urban futures, this paper proceeds to explain the methodology and the data collected for this project. Subsequently, the case studies of LA and London are presented before concluding with recommendations and a discussion on how ecofeminism and solarpunk imaginaries can foster more inclusive and resilient cities in the future.

1.1. Ecofeminism and Solarpunk futures

Ecofeminism, similar to the waves of feminism, has changed through time, and can be defined as a philosophical, political and social movement which combats the male-dominant system in which women and nature are exploited by [4]. An ecofeminist approach provides a critical lens for understanding the intersection of gender, mobility, and sustainability. It highlights how society, and furthermore the city, mirrors patriarchal exclusions [5]. The marginalising of women's roles reinforces infrastructures of carbon dependency, as findings show that female political representation in national parliaments can drastically promote lower carbon dioxide emissions [6]. To build, ecofeminist perspectives can and do foreground care, interdependence, and inclusivity, offering a normative framework for mobility systems that centres justice as much as efficiency [7].

Urban mobility can be viewed through many different lenses, but there is a focus here on what it means to move around a city. Solarpunk imaginaries extend the vision of sustainability by offering speculative yet grounded reimagining of urban futures to challenge ego-centric narratives with more sustainable paths for eco-centric possibilities [8]. Cities where green infrastructure, renewable energy systems, and community-centred design are not just technical add-ons but cultural shifts. A real-life example of solarpunk imagination can be seen in the Netherlands, whereby the “SolaRoad” demonstrated how cycle lanes can be successfully integrated with solar panels, promoting community, active mobility, and sustainability [9]. In mobility terms, solarpunk would encourage us to view Cities not only as places of movement but as part of a living ecosystem where safety, accessibility, and resilience are shared priorities [8].

This theoretical framing allows for a forward-thinking approach to urban mobility. How can we move from carbon-heavy types of movement to solarpunk-inspired, ecofeminist cities of inclusivity?

2. Methodology

This analysis is based on a mixed and multiple methods approach:

- A systematic literature review of academic articles examining how women are represented and discussed in relation to urban space, with a focus on net zero and climate resilience.

- Policy document analysis of sustainability strategies from the 2012 London Games and (looking towards) the 2028 Los Angeles Games.

- Semi-structured interviews with community members and organisation representatives in London and LA, focusing on women’s perspectives on mobility, resilience, and legacy impacts.

3. Results

As an initial step, the existing supporting facilities were observed, including women-only carriages, hand straps, priority seats, lighting, air conditioning, and on-board security. While most facilities functioned properly, air conditioning performance varied across carriages, which could potentially affect passengers’ perception of comfort and safety. Priority seats were occasionally occupied by non-priority passengers. However, they promptly vacated their seats when priority passengers boarded, a process reinforced by security reminding users of proper seat usage.

In total, 87 respondents met the study criteria, and validity and reliability tests were conducted on an initial sample of 57 respondents, confirming the reliability of the data, as follows:

3. 1. Case Study 1: Los Angeles: “The Carbon City”

From findings carried out during fieldwork research in May 2025, LA exemplifies the challenges of transitioning to net zero in a car-dependent metropolis. Official planning for the 2028 Games highlights electrification of buses and investments in active travel [10]. Yet, the city’s sprawling geography and entrenched car culture poses structural barriers to reducing emissions. Alongside this, participants and the researcher noted a lack of infrastructure occurring around the sprawling city; with participants noting that LA had even removed a large part of their public transit system in the 20th century to accommodate for cars.

Participants interviewed in LA expressed scepticism about these ‘green’, net zero plans. Women noted that concerns surrounding public transport, solo movement around the city and inadequate late-night services made private cars feel indispensable. Furthermore, participants alluded to the idea of EV private cars at not being quite net zero due to the space they take up in the city.

In ecofeminist terms, LA remains a "carbon city" - one where fossil fuel mobility infrastructures dominate, and opportunities for feminist and solarpunk reimaginings are sidelined.

3. 2. Case Study 2: London: A Feminist City in Progress

London's 2012 Olympics positioned sustainability and legacy at the forefront of their motives, with investments in public transport, cycling infrastructure, and green regeneration projects sought to shift mobility away from private cars [11].

For many women in east London, the Olympic space brings tangible differences to that of LA: safer public spaces, better transport connections, and enhanced access to green infrastructure. These changes supported care-based mobilities, particularly among older women. However, benefits were uneven. Findings show that displacement, gentrification, and rising living costs undermined gains for women, revealing the contradictions of regeneration framed as inclusive but often driven by market logics such as for example, ULEZ initiatives.

While still falling short of a fully feminist city, London's trajectory hints at the possibility of aligning net zero transitions with ecofeminist principles of care and interdependence.

3. 3. Discussion

The comparative study highlights two key insights into the politics of movement:

1. Whilst both cities use net zero language, LA does so without incorporating gender justice, and its carbon goals remain disconnected from specific initiatives.

2. Ecofeminist and Solarpunk lenses can reframe mobility - by envisioning mobility systems as places of care, not just carbon reduction, these perspectives reveal pathways toward more inclusive, resilient, and imaginative futures.

4. Conclusion

Comparing London and LA demonstrates a unique lens through which to examine the politics of urban mobility. Both cities reveal findings that suggest that women's empowerment is essential for aligning net zero transitions with socially inclusive, resilient urban mobility systems.

This research affirms that the politics of movement must be understood not only in terms of emissions reduction but also in terms of who is empowered to move through the cities. Only by talking an ecofeminist approach with solarpunk imaginaries can we integrate gender justice into net zero strategies, to which then, urban mobility transitions will then meet the goals of climate resilience and social equity.

4. 1. Contribution and implications

This study demonstrates how interdisciplinary approaches are necessary to understand and shape urban mobility. It also highlights the value of knowledge transfer between theory (ecofeminism, solarpunk) and practice (Olympic case study planning) whilst addressing pressing urban challenges by foregrounding women's empowerment as a critical determinant of net zero strategies. Further research is needed into how women are placed within policy discussions and future recommendations are to incorporate ecofeminism and solarpunk ideas into policy.

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WOMEN AND PUBLIC TRANSPORT: THE ROLE OF SUPPORTING FACILITIES IN JAKARTA'S METROPOLITAN RAIL SYSTEM

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1. Introduction

Indonesia's Jabodetabek, a major metropolitan area that contains five cities (Jakarta, Bogor, Depok, Tangerang, and Bekasi), relies on a wide-reaching and heavily utilized rail-based public transport. The Commuter Line, commonly referred to as KRL (an acronym for "Kereta Rel Listrik", meaning electric train), connects at least five cities across three provinces on Java Island. The route from Bogor City to Jakarta City is particularly notable, with the highest daily users, reaching up to 546,420 users, which accounts for 69% of all Jabodetabek Commuter Line users [1]. This high ridership illustrates not only the importance of commuter rail in supporting daily mobility, but also the urgency of ensuring that the system is safe and comfortable, especially for women who form the majority of passengers.

The main objective of this study is to examine the extent to which supporting facilities influence women's perceptions of safety and comfort in public transportation. Unlike main facilities that are essential for operations, or complementary facilities that directly support system performance, supporting facilities are not mandatory for train operations but significantly shape the feeling of safety and comfort from the passenger. Nevertheless, they play a decisive role in shaping the overall user experience, particularly in terms of safety and comfort for passengers [2].

Research has long indicated that women are the predominant users of public transportation, primarily due to their more complex travel needs, such as traveling with children, the elderly, or during pregnancy [3, 4]. Yet, they still face the challenge of sexual harassment, leading them to feel unsafe and uncomfortable. In 2020, there were 14,719 cases of sexual harassment reported by Indonesian women, and 962 of them happened in public spaces [5]. A survey from Koalisi Ruang Publik Aman (Safe Public Spaces Coalition) reported that in 2022, 4 out of 5 women in Indonesia experienced sexual harassment in public spaces. Furthermore, 23% of these cases occurred in public transportation [6].

The provision of two women-only carriages on each train has been implemented since 2011 as an effort to reduce and prevent cases of sexual harassment on the KRL. However, field observations reveal that there are negative experiences associated with using these women-only carriages, leading many passengers to feel more comfortable in the general carriages [7]. These issues underline the need to re-examine how supporting facilities are designed and perceived, and why they matter for building a more inclusive and gender-mainstream public transportation.

2. Methodology

This study was conducted on the Jabodetabek Commuter Line, with a specific focus on the Bogor–Jakarta Kota corridor (and its reverse direction). Data were collected through a structured survey distributed to 87 female passengers aged 15–64 who had experience using both women-only and general carriages. These criteria are necessary to compare passengers' preferences between women-only and general carriage. Respondents were selected using purposive sampling to ensure representation of frequent users, and the survey was carried out during peak commuting hours (07:00–09:00 and 16:00–18:00) to capture conditions at the highest ridership levels.

The survey instrument was developed to capture perceptions of safety and comfort in relation to the performance of supporting facilities. Thirteen indicators were included and grouped into three main variables, as you can see in Table 1 below [8].

Variable	No.	Indicator
Y (Performance of Supporting Facilities)	1.	Women-only Carriage
	2.	Handrails
	3.	Priority Seating
	4.	Lighting
	5.	Air Conditioning (AC)
	6.	On-board Security
X1 (Safety)	7.	Feeling safe when using the women-only carriage
	8.	Feeling safe with the presence of security personnel
X2 (Comfort)	9.	Feeling comfortable when using the women-only carriage
	10.	Comfort when using handrails (while standing)
	11.	Priority seating used as intended
	12.	Comfort with the presence of lighting
	13.	Comfort with the presence of Air Conditioning (AC)

Table 1: Variables and Research Indicators

IThe analytical approach adopted for this research was a mixed-method approach, combining both quantitative (Spearman Rank Correlation) and qualitative (Descriptive Analysis). Descriptive Analysis was applied to outline respondent characteristics and general trends in facility usage. Spearman Rank Correlation was employed to measure the correlation strength, the direction of relationships between supporting facilities and the two dependent variables, and the significance of these relationships, using 0.05 as the significance level.

The interpretation of the Spearman rank correlation coefficient in this study follows the general classification [9, 10]:

0	= No correlation
>0.00–0.25	= Very weak correlation
>0.25–0.50	= Moderate correlation
>0.50–0.75	= Strong correlation
>0.75–0.99	= Very strong correlation
1	= Perfect correlation

The direction of the relationship is indicated by the sign of the coefficient. A positive (+) coefficient shows a unidirectional relationship, meaning that as the value of variable Y increases, variable X also increases. Conversely, a negative (–) coefficient indicates an inverse relationship, where an increase in variable Y corresponds to a decrease in variable X, and vice versa. The significance of the correlation is determined through the p-value (sig.). If the p-value is smaller than alpha (0.05), the variables are considered to have a statistically significant correlation; if the p-value is greater than 0.05, the correlation is not statistically significant. Prior to analysis, the questionnaire underwent validity and reliability testing to ensure internal consistency.

3. Results

As an initial step, the existing supporting facilities were observed, including women-only carriages, hand straps, priority seats, lighting, air conditioning, and on-board security. While most facilities functioned properly, air conditioning performance varied across carriages, which could potentially affect passengers' perception of comfort and safety. Priority seats were occasionally occupied by non-priority passengers. However, they promptly vacated their seats when priority passengers boarded, a process reinforced by security reminding users of proper seat usage.

In total, 87 respondents met the study criteria, and validity and reliability tests were conducted on an initial sample of 57 respondents, confirming the reliability of the data, as follows:

Variable	No.	Indicator	Calculated r Value	Critical r Value	Desc.
Y (Performance of Supporting Facilities)	1.	Women-only Carriage	0,530	0,2681	Valid
	2.	Handrails	0,602		Valid
	3.	Priority Seating	0,686		Valid
	4.	Lighting	0,704		Valid
	5.	Air Conditioning (AC)	0,686		Valid
	6.	On-board Security	0,696		Valid
X1 (Safety)	7.	Feeling safe when using the women-only carriage	0,851		Valid
X2 (Comfort)	8.	Feeling safe with the presence of security personnel	0,846		Valid
	9.	Feeling comfortable when using the women-only carriage	0,567 0,618		Valid
	10.	Comfort when using handrails (while standing)	0,602 0,688		Valid
	11.	Priority seating used as intended	0,783		Valid
	12.	Comfort with the presence of lighting			Valid
	13.	Comfort with the presence of Air Conditioning (AC)			Valid

Table 2: Validity Test Results

Variable	Cronbach's Alpha	Total Indicator (N)
Y (Performance of Supporting Facilities)	0,722	6
X1 (Safety)	0,611	2
X2 (Safety)	0,651	5

Table 3: Reliability Test Results

The validity and reliability tests indicated that all 57 samples were valid and reliable, allowing the analysis to proceed with Spearman's rank correlation. The following table presents the results of Spearman's rank correlation between passengers' perceptions of safety and comfort and the supporting facilities.

Variable	No.	Indicator	Sig.	Correlation Coefficient	Desc.
X1 (Safety)	1.	Feeling safe when using the women-only carriage	0,000	0,485	Moderate
	2.	Feeling safe with the presence of security personnel	0,000	0,551	Strong
X2 (Comfort)	3.	Feeling comfortable when using the women-only carriage	0,000	0,405	Moderate
	4.	Comfort when using handrails (while standing)	0,000	0,476	Moderate
	5.	Priority seating used as intended	0,036	0,226	Very Weak
	6.	Comfort with the presence of lighting	0,000	0,613	Strong
	7.	Comfort with the presence of Air Conditioning (AC)	0,000	0,548	Strong

Table 4: Spearman Rank Correlation Analysis Results

The analysis results indicate that all indicators across the variables showed positive (+) and significant relationships. Differences can be observed in the correlation coefficients. Spearman's rank correlation results revealed that some indicators had relatively low correlation levels. The use of women-only carriages showed only a moderate correlation with both perceived safety (0.485) and comfort (0.405), suggesting that their presence does not yet fully provide a positive experience for passengers, which is consistent with the previous studies.

A similar pattern was observed for the comfort of using hand straps while standing (0.476), which also falls into the moderate category. Meanwhile, the priority seat indicator had the lowest correlation value (0.226), indicating a very weak relationship with perceived comfort. These findings suggest that several of the provided facilities are not yet fully optimized to support women's comfort and safety. Although such facilities may appear less essential to some passengers, this study shows that features like hand straps significantly influence women's sense of safety and comfort. In addition, one respondent highlighted the limited provision of women-only carriages, noting that having only two carriages per train contradicts the reality that public transport users are predominantly women.

4. Conclusion

The findings of this study confirm that supporting facilities are not secondary but central to women's perceptions of safety and comfort in Jakarta's metropolitan commuter rail system. All examined indicators show positive and significant correlations, proving that facility performance directly influences passenger experience. Lighting emerged as the most decisive factor (r = 0.613, strong), reflecting its role in enhancing comfort and safety, while priority seating displayed the weakest effect (r = 0.226, very weak), indicating limited impact in its current design and use. Women-only carriages were also found to contribute to both safety and comfort; however, their correlation levels remain moderate, suggesting that the current arrangement is not yet sufficient to make passengers feel truly safe and comfortable. These results highlight a dual message: supporting facilities matter, but some require urgent improvement. Addressing weak-performing facilities, such as priority seating and women-only carriages, while sustaining the effectiveness of strong ones like lighting, is crucial to advancing a more inclusive and gender-sensitive public transport system.

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URBAN SQUARE ANALYSIS IN THE CONTEXT OF TRANSPORTATION-BASED SPATIAL ARRANGEMENTS: BEYAZIT AND EMINÖNÜ SQUARES

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1. Introduction

Urban squares are prominent multi-functional public spaces where residents and visitors gather, rest, and interact, historically serving social, civic, and leisure purposes [1]. However, increased vehicle use, urban densification, and technological advances have reduced the availability of well-defined public spaces, leading squares to lose some historical functions [2]. Architecturally, squares are open areas often surrounded by buildings and designed for public use [3]. Conceptually, they function as urban nodes, supporting social, psychological, and spatial interactions [4][5][6][7]. Spatially, squares can be classified by enclosure, geometry, and formal or informal characteristics, often reflecting nearby centers of power [8][9][10]. Today, many squares face transformation into vehicular intersections, altering their public and social roles [11].

The relationship between squares and transportation shapes their accessibility, functionality, and user experience. Key parameters include: (1) Location – centrality and ability to attract diverse users [12]; (2) Accessibility – pedestrian routes and public transport connectivity [13][14]; (3) Vehicular Traffic – intensity and organization affecting pedestrian comfort [15]; and (4) Pedestrian Environment – quality of paving, landscaping, safety, and social interaction opportunities [12][16]. Examining squares through these parameters provides insight into how historical and contemporary urban processes influence their function and public use.

2. Methodology

This study investigates Eminönü and Beyazıt Squares in the Historical Peninsula of Istanbul through the lens of transportation-oriented spatial transformations. The analysis was carried out using parameters defined in the literature: location within the urban fabric, accessibility, vehicular traffic, and pedestrian environment. The methodology combined archival research, historical documentation, and spatial observation with visual analysis of current conditions. Historical layers of transformation were evaluated by reviewing secondary sources and planning documents, while field observations focused on pedestrian–vehicle interactions, circulation patterns, and the spatial organization of the squares. Traffic density and pedestrian movement were examined at peak hours (08:00–09:00 and 17:00–18:00) to understand the temporal variations in accessibility and usability

3. Results

The findings reveal that both Eminönü and Beyazıt Squares have undergone significant changes due to transportation-oriented decisions, leading to spatial fragmentation and loss of traditional square characteristics.

Eminönü functions as one of Istanbul's major transportation hubs, integrating maritime, road, and rail systems. Its proximity to commercial and touristic centers enhances its metropolitan significance. However, vehicle and tramway lines have limited direct pedestrian access between the square and the waterfront, restricting continuity. Although the square remains pedestrian-oriented around Yeni Camii and the Spice Bazaar, pedestrian–vehicle segregation relies heavily on physical barriers such as bollards and railings. Field observations show that morning traffic density is low to medium, while evening density increases significantly, particularly on the adjacent main arterial roads. Pedestrian underpasses and overpasses provide connections but often create negative sensory experiences due to poor physical conditions.

Historically a central forum and later an Ottoman palace square, Beyazıt has been reshaped through multiple planning interventions. The most significant changes occurred in the 1950s, when road-widening and vehicular prioritization fragmented the square. Although later pedestrianization efforts partially improved accessibility, spatial identity remained weak. Current observations indicate that the square primarily functions as a transitional space rather than a social gathering place. Despite its central location and accessibility via multiple public transportation options, vehicular interventions around Ordu Street and Vezneciler weakened the integration between the square and its surroundings. The pedestrian experience is characterized by undefined circulation paths, lack of guiding elements, and a homogenous paving material that amplifies the sense of scale but reduces legibility. Traffic density analysis shows medium to high levels in the morning and shifting patterns in the evening, with surrounding roads consistently affecting pedestrian comfort.

4. Conclusions

The analysis of Eminönü and Beyazıt Squares demonstrates that transportation-oriented planning has played a decisive role in shaping their spatial configurations and functions. Both squares, once vibrant public realms, have increasingly assumed the character of transportation nodes, where vehicular circulation dominates over pedestrian comfort and social interaction. Eminönü exemplifies a highly accessible but fragmented hub, where physical barriers compromise the continuity between waterfront and inner-city spaces. Beyazıt, on the other hand, has been subject to successive redesigns that prioritized vehicular traffic, resulting in a weakened spatial identity and a square that functions more as a passage than a gathering place.

The results highlight the necessity of rebalancing transportation and public space priorities. Future interventions should emphasize pedestrian-centered design, spatial continuity, and the integration of historical and cultural identity with contemporary urban mobility needs. Strengthening the livability and legibility of these squares requires reducing vehicular dominance and enhancing the quality of pedestrian environments, ensuring that these historically significant spaces reclaim their role as inclusive and dynamic public realms.

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RESIDENT STRATEGIES IN RESPONSE TO LOW PARKING AVAILABILITY IN PRAGUE: A QUALITATIVE EXPLORATION

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1. Introduction

Parking availability is a critical yet often overlooked component of urban design, significantly influencing not only the built environment but also residents' everyday mobility choices and broader urban sustainability goals. In Prague, as in many other cities, the regulation and provision of parking spaces have undergone substantial changes, with recent legislative shifts aiming to reduce minimum parking requirements in new developments [1,2]. These changes reflect a broader international trend toward more sustainable urban mobility, yet they also raise questions about how residents adapt to environments with limited parking availability.

This study investigates the strategies, behaviors, and perceptions of residents living in areas of Prague characterized by low availability of public parking. It aims to fill a gap in the research landscape, where little is known about how individuals navigate and respond to parking scarcity in their daily lives. The research adopts a qualitative, exploratory approach, grounded in the principles of grounded theory, to uncover the nuanced and context-specific strategies employed by residents.

2. Background and State of the Art

Parking infrastructure constitutes a significant portion of construction costs [3], and its spatial requirements influence urban form, land use, and the quality of public spaces [4]. The traditional reliance on parking minimums – regulations mandating a fixed number of parking spaces per unit of development – has been increasingly criticized for promoting car dependency and inflating housing costs [5,6].

Internationally, cities such as Berlin and London have abolished or significantly reduced parking minimums [7,8], while others like Copenhagen have adjusted their standards in response to changing mobility patterns [9]. In Prague, the 2016 revision of the Prague Building Regulations and the 2024 amendment to Decree No. 146/2024 Sb. reflect a similar shift toward more flexible parking policies [2].

Research has shown that the availability of residential parking directly affects car ownership and usage [10,11]. Households with access to off-street parking are more likely to own and use cars regularly [12]. Conversely, limited parking availability can encourage alternative mobility strategies, including public transport use, car-sharing, and active travel [13,14].

However, much of the existing literature is based on quantitative analyses, often relying on large-scale datasets such as census data or mobile phone tracking [15,16]. While these studies provide valuable insights into aggregate patterns, they often fail to capture the lived experiences and subjective strategies of individuals navigating parking scarcity. Moreover, the phenomenon of residential self-selection – where individuals choose their place of residence based on mobility preferences – complicates causal interpretations of observed behaviors [17,18].

Qualitative research offers a means to address these limitations by exploring the motivations, constraints, and adaptive strategies of individuals in depth. Previous studies have employed interviews and ethnographic methods to examine mobility behaviors, but few have focused specifically on parking-related strategies, particularly in the Czech context [19,20].

3. Methodology

This study employs a qualitative research design grounded in the principles of grounded theory methodology (GTM), as outlined by Urquhart [21]. GTM is particularly suited to exploratory research where existing theories are insufficient or underdeveloped. It allows for the inductive development of theory based on empirical data, emphasizing iterative data collection and analysis.

3.1 Sampling and Recruitment

Participants will be recruited through a mail-based outreach campaign targeting residents of Prague living in areas with demonstrably low availability of public parking. The sampling frame will be constructed through a multi-step spatial analysis process:

1. Classification of Urban Areas: Using a GIS-adapted dataset developed by Bednár [22] and refined by the Prague Institute of Planning and Development (IPR), residential areas will be classified based on the availability of public parking spaces. This will be supplemented by data from the Technical Administration of Roads (TSK) on paid parking zones, address point data from IPR, building use data, and population data from the 2021 Czech Census.

2. Calculation of Parking-to-Population Ratios: By linking disaggregated address-level population data with public parking availability, a fine-grained map of parking scarcity will be developed. Areas with the lowest ratios of public parking spaces per capita will be identified as target zones.

3. Filtering for Private Parking: A combination of field surveys, analysis of Mapy.cz's Panorama tool, and existing datasets will be used to exclude buildings with private parking facilities or access to public garages. This ensures that the sample focuses on residents who rely primarily on public street parking in areas with very low parking supply.

4. Mail-Based Recruitment: Several thousand households in the individual selected buildings will be contacted via postal mail in one to three waves. Based on prior research, response rates for mail-based qualitative interviews are expected to be in the low single digits [23,24]. This approach is anticipated to yield several dozen interviews, sufficient for grounded theory analysis.

3.2 Data Collection and Analysis
Semi-structured interviews will be conducted with respondents who agree to participate. Interviews will explore topics such as:
- Daily parking routines and challenges
- Strategies for securing parking
- Impacts on mobility choices and household planning
- Perceptions of fairness, accessibility, and urban policy

Data will be analyzed using the constant comparative method, with open, axial, and selective coding phases. Theoretical sampling will guide the iterative refinement of interview questions and participant selection. The goal is to develop a grounded theory that explains how residents adapt to and navigate environments with limited parking availability.

4. Expected Contributions

This study contributes to the growing body of research on urban mobility and parking by:
- Providing empirical insights into the lived experiences of residents in parking-scarce environments.
- Developing a grounded theory of resident strategies in response to parking scarcity.
- Informing urban planning and policy in Prague and similar contexts, particularly regarding the design of parking regulations and mobility infrastructure.

The findings will also serve as a foundation for future quantitative studies and policy evaluations, offering a nuanced understanding of behavioral responses to urban form and regulation.

5. Conclusion

As cities grapple with the challenges of sustainable mobility and urban densification, understanding how residents adapt to changing parking conditions becomes increasingly important. This study addresses a critical gap in the literature by exploring the strategies employed by residents in Prague's most parking-constrained neighborhoods. Through a grounded theory approach, it seeks to illuminate the complex interplay between urban form, regulation, everyday mobility practices ang long-term life strategies.

6. Use of AI in the Preparation of This Text

The preparation of this text involved the use of artificial intelligence in accordance with the Framework Rules for the Use of Artificial Intelligence at CTU for educational and academic purposes in Bachelor's and Master's studies. The tools used included M365 Copilot, Perplexity, and SCISPACE. M365 Copilot was employed for retrieving additional sources, summarizing topics from individual articles, explaining certain concepts, and formulating parts of the text. Perplexity was used for so-called deep research—comprehensive foundational literature reviews on the given topic. SCISPACE was used for source retrieval and subsequently for identifying and summarizing individual topics covered in the texts.

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FROM INDUSTRIAL CORRIDOR TO SERVICE AND LOGISTICS CLUSTER: TEB1 AS CATALYST OF TERRITORIAL TRANSFORMATION IN THE LOWER SERIANA VALLEY, BERGAMO

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1. Introduction

Mobility infrastructures today are increasingly called upon to provide flexible and adaptive responses to new social rhythms, technological transitions, and changing work practices [1]. Far from being neutral devices, they reorganize economies, landscapes, and opportunities, acting as structural agents of territorialization [2][3]. Tramways illustrate how transport systems can become socio-technical projects that foster proximity and cohesion when embedded in inclusive governance arrangements.

A decisive issue is that of urban vulnerability: in fragile territories, functional fragmentation undermines social cohesion, weakens belonging, and erodes everyday urbanity [4]. This condition is closely linked to what scholars have framed as a new urban question, one that extends beyond the traditional challenge of linking centers and peripheries to include the equitable distribution of welfare and access to high-quality public spaces [5].

The pandemic has accelerated this awareness by reintroducing proximity as a central theme of planning. The 15-minute city has become a powerful metaphor for cities where services, welfare assets, and public amenities are accessible within a short radius [6]. Yet proximity should not be reduced to a mere planning slogan: it is the result of negotiations, practices, and situated decisions that must be supported by infrastructures able to sustain everyday life [7].

This resonates with the recognition that travel remains, above all, a corporeal practice: journeys involve embodied movements and face-to-face interactions that digital surrogates cannot fully replace [8]. In an era shaped by polycrises, economic turbulence, and the redefinition of globalization [9], this corporeal dimension highlights the continued centrality of physical mobility.

Meanwhile, cities—large and medium alike—are experiencing contradictory trajectories: densification versus desertification, centrifugal versus centripetal flows, regeneration versus decline. Governing these processes requires the ability to mediate between global flows and local networks, digital infrastructures and physical connections [10]. Urban agendas are thus moving beyond the rigid center–periphery paradigm, evolving into post-metropolitan conditions characterized by polycentric arrangements, fluid hierarchies, and hybrid proximities [11][12].

It is in this complex scenario that the TEB1 Bergamo–Albino (2009) emerges as a paradigmatic case of infrastructural reuse. By recovering a historic railway alignment, the line now crosses an ex-industrial corridor reconfigured by commerce, services, light logistics, and hospitality. In doing so, it functions as a lever for redistributing opportunities and shortening distances within a densely inhabited linear valley

.

1.1 Body

Recent policies oriented towards proximity have reopened the debate on daily mobility, accessibility to services, and the overall quality of urban living. Yet proximity is not an abstract condition, but rather a situated process, the outcome of local decisions and practices that must be supported by integrated governance and planning tools capable of reducing barriers to essential services. Without such support, infrastructures risk "failing the short play" in terms of their local impacts [13]. Public transport systems such as tramways can therefore be understood as genuine transition experiments, which – if accompanied by inclusive and multi-level governance structures – foster social cohesion and urban regeneration [14][15].

In the case of the lower Seriana Valley, this framework intersects with a territorial context deeply shaped by industrial history and by a dense, linear settlement pattern. The DUSAF 7.0 (2021) land-use map (figure 1) shows a valley floor almost entirely urbanized, with compact residential areas (in pink) interspersed with industrial and logistics facilities (in grey). Agricultural land (light orange) persists mainly at the edges, while forested slopes (dark grey) dominate the valley sides. Along the TEB1 alignment, clusters of services & facilities (in purple) indicate the ongoing reconfiguration of the corridor: from an ex-industrial backbone to a corridor of logistics and services. The valley's morphology — long and narrow — forces settlements to develop sequentially, reinforcing the centrality of the infrastructure as a territorial spine and allowing the valley to be interpreted as a form of "linear city".

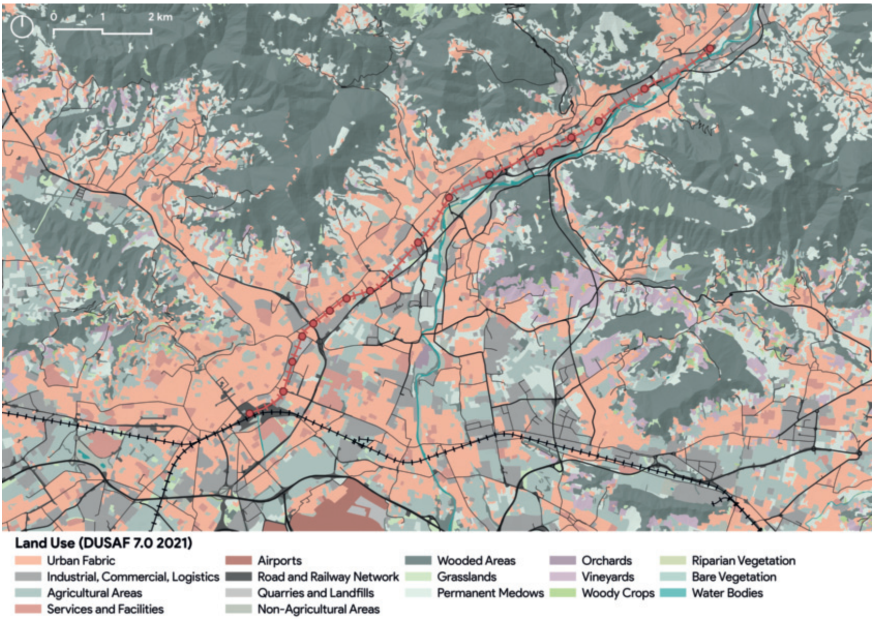

Figure 1: Land use in the area of Bergamo and lower Seriana Valley

This spatial organization is rooted in a process of early industrialization. Thanks to the accessibility of the valley floor and its connection to the Bergamo plain, a robust manufacturing fabric emerged between the nineteenth and twentieth centuries, particularly in the textile sector, which became a cornerstone of the local economy [16]. Alongside textile production, paper and mechanical industries developed, generating a landscape of factories, workers' villages, and industrial districts [17]. The subsequent deindustrialization left behind disused plants and underutilized areas, today partly absorbed by new service functions and light logistics.

This history intersects with the infrastructural trajectory of the Val Seriana railway, inaugurated in 1884 to connect Bergamo to Albino and for decades a backbone for the transport of goods and labor [18]. With the rise of road transport [19], the line was closed in 1967 [20]; its alignment remained inactive until the launch of the TEB project, which in 2009 reopened the corridor as a modern tramway, realigning it with the demands of daily mobility and strategies of regeneration [21]. In this sense, the TEB1 is not merely a Bergamo-Albino route, but a proximity device that shortens distances along the valley's "linear city" and enables the redistribution of services according to compact and accessible city principles, thus supporting the transition of the corridor from industrial backbone to civic corridor of services.

2. Materials and methods

The study adopts a qualitative-integrated approach. The territorial framework was first reconstructed through a land-use map (DUSAF 7.0, 2021), including the TEB1 alignment and stops, in order to highlight the valley's compressed linear morphology and the distribution of services and logistics hubs.

The core analysis employed GIS-based accessibility measures. Isochrones of 5-, 10-, and 15-minutes walking and 5- and 10-minutes cycling from each tram stop were generated and intersected with the built-up area, service facilities (figure 2), and logistics (figure 3). This enabled the estimation of the residential share covered, the number of reachable facilities, and the potential population served.

Two additional indicators were considered: demographic trends (2006–2024) for all municipalities along the line; and residential property values for Alzano Lombardo, Nembro, and Albino, chosen as illustrative cases since they are the most populous centers of the lower valley after Bergamo. These data were used to explore whether the activation of the tram corresponded to

Interpretation drew on the notion that tramway infrastructures may reactivate peripheral territories, recalibrate welfare and service distribution, and act as catalysts of proximity when supported by governance strategies to mitigate socio-spatial inequalities [22][23].

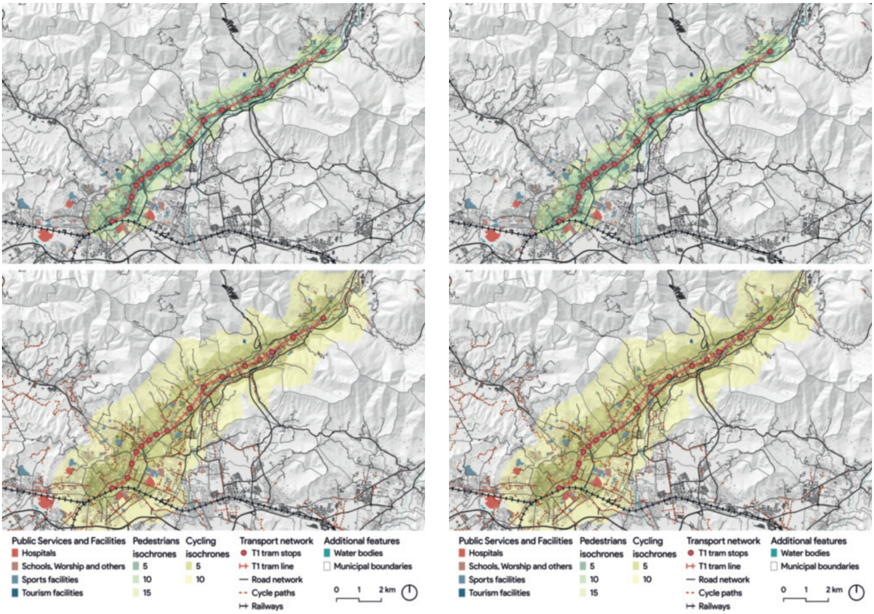

Figure 2: and Figure 3: Pedestrians and cycling isochrones intersected with services and logistics

3. Results

3.1 Proximity accessibility

Cartographic analyses demonstrate that in a narrow valley, characterized by elongated yet compact settlements, isochrones of 5, 10, and 15 minutes on foot and 5 and 10 minutes by bicycle encompass a large share of the built-up fabric. The overlap with public and collective services (hospitals, schools, sports facilities, tourism facilities) as well as logistics functions (distribution centers, 3PL operators, couriers, forwarders and hauliers) highlights a wide coverage. This suggests a tangible modal potential in which the tram acts as the main access backbone, while the active last mile – walking or cycling – secures daily connections between housing, workplaces, and services.

3.2 Extended catchment areas and local intermodality

The system's effectiveness is not limited to the municipalities directly traversed by the line: hillside and slope settlements can reach the valley floor by car or bicycle, park near tram stops, and continue towards Bergamo or other valley centers by tram. This form of spontaneous "park and ride" expands the effective catchment area of TEB1 and reinforces the possibility of reducing private car use for systematic commuting.

3.3 Bergamo node and airport access

In the Bergamo node (figure 4), the TEB1 terminus – co-located with the city's Central railway station – places most of the inner city within a 5-10-minute cycling isochrone; at the same time, it functions as a high-capacity interchange for regional and national rail. Moreover, the rail link currently under construction, which will connect the Central station with the international airport of Orio al Serio, will considerably improve airport accessibility for valley residents, enabling intermodal travel chains without recourse to private cars. The integration of the urban cycling network, the TEB1 tramway, and the forthcoming rail link to the airport thus consolidates a system of extended proximity at the metropolitan scale.

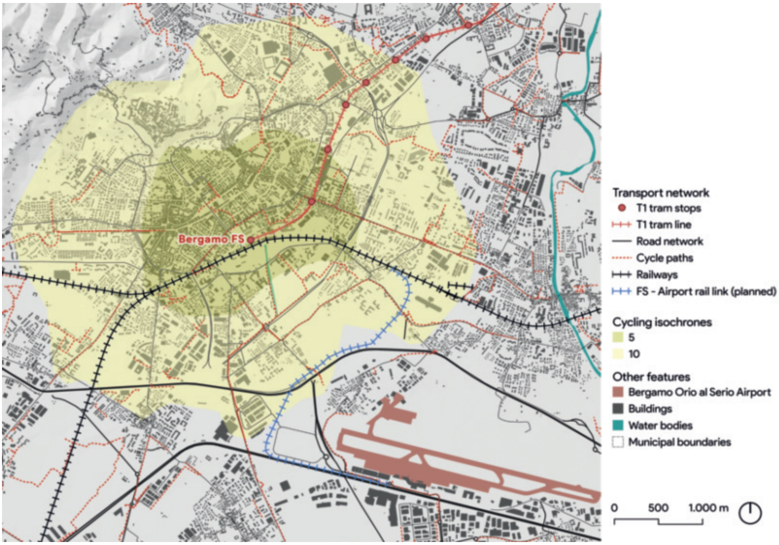

Figure 4: Bergamo Central Station as a node of modal shift

3.4 Demography and real estate values

Analyses do not reveal significant demographic growth after the activation of the line; likewise, residential property values in the main centers (Alzano, Nembro, Albino) do not show positive variations directly attributable to the tramway, being instead influenced by broader economic cycles (2008 and 2020). The most tangible impact of TEB1 therefore lies in its ability to enable proximity and to promote a new distribution of services in relation to the tram stops.

3.5 Targeted regeneration

The combined reading of the maps suggests that disused areas near tram stops represent opportunities for public spaces, social housing, and cultural functions, fostering civic centralities within the framework of a “linear city.” The concentration of services and the active accessibility within 5–15 minutes support targeted projects of reconnection and functional redistribution, in line with international evidence on the enabling role of tram networks in urban reactivation and landscape revitalization [24]

4. Conclusions

The TEB1 tram demonstrates how a local public transport project can shape territorial transitions. Despite limited demographic or real estate impacts, the line has enabled a reconfiguration of accessibility: within 5-15 minutes, most of the built-up area, services, and logistics facilities become reachable through active modes linked to the tram. This potential supports a modal shift away from private cars and fosters conditions for targeted regeneration of disused areas near stops. More broadly, the case illustrates how tram networks can function as civic corridors, redistributing opportunities and reinforcing the fabric of a linear and densely inhabited valley. This also points to the need for a polycentric redistribution of services across municipalities, enabled by TEB1 as the backbone of accessibility.

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SEAMLESS AIRPORT ACCESS WITH MICRO-HUBS FOR ALL AGES

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1. Introduction: Ageing, Families, and the Airport Journey

1.1 Global Demographic Shifts
By 2030, the number of people aged 60 years and above will exceed 1.4 billion—representing nearly one-sixth of the global population [3]. Families with young children also remain consistent travelers in both domestic and international aviation. Together, these groups are high-frequency yet vulnerable users of multimodal airport trips.

1.2 Stress Points in Journeys
Multimodal airport access often involves multiple transfers (bus, metro, commuter rail, airport people movers). Small discontinuities—such as a missing bench, confusing signage, or lack of storage—become disproportionately challenging. Older adults may experience fatigue or fall risks, while caregivers juggle strollers, luggage, and children simultaneously [4].

1.3 Sustainability and Equity Implications
When public transport is stressful, families and seniors often default to ride-hailing or private cars, which are more expensive and carbon-intensive [5]. Redesigning transfer environments to reduce stress and increase dignity is, therefore a climate and social equity priority.

2. Problem Context and Literature Review

2.1 Airport Accessibility Gaps
Research has heavily emphasized terminal services—wheelchairs, elevators, assistance desks [6]. By contrast, the door-to-terminal journey remains under-researched [7].

2.2 Mobility and Ageing
Older adults prioritize continuity, rest, safety, and cognitive clarity [8]. In London, TfL's Step-Free Tube Map shows the growing recognition of accessibility, but continuity still breaks at interchange nodes [9].

2.3 Family Travel Challenges
Research on family mobility highlights burden layering: luggage, children, and time sensitivity compound stress at transfers [10]. Changi Airport in Singapore piloted "family pods" at terminals, but pre-terminal journeys remain largely unsupported [11].

2.4 Multimodal Integration and Inclusion
Multimodal systems often focus on efficiency rather than equity. Tokyo's integrated rail–bus networks illustrate how clear wayfinding and staff assistance improve dignity for seniors [12]. Yet such examples are rarely scaled beyond isolated cities.

3. Research Questions and Objectives

3.1 Research Questions
- Which spatial and service features at transit–airport interfaces most effectively reduce stress for older adults and caregivers?
- How can replicable micro-hub models—combining physical design, services, and wayfinding—be developed, sited, and evaluated?

3.2 Objectives
- Develop a siting algorithm using accessibility-weighted GIS analysis.
- Prototype two scalable typologies.
- Establish evaluation protocols combining behavioral, stress, and dignity indicators.
- Produce a policy playbook for replication.

4. Conceptual Framework

4.1 Capability Approach
Sen's capability approach frames mobility as more than movement—it is about enabling people to participate fully in society. Lack of accessible journeys limits "functionings" and denies dignity [1].

4.2 Dignity-Centered Mobility
Sheller emphasizes that mobility systems embed power and exclusion. A dignity lens requires interventions that restore autonomy, comfort, and respect [2].

4.3 Micro-Hub Principles
From literature and practice [8–12], micro-hubs should provide:
- Step-free continuity.
- Comfortable seating (sheltered, with armrests).
- Quiet/nursing pods.
- Secure lockers.
- Pictographic, multilingual wayfinding.
- Staffed, respectful assistance.

5. Methods and Research Design

5.1 Participatory Engagement
- Workshops with older adults and caregivers to identify barriers.
- Journey-mapping to highlight pain points.
- Low-fidelity prototypes tested in situ (e.g., temporary seating, signage trials).

Case example: In Toronto, participatory workshops with seniors shaped the city's Age-Friendly Action Plan, demonstrating how co-design reveals subtle stress points [13].

5.2 GIS-Based Spatial Siting
Candidate sites will be ranked using:
- Transit frequency and multimodal connectivity.
- Proximity to demographic clusters of seniors and families.
- Barriers such as stairs or long unbroken corridors.

Case example: Munich Airport's S-Bahn connector highlights how interchange nodes determine confidence in transit-based access [14].

5.3 Prototype Development
Two typologies are envisioned in Table 1:

Hub Type	Key Features	Services	Target Users	Evaluation Metrics
Transit-Edge Pocket Hub	Modular benches, locker, small pod	Limited staffed assistance	Seniors & caregivers at small nodes	Stress scale, travel diaries
Interchange Node Hub	Larger units, storage banks, quiet pods, staffed desk	Full-service assistance	Seniors & families at major interchanges	Stress scale, confidence survey, missed transfer counts

Table 1: Table showing hub type and user evaluation distribution

5.4 Pilot Testing and Evaluation
Evaluation includes:
- Quantitative: Perceived Stress Scale [15], travel diaries, missed transfer counts.
- Qualitative: interviews on dignity, confidence.
- Cost-effectiveness: cost per reduced stress unit, cost per additional successful assisted trip.

Case example: Hong Kong MTR's Elderly Friendly Stations initiative demonstrated reduced falls and improved satisfaction after installing benches and tactile wayfinding [16].

5.5 Ethics
- Inclusive recruitment through community organizations.
- Informed consent and anonymization.
- Safeguarding training for staff assisting children and seniors

6. Anticipated Results and Contributions

6.1 Expected Impacts
- Reduced stress and fatigue for seniors and families.
- Increased willingness to use transit for airport trips.
- Lower reliance on private cars.

6.2 Deliverables
- GIS siting algorithm for hub placement.
- Design prototypes with cost and maintenance specifications.
- Evaluation toolkit integrating behavioral, stress, and dignity metrics.
- Policy playbook for airports and municipalities.

7. Policy, Governance, and Operational Implications

7.1 Funding Models & Implementation
Some funding models are shown in Table 2:

Funding Source	**Potential Contribution**	**Governance / Oversight**	**Implementation Notes**
Airport Community Benefit Fund	Construction & installation	Airport authority	Must align with community goals
Municipal Accessibility Budget	Maintenance & staffing	City transport dept	Can be integrated with transit plans
Public-Private Partnerships	Staff training, signage, pods	Private mobility operators	Requires MOUs and KPI tracking

Table 2: The table shows a variety of funding sources as potential options

8. Limitations and Ethical Considerations

The study may face recruitment bias, regulatory differences, and unclear maintenance responsibilities, which can be mitigated through diverse community recruitment, modular adaptable designs, and shared governance agreements.

9. Conclusions and Next Steps

9.1 Conclusions
Child- and senior-centered micro-hubs are a pragmatic, scalable strategy to restore dignity in multimodal airport journeys. They align with UN Age-Friendly Cities frameworks and Sustainable Development Goal 11 on inclusive transport.
9.2 Next Steps
Next steps include forming partnerships with transit authorities and airports, finalizing micro-hub designs, monitoring impacts over 6–12 months, and disseminating results through an open-source playbook, training toolkit, and policy recommendations.

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SIMULATION AND DESIGN ASSESSMENT OF AUTONOMOUS VEHICLE EFFECTS ON PEDESTRIAN CROSSINGS: DELAY, ENERGY, AND VISIBILITY PERSPECTIVES

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1. Introduction

Pedestrian mobility is a vital component of sustainable urban transport, yet pedestrians remain among the most vulnerable road users. A considerable share of urban collisions occurs at unsignalised pedestrian crossings, where pedestrians legally have priority but rely heavily on driver compliance and visibility to judge safe gaps [1, 2]. The emergence of autonomous vehicles (AVs) promises to reshape these interactions through more predictable yielding behaviour and smoother speed control [3]. However, as human-driven vehicles (HDVs) and AVs will coexist for decades, understanding their combined influence on safety, traffic performance, and infrastructure design has become a critical research challenge [4].

Previous studies have explored individual aspects of this problem. Microsimulation research has demonstrated that the introduction of AVs alters pedestrian gap acceptance and delay patterns at unsignalized crossings [5], producing smoother traffic flow and reduced stop frequency [6]. Meanwhile, eco-driving studies indicate that anticipatory control can lower fuel consumption by up to 20% [7], while automation research shows that stable headways and optimized trajectories reduce emissions independent of powertrain type [8, 9]. At the same time, road-design literature highlights that visibility-related geometric parameters—particularly stopping sight distance (SSD) and lateral clearance—are expected to change substantially as reaction times shorten from ~2.0 s to ~0.5 s [10, 11] and deceleration capabilities evolve under automated operation [12]. Collectively, these works demonstrate that AV penetration will not only transform operational-level behaviour but also necessitate revisions to the assumptions underlying traditional design manuals such as AASHTO (2018) [13] and FGSV (2012) [14].

Despite these advances, existing research has typically addressed traffic performance, fuel consumption, and geometric visibility as separate problems. Our research programme bridges these dimensions by integrating three complementary perspectives: simulation-based delay analysis [5], fuel-consumption modelling [15], and a visibility-zone design framework. Together, these studies provide a systematic assessment of how automation affects pedestrian priority, energy efficiency, and infrastructure requirements at urban crossings. This extended abstract synthesizes the key findings from these three investigations, demonstrating how delay patterns, environmental impacts, and geometric design criteria interact to shape the overall safety and efficiency of pedestrian crossings in mixed AV–HDV environments.

2. Methodology

2.1 Traffic and behavioural simulation

Pedestrian–vehicle interactions were simulated in PTV Vissim based on video-recorded field data from an unsignalised pedestrian crossing in Budapest. The dataset included pedestrian arrival times, gap-acceptance patterns, and driver yielding rates. Sixty pedestrian classes were defined based on gender, age group, crossing decision (cross or stop), and accepted vehicle distance category. Vehicles were represented as three driver types: yielding HDVs, non-yielding HDVs, and AVs operating under rule-based yielding.

Simulation scenarios covered AV penetration from 0% to 100% in 25% increments, with AVs maintaining fixed headways of 50, 60, or 70 m. The VisVAP module was used to implement distance-based pedestrian decision logic, overcoming limitations in Vissim's default priority rules. Pedestrians were modeled to cross when the approaching vehicle distance exceeded predefined thresholds derived from field observations (ranging from 20-30 m to 60-70 m, depending on pedestrian characteristics). As AVs maintained consistent spacing, pedestrians experienced more predictable gaps, resulting in fewer stops and reduced waiting times.

Performance indicators included average stop time, number of stops, and average travel time for both pedestrians and vehicles. The modelling approach combines field observation with microscopic traffic simulation, reflecting methodologies that integrate behavioral calibration to capture AV–pedestrian dynamics [16].

2.2 Fuel consumption modelling

To evaluate environmental effects, a Python-based external control algorithm was linked to Vissim through the COM interface. The algorithm monitored each pedestrian's position and speed in real time and dynamically adjusted the longitudinal motion of AVs. When a pedestrian entered the detection range (10 m in front of the crossing), the algorithm predicted whether a yield would be required and computed a smooth deceleration profile. This control loop produced realistic acceleration and braking curves reflecting anticipatory AV behaviour.

At each simulation time step, the instantaneous total resistance force was calculated as the sum of inertial, rolling, and aerodynamical forces:

$$F_{tot}(t) = F_{inertial}(t) + F_{rolling}(t) + F_{aero}(t) \tag{1}$$

The inertial force depends on vehicle mass and acceleration, the rolling resistance on tire friction, and the aerodynamic force on air density, drag coefficient, and the square of the vehicle's speed. The instantaneous power P(t) demand was then converted into fuel consumption using engine efficiency and fuel heating value data.

Nineteen scenarios were simulated, combining AV traffic shares (0–100 %), three human driver styles (cautious, normal, aggressive), and three AV headway settings. This method builds on and extends our previous eco-driving simulation study [15].

2.3 Visiblitiy-zone framework

The third component addressed infrastructure design, quantifying how automation alters required sight distances and kerbside clearance. The model compared HDV and AV visibility zones using consistent assumptions for pedestrian walking speed and deceleration capability, following international guidelines.

Stopping sight distance (SSD) was expressed as:

(2) $$SSD = 0.278 * v_0 * T_r + 0.039 * \frac{V^2}{a}$$

where v_0 is initial speed (km/h), T_r is perception–reaction time (s), and a is deceleration (m/s²). Reaction time was set to 2.0 s for HDVs and 0.5 s for AVs, while a=4.0 m/s².

The minimum lateral sight distance ensuring a pedestrian is detected in time to yield was defined as:

(3) $$D_{crit} = t_{stop} * v_{ped}$$

with v_{ped} = 1.5 m/s.

The kerb-side clearance length — the zone that must remain free from parked vehicles—was determined as:

(4) $$L_{clesr} = SSD * \frac{D_{crit} + w_{park}}{D_{crit} + w_{park} + w_{lane}/2}$$

Figure 1 illustrates the geometry of SSD, D_{crit}, and L_{clear} at an unsignalized pedestrian crossing

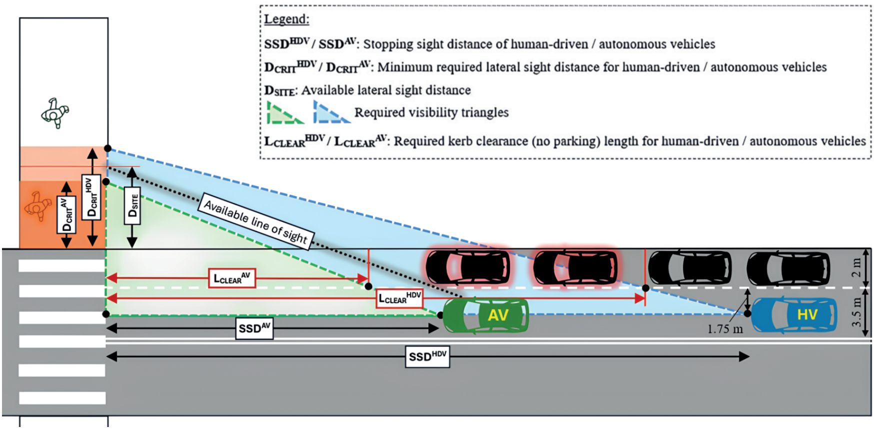

Figure 1 Stopping sight distance (SSD), required (D_{crit}) vs available (D_{site}) lateral site distance and requiredkerb-side clearance (L_{clear}) for human-driven and autonomous vehicles

3. Results and discussion

3.1. Pedestrian delay and traffic performance

AV penetration produced substantial improvements in pedestrian service levels. In the 100 % AV, 70 m headway scenario, average pedestrian stop time decreased by 43.7 %, and stops per crossing fell by 22 %. This effect arise mainly from pedestrians being able to cross within the stable headways between AVs, rather than from more frequent driver yielding. As a result, pedestrians faced fewer complete stops, and traffic flow became more continuous.

Vehicle travel times increased slightly (≈2–10 %) because AVs obeyed yielding rules more strictly, causing short interruptions in platoon flow. However, these minor delays were outweighed by the improvement in pedestrian safety and predictability. Scenarios with 50–75 % AV penetration achieved the most balanced outcomes, suggesting that moderate automation can already deliver visible benefits for urban crossings.

3.2. Fuel consumption effects

Fuel consumption declined systematically with rising AV penetration, showing 1.2–11.2 % savings compared with fully human-driven traffic. The mechanism is twofold: (i) The primary saving comes from avoiding complete stops at the pedestrian crossing through early and smooth deceleration. (ii) Additionally, this predictable behavior minimizes speed variations in the following traffic, leading to further efficiency gains.

At higher detection ranges and with adaptive braking, fuel savings exceeded 10 %, confirming that smoother trajectories yield both environmental and comfort benefits. Aggressive human drivers exhibited the highest consumption, while fully autonomous fleets achieved the lowest. These findings support prior results linking automation to reduced emission variability and improved eco-driving potential.

3.3. Visibility and design implications

Visibility modelling revealed that AVs' shorter perception–reaction times substantially reduce both longitudinal and lateral sight-distance requirements. At 50 km/h, the SSD for AVs was 31 m compared to 52 m for HDVs, representing a 20.8 m difference. Correspondingly, the minimum required lateral sight distance (Dcrit) also decreased by 2.3 m.

These reductions in sight distances translate directly into practical geometric design benefits. As summarised in Table 1, HDVs require approximately 44 m of kerb clearance (equivalent to ~9 parking spaces) to maintain adequate sight lines at 50 km/h, while AVs require only 25 m (~5 parking spaces). This represents a saving of 2–4 parking spaces across typical urban speed limits, offering urban planners valuable flexibility to retain on-street parking without compromising pedestrian safety.

Speed [km/h]	L_{clear}^{HDV} *[m]*	L_{clear}^{AV} *[m]*	ΔL_{clear} *[m]*	***Clear parking spots (HDV)***	***Clear parking spots (AV)***	***ΔParking spots***
30	20.86	9.9	10.96	4	2	2
40	31.62	16.75	14.87	6	3	3
50	44.3	25.46	18.84	9	5	4

Table 1 Required kerb-side clearance lengths and recommended number of clear parking spaces

Under severely constrained lateral visibility (D_{site}<3 m), HDVs vehicles cannot safely yield to a pedestrian walking at 1.5 m/s. AVs, however, can maintain an operational speed of approximately 20 km/h under the same conditions. This demonstrates the critical safety margin afforded by automated perception and underscores the need to integrate these parameters into future design standards.

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ANALYSIS AND OPTIMIZATION OF PUBLIC TRANSPORT SYSTEMS

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1. Introduction

Quality public transport system is an integral part of a society that aims to be sustainable. When well-designed, it plays a major role in people's mobility, lightens the environmental burden and increases the efficiency of land-use, which is especially important in densely populated cities and metropolitan areas that oftentimes suffer from traffic congestions. Proper management, improvement and extension of public transport services are complicated and expensive; a poorly calculated decision may turn out to be very costly and even detrimental to the users and operators of public transport networks. It is therefore in everyone's best interest to plan changes with caution, making use of data-driven approach that the modern time made widely available, which is why the author of this paper decided to develop a methodology to evaluate the current state of public transport systems, and to propose modifications based on the results of multi-agent mobility simulations. The

2. Project description

2.1. Openness

One of the main principles of this work is the usage of the open-source data and software, so that any interested party could apply the mentioned methodology to other locations, and potentially implement its conclusions. For the purposes of creating and testing the methodology the author has created a framework of programming tools that will also be made public under the open GPL license by the time of publishing of the dissertation that this paper refers to. The author has also used the following open source software (the list is not exhaustive):

- Ubuntu Linux operating system;
- Python programming language and interpreter, including several libraries from various authors for calculations and automation;
- QGIS for visualizing geospatial information;
- MATSim for agent-based microscopic simulations of mobility [1];
- OnlyOffice suite for creating the text files and presentations.

Among data sources that were used are:
- the 2021 Census of the Czech Republic [2];
- the *Czech Republic in Motion* survey of 2019 (periodic survey; new results are expected from the year of 2025) [3];
- the 2021 Survey of Mobility Behavior in the Brno Metropolitan Area [4];
- *OpenStreetMap* [5].

2.2. Methodology details

This methodology is not made from scratch, but is carefully compiled with the use of the existing state-of-the-art techniques from different parts of the world of how to analyze and engineer public transport networks. The methodology is tested on the Czech second largest city – Brno – and its metropolitan area; the city has a population of roughly 400 000, and the surrounding settlements have around 300 000 of people, many of whom are dependent on Brno's job opportunities or services. The region's inhabitants are not the only ones, who use its transport infrastructure – there are also tens of thousands of transiting individuals, which also need to be accounted for. It should be noted that according to the available data, some percent of people from different socioeconomic, which reduces the total number of active persons during the day.

2.2.1. Factor analysis

The idea of the methodology is to first examine the current state of a public transport network – how well it serves its inhabitants in different neighborhoods. A similar approach was used in the Canadian city of Edmonton to find disparities of transport supply and estimations of demand [6]; it served as prototype for this analysis. Some procedures and values were corrected according to local conditions. There are five criteria that are determined for each spatial unit (basic settlement unit in case of Brno city):

- coverage of inhabitants that are within 300 m of walking distance from stops (concave hull is created on the pedestrian network);
- service frequency represented by total departures count;
- service diversity represented by number of other spatial units that can be visited from the given spatial unit without changing for other public transport lines;
- accessibility within spatial unit represented by the number of stops within the spatial unit which are served at least once during the analyzed time frame;
- accessibility across spatial units represented by how many unique stops can be visited within 20 minutes from departure from one of the stops in the spatial unit, regardless of number of changes for other lines.

A factor analysis is then performed on the resulting values to get the score and rating of the spatial unit, to later compare the current state with the proposed one.

2.2.2. Simulation of the current state

Second step is dedicated to the simulation of the current state. To perform the simulation, *MATSim* requires the road network (derived from *OpenStreetMap*), public transport schedule (available from the integrated transport system coordinator of the South Moravian region in GTFS format), daily activities of agents (derived from the census) and the configuration of simulation variables. The simulation outputs a very detailed itinerary of every agent in a file, which is then processed to extract aggregated data.

2.2.3. Simulation with random schedule innovation

To better suit the needs of the agents from the synthetic population the semi-random innovation of public transport network is used. This process is handled by *MATSim's* plugin called *minibus*.

In principle, it tries to represent an unregulated system, where all the operators can decide what routes to serve, with how many vehicles and in what time period. The more vehicles are used by an operator and the longer is their route, the more expenses are inflicted onto the operator. If the line is not used by many passengers, the operator may shrink it, let less vehicles onto it, or close it down completely. If some operator's budget stays negative for an extended period of time, he may become bankrupt and will have to sell the vehicles, that other, more profitable operators, may buy to use on their routes. This process continues until an equilibrium is achieved, or when the set number of iterations (that represent days passed) are done.

In case of Brno, all city lines are removed, and the virtual public transport operators are let within the city limits. The railway routes and the suburban bus lines are left unchanged.

2.2.4. Simulation with supervised modification

Simulation with random innovation is followed by the simulation with manually revised public transport lines and schedule to introduce more formal type of organization, which means less variants of the same line, more uniform intervals etc. Operators will not compete anymore.
The results are also collected in the same manner as in the previous simulations.

2.2.5. Comparison and outcomes

The results of these three simulations are compared between each other, and finally, the factor analysis from the chapter 2.2.1 is performed on the output schedules.

The comparison of factors can help understand how mobility demand reacts on the altered supply, and how much more (or less) cost effective the resulting system be, based on different criteria (e.g. number of vehicles needed, total passenger kilometers). It generally may help to expose some neglected relations that would be popular among the users had the changes been implemented.

3. 3. Discussion

The proposed methodology has the potential to be used by urban planners, transport authorities or researchers, as it was designed to be completely open source and flexible. It does not depend on particular sources of data, though in case of usage of other data sources additional programming tools might be needed. As the author's experience has shown, the current state of the open data in case of Brno and the Czech Republic in general are still not in such condition, which would allow for robust prognosis. Nonetheless, it is, to the author's knowledge, the first methodology for public transport systems evaluation and improvement to rely solely on the open data and software, which will continue to be worked on.

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