CTU
CZECH TECHNICAL UNIVERSITY IN PRAGUE

PEOPLE
CITY
TRANSPORT
2024

PEOPLE
CITY
TRANSPORT
2024

Hybrid event!
Free attendance!

Book of Extended Abstracts

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

14th – 15th November 2024
Czech Technical University in Prague & online

PEOPLE
CITY
TRANSPORT
2024

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.

14th – 15th November 2024
Czech Technical University in Prague & online

www.pctconference.com
pctconference@cvut.cz

Editor:
Ing. arch. Jan Bittner, Faculty of Architecture, CTU

People – City – Transport 2024: Book of Extended Abstracts

Event organised by Jan Bittner, David Pfann, Jakub Vorel, Veronika Šindlerová
Department of Spatial Planning, Faculty of Architecture, CTU

Published by Czech Technical University in Prague
Thákurova 9, 160 00, Prague, Czechia

Printed by Tisk Kvalitně, s.r.o, Petržílkova 13, 158 00, Prague, Czechia
100 pages, 40 pieces, 1st edition

Typesetted by Robert Kristofori
ISBN 978-80-01-07359-9

Table of Contents

PREFACE

The second year of the People-City-Transport 2024 conference aims to strengthen research activities in urban mobility, especially its behavioural, economic and social aspects. The conference is organized by the Department of Spatial Planning, Faculty of Architecture, CTU in Prague, in cooperation with the Faculty of Transportation Sciences, CTU in Prague.

People-City-Transport 2024 is primarily a scientific conference of doctorate students. It provides an opportunity for the mutual presentation of their research activities and open discussion of research plans and preliminary results of ongoing projects. The conference aims to give constructive feedback to presenters and, by that, improve their future research. The conference is complemented by presentations by prominent figures of scientific research: Maria Attard, University of Malta, Jesper Bláfoss Ingvardson, Technical University of Denmark and Lukáš Makovský, University of Reading, United Kingdom.

Urban mobility is a complex phenomenon, and the investigation requires the strategic partnership of scientists and experts from technical fields, social sciences and humanities. This year, the conference hosts 18 presentations by young scientists worldwide who investigate the phenomenon from different points of view. I believe that the multi-disciplinary approach of the conference may lead to understanding current urban mobility problems and their possible solutions.

Jakub Vorel

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

GENDER-INCLUSIVE PUBLIC TRANSPORTATION: ADDRESSING THE MOBILITY NEEDS OF LOW-INCOME WOMEN WORKERS IN KOCHI CITY, INDIA

FATHIMA ZEHBA MAANJERI PUZHUSERY *

Bartlett School of Architecture, University College London, 22 Gordon Street, London WC1H 0QB, United Kingdom, Department of Architecture and Planning, National Institute of Technology Calicut, NIT Campus P.O., Kozhikode – 67360, Kerala, India
** corresponding author:*
fathima.puthusery.23@ucl.ac.uk, Fathima_p190147ar@nitc.ac.in, fathimazehba81@gmail.com

Public transportation systems in urban India, like those in Kochi, Kerala, are often designed with limited consideration of the needs of women, particularly low-income female workers. This paper examines the gender-specific challenges faced by domestic workers in Kochi, who rely heavily on public buses for their daily commutes. Through in-depth interviews with 25 female domestic workers, the study identifies critical issues such as poor bus design, overcrowding, inadequate bus shelters, and safety concerns during peak hours and first/last-mile connectivity. The findings reveal that high bus steps, inaccessible handrails, and congested conditions make commuting uncomfortable and unsafe for women, particularly those in traditional attire or older age groups. Women also face safety risks, especially in the early morning or late evening, when harassment and crime are more prevalent. This paper calls for the implementation of gender-responsive transportation planning to address these challenges, including redesigning public buses and shelters and enhancing safety measures. Improving public transportation infrastructure and operations for women can lead to more equitable, inclusive urban mobility and better access to socioeconomic opportunities for low-income women workers.

1. Introduction

Public transportation systems play a crucial role in shaping the mobility and access of urban populations [1], [2]. However, the design and operation of such systems often fail to account for the specific needs of women, particularly low-income women workers [3], [4]. Globally, transport planning has been largely male-centred, with infrastructure and services designed to meet the needs of able-bodied, working-age men. As a result, women, especially those from lower-income groups, are disproportionately disadvantaged when using public transportation systems [5], [6].

This paper examines the challenges faced by domestic workers in Kochi, Kerala, in accessing public transport and how these challenges highlight broader gender inequities in urban mobility. Domestic workers, a predominantly female workforce, rely heavily on public buses for their daily commutes. The study investigates specific design and operational flaws in Kochi's public transportation system that limit the safety, comfort, and convenience of these workers. Additionally, it explores opportunities for integrating gender-responsive design solutions that can enhance the accessibility and efficiency of public transport for women.

2. Background and Context

Kochi, the commercial capital of Kerala, is a rapidly growing city with significant urban expansion. Despite this development, its public transportation infrastructure has lagged in addressing the diverse needs of its users, particularly women [7]. Kochi's public bus system, which serves as the backbone of transportation for low-income workers, is inadequately designed to cater to the unique travel patterns and requirements of women.

Studies show that women travel differently than men, making multiple short trips throughout the day to fulfill both work and domestic responsibilities [8], [9], [10]. Unlike men, who typically travel for paid work, women's travel patterns are often fragmented, involving multiple stops for errands, childcare, and other household-related tasks. Despite this, public transport systems in Kochi are designed primarily for single-destination trips, ignoring the complexity of women's commuting needs [11].

In Kochi, domestic workers—who form a significant part of the low-income working population — face compounded difficulties due to the poor design of public transport vehicles, overcrowded conditions, and the lack of safety measures in transit. These challenges are often exacerbated by the lack of gender-sensitive planning in public transportation.

3. Methodology

This study is based on qualitative data collected through in-depth interviews with 25 female domestic workers in Kochi, conducted over a period of two months. The women were selected using a purposive sampling strategy, ensuring representation from various geographic locations around Kochi, including the islands surrounding the city center. The interviews aimed to capture the participants' daily commuting experiences, their perceptions of safety, and their views on the adequacy of transport infrastructure.

A thematic content analysis was employed to identify key challenges faced by these women. The interviews focused on specific areas such as the design of public buses, the adequacy of bus shelters, safety concerns, and the accessibility of services during peak hours. The findings from these interviews were then mapped against existing literature on gender-responsive transportation planning.

4. Key Findings

4.1. Poor Bus Design and Accessibility Issues

One of the major challenges highlighted by participants was the poor design of public buses, which fails to accommodate women's needs. For instance, the steps of the buses are too high, making it difficult for women, especially those dressed in sarees (traditional Indian attire), to board. This design flaw is particularly problematic for older women and those carrying shopping bags or children.

Additionally, the internal layout of the buses does not account for women's shorter stature. Many participants reported difficulty in reaching the overhead handrails, which are designed with average male height in mind. This forces shorter women to stand unsteadily, holding onto the partition between the driver and passengers, leading to discomfort and increased fatigue during the journey.

4.2. Overcrowding and Health Implications

Overcrowding is a significant issue during peak hours, with women often forced to stand for the entire duration of their commute. Despite the availability of a greater number of buses during rush hours, all buses are heavily congested, leaving women with no choice but to travel in uncomfortable conditions. Many participants reported experiencing body pain and fatigue due to prolonged standing in cramped spaces.

Women also expressed concerns over the speed at which buses operate during peak hours. Drivers, in an effort to meet schedules, often drive recklessly, leading to frequent accidents or near-accidents. Participants recounted incidents of women falling inside buses due to sudden braking or falling while alighting from fast-moving buses.

4.3. Uncomfortable and Unsafe Bus Shelters

Bus shelters are another area where gender-insensitive design affects women's mobility. Many participants noted that they avoid sitting on bus shelter benches even when they are available, citing reasons such as discomfort, dirt, or the presence of men at the bus stop. The lack of cleanliness at bus shelters was a recurring issue, with several women mentioning the smell of urine and unclean surroundings.

The absence of well-designed and well-maintained bus shelters also affects women's safety. Many women reported feeling unsafe while waiting for buses in isolated areas, particularly during early morning or late evening hours. In some cases, women take longer, more expensive routes to avoid unsafe areas or opt to travel with male relatives or friends.

4.4. Safety Concerns: Fear of Crime and Harassment

Safety remains a paramount concern for women using public transport in Kochi. Although the frequency of sexual harassment on buses has decreased in recent years, primarily due to age and vigilance, younger women and daughters of participants have experienced harassment. First and last-mile connectivity, i.e., the walk between home and the bus stop, remains a particularly dangerous part of the commute, with women reporting incidents of catcalling, exhibitionism, and other forms of harassment.

In response to these concerns, some women pay extra for autorickshaw rides to avoid walking long distances in the dark, highlighting the financial cost of poor urban planning and public safety. Fear of crime significantly restricts women's mobility and forces them to make choices that compromise their safety, time, and financial well-being.

4.5. Discussion

The challenges faced by women domestic workers in Kochi underscore the need for a gender-responsive approach to public transportation planning. The current design of public transport systems prioritizes efficiency over inclusivity, with little attention paid to the specific needs of women.

Gender-sensitive transportation planning could address many of the issues raised by the participants. For instance, bus designs with lower steps and accessible handrails would make it easier for women to board and travel safely. Additionally, increasing the frequency of buses during peak hours and improving the design of bus shelters would reduce overcrowding and improve safety for women.

5. Conclusion

This paper highlights the critical gaps in the design and operation of public transportation systems in Kochi, particularly from the perspective of low-income women workers. By examining the experiences of domestic workers, the study demonstrates how public transportation, as it currently exists, fails to meet the needs of a significant portion of the urban population.

To create a more inclusive and equitable transportation system, city planners and policymakers must adopt gender-responsive design principles that consider the unique mobility patterns and safety concerns of women. This will not only improve the quality of life for women but also contribute to more sustainable and efficient urban transport systems.

References

[1] C. G. Pooley, "Mobility, History of Everyday," *International Encyclopedia of Human Geography*, pp. 144–149, 2009.

[2] J. L. Bossemeyer and D. C. Washington, "Travel: American Mobility," *Annals of the American Academy of Political and Social Acience*, vol. 313, pp. 113–116, 1957.

[3] R. Bhattacharyya, "Street Violence against Women in India: Mapping Prevention Strategies," *Asian Social Work and Policy Review*, vol. 10, no. 3, pp. 311–325, Oct. 2016, doi: 10.1111/ASWP.12099.

[4] K. Travers, P. Khosla, and S. Dhar, "Gender and Essential Services in Low-income Communities - Report on the Findings of the Action Research Project Women's Rights and Access to Water and Sanitation in Asian Cities," New Delhi, 2011.

[5] World Bank, "India - Toolkit for Enabling Gender Responsive Urban Mobility and Public Spaces," 2022, Accessed: Feb. 20, 2023. [Online]. Available: https://openknowledge.worldbank.org/handle/10986/38199

[6] S. A. Hirt, "Stuck in the suburbs? Gendered perspectives on living at the edge of the post-communist city," Cities, vol. 25, no. 6, pp. 340–354, Dec. 2008, doi: 10.1016/j.cities.2008.09.002.

[7] SMART-SUT GIZ, "GENDER-SENSITIVE REFORMS IN PUBLIC TRANSPORT; A CASE OF KERALA," December, Dec. 2021.

[8] H. A. Tran and A. Schlyter, "Gender and class in urban transport: The cases of Xian and Hanoi," *Environ Urban*, vol. 22, no. 1, pp. 139–155, Apr. 2010, doi: 10.1177/0956247810363526.

[9] A. Falu and S. Sassen, "Women and the city: It's time to rethink urban planning from a gender-based perspective," Scroll.in. Accessed: Jun. 30, 2021. [Online]. Available: https://scroll.in/article/864449/women-and-the-city-its-time-to-rethink-urban-planning-from-a-gender-based-perspective

[10] E. Vacchelli and E. Kofman, "Towards an inclusive and gendered right to the city," *CITIES*, vol. 76, pp. 1–3, 2018, doi: 10.1016/j.cities.2017.10.013.

[11] N. A. Kumar, B. Goswami, and K. K. George, "PATTERNS OF COMMUTING FOR WORK: A CASE STUDY OF KOCHI CITY," 2010.

GENDER AND URBAN TRANSPORT: WOMEN'S PERCEPTIONS AND POLICY RECOMMENDATIONS FOR SAFER SPACES

ASHFA SATTAR *

Charles University in Prague, 560/5 Prague 1, 116 36, Czechia
** corresponding author: ashiswatikhan@gmail.com*

1. Introduction

Urbanization and mobility are interconnected concepts, bringing both obstacles and opportunities, in contemporary civilizations. Accelerated urban growth strains transportation infrastructure, leading to congestion, longer travel times, and increased pollution. Effective mobility promotes economic activities, whereas inefficient mobility undermines the economy and quality of life. This research establishes a framework for the complex interplay between gender inequalities and everyday mobility in urban areas, to understand how public transport planning, the design of cities, and the physical environment of transport spaces may exacerbate or reduce such gaps.

People tend to move around in cities in their social and physical arena, leading to the fact that cities are not gender-neutral. Social inequity in urban design can act as a magnifying glass to aggravate the differences among social groups. Social equity and community interaction are key drivers of a sustainable urban development model. Public transport is integral in upholding both social equity, as well as community engagement. Gender differences often remain hidden while designing and implementing mobility planning for cities, mainly disempowering women from enjoying equal freedom of access to transport. These differences are hardly ever addressed in the urban development plans, particularly for developing nations [9].

This study attempts to respond to enduring difficulties in this area while contributing to an improved comprehension of how public transport space could be designed to answer the safety needs of women, who comprise most users. Even though the implications for urban planning are not fully understood, women's travel behaviors differ significantly from men's [5]. European urbanization has the effect of reinforcing gender inequalities through spatial and social segregation [12].

Women would have little hope of finding relatively cheap accommodation in city center neighborhoods that offer maximum job opportunities, thus resulting in long distances to travel to work and not much choice in the career they wish to pursue [10].

Public transport transitory spaces should not be designed gender-neutral since the mobility demands and realities of men and women are very different in this respect. Traditional urban planning prioritizes linear traffic patterns that fit well while meeting the demands of commuting males who need undisturbed commutes. Women have generally complex travel patterns, which are short trip chains, connected to obligations in work and family domains [4]. Women also travel less distance than men within their local areas, owing to major part to their increased duties as mothers [8]. Women's safety issues in public transportation is a critical subject. The space of the public sphere influences the psychological dimension of comfort, security, or even serenity, as it serves as a conduit for social connection [1]. Several studies have made gender specific analytical

findings regarding, perceptions of risk while using transportation services, including crime and harassment [2]. Lack of effective safety measures in public transit networks, inadequate illumination in public spaces, poorly designed public spaces, and disorganized infrastructure, may cause anxiety among women, especially in the evenings [3].

In post socialist regions like Prague, urbanization processes and socioeconomic transformations have specific consequences on gendered mobility. The women in these regions face enormous impediments to mobility due to economic inequality, poor public transport systems, and security concerns [11]. The city center is arguably one of the most disjointed parts of Prague, with a blend of tourism and commercial service activity, but seems to be a space where social evils manifested and gained momentum. The city center has also the highest per capita crime rate of all parts of Prague [6].

To better understand and solve the special mobility demands for safety reasons and obstacles experienced by females, this research attempts to incorporate the female viewpoint in the public transportation transit area and policy-making processes. It aims to advance the methods of data collection and analysis toward an enhanced understanding of gender disparities in public transport with evidence based decision making and safety for females in daily mobility.

1.1 Objectives and question

- Female perspective incorporation to public transport transits area and policy making processes in the understanding of particular mobility needs and challenges facing females, at their disposal, including safe and convenient alternatives for transportation.
- Undertake online quantitative research to examine women's everyday mobility patterns, physical surroundings, practices in public transportation, mode selections, motivations for a trip, and spatial behaviors. A range of techniques including questionnaire-based quantitative research, observation studies, comprehensive interviews, and travel diaries to understand issues related to environmental factors, gender dynamics, and relevant context-specific factors that determine women's mobility experiences in public transport transit spaces. Based on these qualitative and quantitative data, targeted interventions and policy recommendations aimed at, strengthening the security of public transport systems for women shall then be derived.
- Improving data collection and analysis methodologies will be instrumental in furthering their understanding while improving the provision of evidence based decisions and increased security for women in their daily mobility, especially in public transport.

In this research, I address these questions:

- What are the perceptions of women about different transport spaces in Prague regarding their feelings of safety? It will utilize online research to identify which spaces of transportation are perceived as unsafe by women and what features evoke feelings of unsafety among them. Diversity of experience among women will be in the foreground.
- What characteristics of the transport spaces of Prague make them insecure for women? The on line survey will partially answer this question, while observations made in selected locations identified and validated by women, will mainly provide answers. I will focus on identifying the specific social and physical aspects that create feelings of insecurity in chosen locations, based on literature.
- Using literature, I will uncover social and physical elements of selected areas that may contribute to feelings of insecurity.
- How safe is Prague's urban transportation for women right now, and the scope for betterment? In-depth interviews with professionals in Prague planning would be conducted to get information for the answer to the query.

2. Methodology

The mixed-method approach will be the research methodology employed, which combines the gathering and analysis of qualitative and quantitative data. The study will have three phases mainly:

i. Online Questionnaire Survey:
This online survey will be designed and administered to the women living in Prague. The perception of safety at various chosen public transportation places and their surroundings will be measured. It will utilize Likert scales and multiple choice questions to gather extensive qualitative data about perceptions of safety, travel habits, and experiences. For designing the survey, Qualtrics will be used and distributed through social media avenues and local community groups.'

ii. Observational Studies:
Systematic observation will be executed at specific public transport hubs, stops, and adjacent areas. Researchers will rely on standardized observation protocol to document the underlying aspects affecting women's safety such as lighting, visibility, crowd density, and security deployment. Data will be recorded from mobile devices, equipped with a custom made observation application.

Expert Interviews:
Urban planners, geographers, and architects will be interviewed using a semi-structured format. Professional attitudes towards the connection between the urban design, public transportation, and women's safety would be involved in the topics of interviews. The interviews will be taped and transcribed using Atlas.ti software for qualitative analysis.

Data Analysis:
- SPSS Software will be used to analyze the quantitative data from this survey.
- The software ArcGIS will be used for processing and visualizing spatial data to devise perception maps of safety.
- Responses from the open ended survey and the qualitative interview will be coded with the support of Atlas.ti for key themes.
- The integration of the above methodologies would give an overall understanding of women's safety in the public means of transport in Prague, hence evidence based recommendations for improvement.

3. Conclusion

This study hopes to get an in depth understanding of women's safety issues in the public transport system, in Prague, by using quantitative and qualitative methods of data collection and analysis. The results will inform policy recommendations and measures to increase female safety and accessibility in urban public transportation. The study aims to support the broader interests of gender studies and urban geography by inquiring into how a specific, socially politicized, and individualized experience of safety can be promoted in Prague as a city that has taken on such radical changes since the fall of socialism [7].

The research will focus on improving women's safety in public transportation in Prague due to multiple experiences living in and studying different metropolitan areas. In doing so, one can build an even more just urban environment where everyone has the opportunity to reach their full potential. The experience of this research will be applicable to drive systemic change and make intelligent policy decisions toward achieving gender parity in urban planning and public transport.

Gender and Urban Transport: Women's Perceptions and Policy Recommendations for Safer Spaces

References

[1] Carmona, M., Tiesdell, S., Heath, T., & Oc, T. (2003). Public places Urban spaces: The dimensions of human scale. Architectural Press.

[2] Delbosc, A. K., & Currie, G. (2012). Understanding women's perceptions of risk in public transportation. *Journal of Public Transportation*, 15(4), 23 43.

[3] Ceccato, V., & Paz, M. (2017). Perceptions of safety among women in urban spaces: A systematic review. *Journal of Urban Planning and Development*, 143(3).

[4] Dobbs, B. R. (2005). Understanding the travel patterns of women. *Journal of Public Transportatio*n, 8(3), 1 21.

[5] Hanson, S. (2010). The impact of the built environment on women's travel choices: A review of the literature. Journal of Planning Literature, 24(4), 311 325.

[6] Jíchová, J., & Temelová, J. (2012b). Crime and urban development in the city centre of Prague. *European Urban and Regional Studies*, 19(3), 321 338.

[7] Kóvacs, B. (2014). The impact of post socialist transformation on gender roles and family traditions in East Central Europe. *Journal of Family Issues*, 35(4), 663 686.

[8] Li, M., Zhang, Y., Wang, X., & Park, J. (2004). Women's travel behavior and transportation planning: A review of the literature. *Journal of Urban Planning and Development*, 130(3), 144 155.

[9] Moser, C. O. N. (1993). Female circumcision and urban development: The social and spatial implications of a "traditional" practice in Africa. *Urban Studies*, 30(4), 721 741.

[10] Peters, T. A. (2013). Examining the effects of residential location on women's travel patterns. *Journal of Women & Geography*, 19, 1 22.

[11] Porter, G. (2002). Implementing gender equality in post socialist spaces: Lessons from Prague, Budapest, and Warsaw. *In Implementation: From Policy to Practice* (pp. 31 44).

[12] Tacoli, C., & Satterthwaite, D. (2013). Urbanization and the majority world. International *Journal of Urban and Regional Research*, 37(2), 337 354.

BEYOND SIGNAGE: RETHINKING WAYFINDING IN BENGALURU'S METRO STATIONS

SAHANA SUNDARARAJAN [a, b] *, LAKSHMI SRINIVASAN [c]

[a] *PeepalDesign, 19th Main, Sector 2, HSR Layout, Bengaluru 560102, India*
[b] *Srishti Manipal Institute of Art, Design and Technology, Govindapura, Yelahanka, Bengaluru 560064, India*
[c] *BITS Design School, Faculty of Design, BSNL Colony, Powai, Mumbai 400076, India*
* *corresponding author: sahanasundar161@gmail.com*

1. Introduction

Public transit systems are the backbone of mobility in cities. With the increased dependency on these systems, good quality public transit spaces and infrastructure are essential for enabling inclusive mobility. Mainstream literature demonstrates that the assessment of efficiency in transit systems has involved evaluating factors like accessibility to destinations, network connectivity and transit mode integration among others [1]. However, the way people experience a space is a function of how they navigate it. Wayfinding is the medium through which people interact with transit systems, thereby forging a deeper connection with their cities. It is defined as the comprehensive process of seeking, exploring and route-planning from one location to another [2]. The different elements of wayfinding design that have been studied are signs, maps, landmarks and tactile or auditory elements.While literature has documented the complexity of wayfinding due to its reliance on both cognitive behavior and information processing [3], its practical implementations are often limited to signages. Transit spaces can truly be navigable when wayfinding systems are considered experientially, with attention drawn to aspects such as sensory cues, spatial perception, existing navigation mental models, crowd movement andindividual mobility behaviors.

Wayfinding design must consider people of diverse physical, social, intellectual and cultural needs. However, this can be challenging as individuals' identities are intersectional in nature. Intersectionality is well-explored in disciplines such as law, racial, gender studies or health but remains unconsidered in wayfinding design. The lack of an intersectional approach induces the risk of creating blind spots or exclusions of specific groups that are affected more deeply, thereby hampering how people navigate and experience cities. Current rapid transit systems like metro stations cater primarily to high-mobility users with healthy bodies and require quick physical movement. Commuters from lower socio-economic backgrounds who are dependent on public transport, non-english or non-native language speakers, first-time commuters and senior citizens are among those who are particularly vulnerable due to the lack of accessible wayfinding systems. Limited mobility and reduced cognition can hinder senior citizens' ability to navigate complex spatial layouts and gather essential travel information [4]. These challenges are exacerbated for senior citizens with intersectional identities, such as first-time commuters, women, or those who cannot speak English or the local language. This results in an intimidation caused by infrastructure, highlighting the need for wayfinding to be made more inclusive by integrating concepts from social, behavioral and cognition studies.

Currently, metro stations connect commercial, residential areas and educational hubs in Bengaluru through its two operational lines, making urban travel more accessible. It is proposed that six new lines will connect unserved parts of the city, leading to the increase in the number of junctions or interchange stations. To ensure accessibility of the city, it is necessary for public transit infrastructure within these stations to be inherently inclusive, especially with respect to the wayfinding systems. The scope of this research focuses on the only interchange station in Bengaluru, which is a critical node and can serve as a case study for emerging stations.

2. Research Questions

Building an inclusive wayfinding system demands a comprehensive approach of study beyond redesigning signage graphics or providing additional mobility support – an area where current research is lacking. All elements within the built environment need to be evaluated from different perspectives to satisfy heterogeneous needs. This research aims to establish a method to study interactions in transit systems through the lens of wayfinding infrastructure and develop a more nuanced approach of evaluation to uncover layers of social exclusion. This was guided by the following fundamental research questions:

- How can wayfinding systems be enhanced to make public transport and therefore, our cities more accessible?
- How can insights from literature and concepts relevant to inclusive design and intersectionality be applied to wayfinding design?

3. Method

Wayfinding studies have outlined multiple frameworks of evaluation in literature. However, to evaluate the inclusivity of an existing system, hybrid or interdisciplinary methods need to be devised to understand users' existing perception, their usage of infrastructure in action and nuances of their specialized needs. The interchange metro station in Bengaluru was considered as a case study and was initially studied through commuter audits and spatial mapping.

Existing wayfinding evaluation frameworks studied the impact of color, graphics or employed usability testing methods [5]. However, in order to let users' perspectives guide the methodology, this research was driven by participatory design activities. Multiple iterations of activities with categories of wayfinding elements (signage, cues, floor markings, announcements, etc.) were designed to gain unique feedback from commuters. Each of these were based on different objectives like understanding the existing perception of signages, elements of signages they responded to, audio-visual cues they sought, all as a function of their identities. The wayfinding elements were classified according to the various identities and their types of perception.

Mobility exclusions are challenging to articulate, especially by those experiencing it. To address this, the methodology needed to identify which individuals were affected, physical areas of impact, and the different factors contributing to this. Commuters in the station were shadowed and their routes were mapped. These route maps were largely based on observation and studied a user's journey through the station as a function of their identities. Additionally, layers of data on interactions with elements, cues sought, movement times, wait times, and detours were recorded. To study their correlation with the space, these maps were overlaid on each other, highlighting distinct spaces or junctions that were 'excluding' users – termed 'conflict zones'. This visualization

technique was a crucial step in achieving a cross-sectional view of physical areas of exclusion during movement.

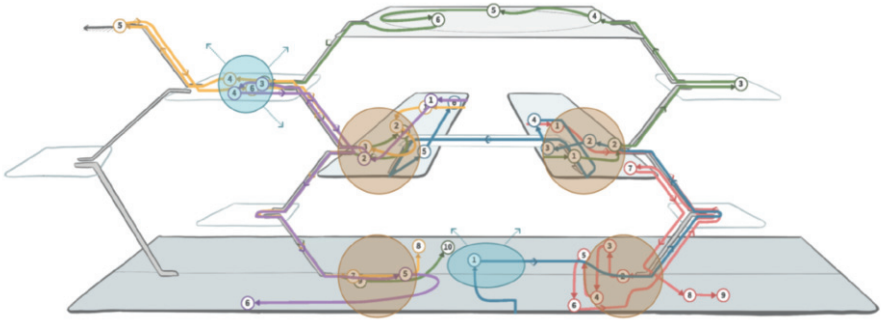


Figure 1. Spatial representation of the Majestic station with mapped user routes overlaid over each other to identify 'conflict zones'

This method revealed insights beyond literature's understanding that elderly commuters struggled with small signage, inconsistent design, large distances [6]. It provided context-specific findings from spatial, signage and identity perspectives. Behavioral nuances like women refraining from asking directions, physical limitations such as senior citizens with canes experiencing fatigue, or pre-existing mental models from other navigational systems - all factors that would have gone unnoticed emerged as significant drivers of navigation patterns. These 'invisible' nuances along with the identified junctions led to a richer understanding of intersectional navigational experiences. To dig deeper into this data and collect intensive qualitative accounts, semi-structured interviews were also conducted.

4. Results

Combining these methodologies bridged the gaps of studying nuanced human navigation and adaptability to existing systems. Though wayfinding principles seem effective in theory, their real impact hinges on execution. This varies according to contexts, geographies and identities of users. Hence, an experiential analysis through a people-centric approach such as this could effectively evaluate the inclusivity of a wayfinding system to build practical solutions to address the challenges.

The findings of this research culminated in a design guidebook that demonstrated methods to reorient existing wayfinding systems to accommodate the needs of elderly commuters. The guidebook consisted of – revised design principles to inform the design of wayfinding components, strategies to design 'conflict zones' in Indian metro stations and a set of dos and don'ts for signage design. While this case study focused on the elderly, the research contributes a nuanced framework of decoding exclusion due to wayfinding in public transit spaces that can be adapted to any context, to identify context-specific 'conflict zones'. It considers intersectional identities and effectively brings out intricacies of their exclusion by identifying its primary areas and causes through spatial visualization. This methodological approach can be scaled to evaluate various types of transit environments as well as different identities to uncover the different forms of exclusions that are present.

Beyond Signage: Rethinking Wayfinding in Bengaluru's Metro Stations

References

[1] R. Tamakloe and J. Hong, "Assessing the Efficiency of Integrated Public Transit Stations based on the Concept of Transit-Oriented Development," *Transportmetrica A: Transport Science*, vol. 16, no. 3, pp. 1–49, Apr. 2020, doi: https://doi.org/10.1080/23249935.2020.1753849.

[2] H. Iftikhar, P. Shah, and Y. Luximon, "Human wayfinding behaviour and metrics in complex environments: a systematic literature review," *Architectural Science Review*, pp. 1–12, Jun. 2020, doi: https://doi.org/10.1080/00038628.2020.1777386

[3] A. C. Farr, T. Kleinschmidt, P. Yarlagadda, and K. Mengersen, "Wayfinding: A simple concept, a complex process," *Transport Reviews*, vol. 32, no. 6, pp. 715–743, Aug. 2012, doi: https://doi.org/10.1080/01441647.2012.712555.

[4] K. Solecka, K. Nosal Hoy, and A. Deryło, "Assessment of transport interchanges for the needs of people with reduced mobility," *Travel Behaviour and Society*, vol. 21, pp. 48–56, Jun. 2020, doi: https://doi.org/10.1016/j.tbs.2020.05.004.

[5] K. Bubric, G. Harvey, and T. Pitamber, "A User-Centered Approach to Evaluating Wayfinding Systems in Healthcare," HERD: *Health Environments Research & Design Journal*, p. 193758672095907, Sep. 2020, doi: https://doi.org/10.1177/1937586720959074.

[6] A. D. Mishler and M. B. Neider, "Improving Wayfinding for Older Users With Selective Attention Deficits," *Ergonomics in Design: The Quarterly of Human Factors Applications*, vol. 25, no. 1, pp. 11–16, Nov. 2016, doi: https://doi.org/10.1177/1064804616659992.

URBAN WALKABILITY RESEARCH IN TURKEY: TRENDS, CHALLENGES, AND FUTURE DIRECTIONS

ARAF OYKU TURKEN [a] *, CENK HAMAMCIOGLU [b],

[a] [b] *Department of Urban and Regional Planning, Yildiz Technical University, Istanbul, Turkey*
**corresponding author: aturken@yildiz.edu.tr*

1. Introduction

Walking is a fundamental form of transport and a sustainable, healthy way of experiencing the city. However, walking behavior contains complicated decision mechanisms based on personal attitudes, preferences, and environmental variables [1], and it can be conducted with various motivations and in different types, such as utilitarian, social, and recreational [2]. So, studies related to walkability/walking behavior have many layers to understanding real-life situations and pedestrian dynamics. From an urbanistic perspective, especially with the new urbanism movement, accessing activities for daily life within walking distance is highlighted in terms of neighborhood design [3]; walkability is associated with quality of urban space, activities, and walking as a tool for boosting pedestrian culture and urban advantage [4], and several researchers focus on pedestrian movements, public space and urban life for better cities [5], [6]. Recently, with the impact of the pandemic, the importance of walkability and proximity-based ideas became more visible in the urban agenda [7].

Despite the existence of planning documents, such as the national development plan and several strategic and action plans, which espouse pedestrian-centric approaches, numerous cities in Turkey continue to exhibit deficiencies in infrastructure and the absence of comprehensive systems for green transportation. However, in general, urban transportation strategies are less oriented towards bicycles and pedestrians than other modes of transportation [8]. Accordingly, the objective of this paper is to gain insight into the pattern of urban walkability research in Turkey by analyzing academic studies in the WoS database. To this end, the following questions will be addressed:

Q1: What are the emerging trends in urban walkability studies in Turkey, and what sub-topics and scales are commonly used in these studies?
Q2: What are the overstudied areas and neglected dimensions of walking-related studies in Turkey?

2. Materials and methods

This study adopts a systematic approach to analyze urban walkability research patterns in Turkey-based cases to reveal trends, challenges, and needs for future directions. In that manner, articles in the WoS database were scanned with relevant keywords [(walkability OR "pedestrian behavior" OR "walking behavior" OR "pedestrian movement" OR "pedestrian mobility") AND (turkey OR "türkiye")]. Some were eliminated through urban walkability perspective, duplications, inclusion

of case studies (Turkey), and limited access to full texts. Accordingly, selected articles are categorized into sub-topics such as walkability assessments, walking behavior and its relation with "x," pedestrian-centric approaches, and walking types. Furthermore, the interrelations between parameters are visualized with a Sankey chart to show cumulation dynamics in the research area and direct further research in Turkey.

3. Results

Sub-categorization is conducted through three main highlights following the evaluation of abstracts manually (Figure 1). The first of these is the walkability assessment, which encompasses approaches that employ multi-parameters to measure, score, and evaluate the walkability of a given area. The second category, 'walking behavior and its relation with "x"', includes studies that seek to understand walkability or walking behavior in relation to other concepts or adopt a more limited perspective on the subject. The third category is studies focusing on pedestrian movement from a pedestrian-centric and individual experience perspective.

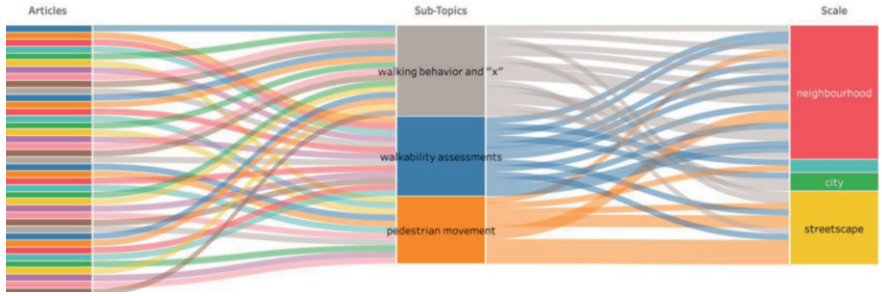


Figure 1. Spatial representation of the Majestic station with mapped user routes overlaid over each other to identify 'conflict zones

3.1 Walkability Assessments

In a simple sense, scoring walkability refers to metrics, indices, or sets of measures that allow us to classify parameters related to walkability in a specific systematic. In that manner, GIS-based approaches are pretty popular regarding built-environment-focused analytic scorings[9]. Relatedly, also in Turkey-cases, several studies conducted assessments often using Space-Syntax or/both GIS analysis; in that context, Şahin-Körmeçli [10] evaluated street network accessibility in Cankiri; Gundogdu [11] examined and scored eleven different axes in the Tekirdag city center considering spatial structure and pedestrian numbers; Akbaba et.al. [12] interested with evaluation of bicycle and walking paths via GIS in Ankara, Ege neighbourhood; Ünal-Çilek [13] design a spectrum for categorizing optimum pedestrian routes to access urban green space through walkability criteria. Some of the studies adopt neighborhood-scale study areas (mostly in Ankara or Istanbul) and also use observatory approaches to consider pedestrian dynamics and to integrate multi-layer perspectives such as Yildirim et. al.'s study [14] about Besiktas which is overlapped spatial analysis, space-syntax (connectivity, local/global integration analysis, mean dept) and mobile techniques; Ozbil et. al. [15] also integrate pedestrian flows and micro & macro-environmental features to compare peripheral neighborhoods in different districts in İstanbul; Ghanat-Bari & Tekel [16] created a walkability index with a survey and spatial analysis considering streetscape values and so on.

3.2 Walking behavior and its relation with "x"
Walking is associated with several topics in urban planning practices. In Turkey-based cases, it has also been seen that it is also often studied through age (for vulnerable groups), as well as proximity/accessibility to facilities. In terms of age-based approaches, children's behavior or route choices to school are subject to several studies [17], [18], [19]; and Bayar & Yılmaz [20] use quantitative data to measure the age-friendliness of urban space through a spatial perspective. Another study interested older adults' life satisfaction related to urban space and accessibility [21]. Apart from that, some studies concrete on accessibility/proximity issues through specific amenities; for instance, Senol et al. [22] discussed park accessibility linked with environmental justice for disadvantaged groups through plans; additionally, Unal et al. [23] calculated service areas of urban green spaces with network analysis at Cukurova considering accessibility dynamics. Durmaz et al. [24] mentioned the relationship between walkability and creative clusters and some advantages of walking distance; additionally, Kahya [25] interested with pedestrian use, street network and art events relation. As another focus, Yildirim et al. [26] examined the difference between low/high social and economic status women's neighborhood walkability perspectives.

3.3 Pedestrian-centric approaches
Regarding pedestrian-centric approaches, some studies use multiple observations to reveal pedestrian dynamics in urban environments, while others focus on pedestrian safety and crossing behavior in more detail. These studies were separated in terms of the scale of the area they studied and the scope of what they searched for. Related to the pedestrian movement-oriented ones, for instance, Yilmaz & Kurkcuoglu analyze pedestrian movement in Istiklal Street in a quantitative way and measure walking speeds, density and flow, personal space of pedestrians [27]; Kesici & Erkan reveal pedestrian movements in two nodes in public space to understand public façade characteristics and behavior relation [28], one of the other study is focus on linkage of pedestrian density, spatial feature and activity in a pedestrianized zone [29]. While other studies concrete on walking habits ant its connection with illegal crossing behaviors [30], the gap distance between pedestrians [31], cultural differences between pedestrian behaviors in five countries including Turkey [32]. Related to the all, Tuydes-Yaman & Karatas [33] highlighted the obvious disconnection between walkability and pedestrian level of service concepts and put forward suggestions about it, and conduct field studies in METU Campus [34].

4. Conclusions

A comprehensive city-scale walking score incorporating perceptual and built environment parameters has yet to be developed for cases in Turkey. Despite Istanbul and Ankara being subjects of extensive study, existing research in these cities is characterized by fragmentation in terms of the research zones and parameters examined. The majority of studies have concentrated on analyses at the neighborhood level and on the built environment. Additionally, some studies concentrate on walking behavior through the lenses of quality of life, age-oriented and proximity perspectives, and the impact of digitalization. This indicates a deficiency in the development of an integrated, city-wide walkability assessment that incorporates both physical infrastructure and user perceptions. Most studies do not clearly define the types of walking behavior under investigation, with only a few studies mentioning recreational walking behaviors. Conversely, there has been a recent surge of interest in these research areas in Turkey, as evidenced by the growing number of academic case studies. Based on reviewed papers, there has been a shift in research trends lately rather than pedestrian movement-oriented approaches and toward exploring walkability overall or with broader themes such as health, sustainability, and urban quality of life.

Acknowledgements

This study is derived and produced as part of a PhD Thesis (in progress) at Yildiz Technical University's Urban Planning Program, prepared by the first author and supervised by the second author.

References

[1] V. Mehta, "Walkable streets: Pedestrian behavior, perceptions and attitudes," 2008. doi: 10.1080/17549170802529480.

[2] E. Choi, "Walkability and the complexity of walking behavior," ITU A|Z, vol. 11, no. 2, pp. 87–99, 2014.

[3] The Congress for the New Urbanism, "The Charter of the New Urbanism." Accessed: Jun. 24, 2023. [Online]. Available: https://www.cnu.org/who-we-are/charter-new-urbanism

[4] J. Speck, "Walkable City," 2012.

[5] W. H. Whyte, *The Social Life of Small Urban Spaces*. 1980.

[6] J. Gehl and B. Svarre, *How to Study Public Life?* Washington: Island Press, 2013.

[7] C. Moreno, "Living in Proximity in a Living City," *Glocalism*, no. 3, Nov. 2021, doi: 10.12893/gjcpi.2021.3.8.

[8] M. Özalp and E. V. Öcalır, "Türkiye'deki Kentiçi Ulaşım Planlaması Çalışmalarının Değerlendirilmesi," METU JFA, vol. 25, no. 2, pp. 71–97, 2008.

[9] R. Shields, E. J. Gomes da Silva, T. Lima e Lima, and N. Osorio, "Walkability: a review of trends," *J Urban*, vol. 16, no. 1, pp. 19–41, 2023, doi: 10.1080/17549175.2021.1936601.

[10] P. Şahin Körmeçli, "Analysis of Walkable Street Networks by Using the Space Syntax and GIS Techniques: A Case Study of Çankırı City," *ISPRS Int J Geoinf*, vol. 12, no. 6, Jun. 2023, doi: 10.3390/ijgi12060216.

[11] H. M. Gundogdu, "Tekirdağ Kent Merkezinin 'Yürünebilirlik' Açısından Değerlendirilmesinde Bir Yöntem Araştırma," *Journal of Planning*, 2020, doi: 10.14744/planlama.2020.50570.

[12] M. Y. AKBABA, G. ATAY, M. BAŞEĞMEZ, and C. C. AYDIN, "Sürdürülebilir bir ulaşım sistemi için bisiklet ve yürüyüş yolu yer seçimi: Ankara ili Mamak ilçesi Ege mahallesi örneği," *Geomatik*, vol. 8, no. 2, pp. 136–151, Aug. 2023, doi: 10.29128/geomatik.1139226.

[13] M. Ünal-Çilek, "Kamusal Alanlara Erişimde Optimum Yaya Güzergah Konforunu Belirlemeye Yönelik Kavramsal Bir Yaklaşım," *MEGARON*, 2020, doi: 10.14744/megaron.2020.16023.

[14] O. C. Yıldırım, A. Sungur, and D. G. Ozer, "Exploring multidimensional aspects of walkability: An innovative analysis approach in Besiktas, Istanbul," *Frontiers of Architectural Research*, vol. 12, no. 6, pp. 1097–1126, Dec. 2023, doi: 10.1016/j.foar.2023.07.004.

[15] A. Ozbil, T. Gurleyen, D. Yesiltepe, and E. Zunbuloglu, "Comparative associations of street network design, streetscape attributes and land-use characteristics on pedestrian flows in peripheral neighbourhoods," *Int J Environ Res Public Health*, vol. 16, no. 10, May 2019, doi: 10.3390/ijerph16101846.

[16] M. Ghanat Bari and A. Tekel, "Fractal Dimension of Streetscape as a Proxy to the Design Dimension of the Built Environment in Walkability Research," *Gazi University Journal of Science*, vol. 35, no. 3, pp. 793–806, Sep. 2022, doi: 10.35378/gujs.721355.

[17] A. Ozbil, D. Yesiltepe, G. Argin, and G. Rybarczyk, "Children's active school travel: Examining the combined perceived and objective built-environment factors from space syntax," *Int J Environ Res Public Health*, vol. 18, no. 1, pp. 1–22, Jan. 2021, doi: 10.3390/ijerph18010286.

[18] A. Ozbil, G. Argin, and D. Yesiltepe, "Pedestrian route choice by elementary school students: The role of street network configuration and pedestrian quality attributes in walking to school," *International Journal of Design Creativity and Innovation*, vol. 4, no. 2, pp. 67–84, 2016, doi: 10.1080/21650349.2015.1123120.

[19] G. Rybarczyk, A. Ozbil, D. Yesiltepe, and G. Argin, "Walking Alone or Walking Together: Spatially Evaluating Children's Travel Behavior to School," *Environ Plan B Urban Anal City Sci*, vol. 50, no. 9, pp. 2560–2578, 2023, doi: 10.1177/239980832311611612.

[20] R. Bayar and M. Yılmaz, "Measuring age-friendliness based on the walkability indices of older people to urban facilities," *Urban Design International*, vol. 28, no. 1, pp. 35–51, Mar. 2023, doi: 10.1057/s41289-022-00194-w.

[21] R. Bayar and H. Türkoğlu, "The Impacts of Urban Environment Aspects on The Life Satisfaction of Older Adults," *Iconarp International J. of Architecture and Planning*, Jun. 2023, doi: 10.15320/iconarp.2023.232.

[22] F. Şenol, S. P. Öztürk, and İ. Atay Kaya, "An urban plan evaluation for park accessibility: a case in Izmir (Türkiye)," *Urban Design International*, vol. 28, no. 3, pp. 220–233, Sep. 2023, doi: 10.1057/s41289-023-00221-4.

[23] M. Unal and C. Uslu, "Evaluating and optimizing urban green spaces for compact urban areas: Cukurova district in adana, Turkey," in *ISPRS International Journal of Geo-Information*, MDPI AG, Feb. 2018. doi: 10.3390/ijgi7020070.

[24] S. B. Durmaz, "Analyzing the Quality of Place: Creative Clusters in Soho and Beyoğlu," *J Urban Des (Abingdon)*, vol. 20, no. 1, pp. 93–124, Jan. 2015, doi: 10.1080/13574809.2014.972348.

[25] G. Y. Kahya, "Sanat Aracılığı ile Birarada Olma Durumları ve Beyoğlu'nun Mekânsal Kültüründeki Yansımaları," *Journal of Planning*, 2020, doi: 10.14744/planlama.2020.60783.

[26] G. Yildirim, M. L. Ince, and M. Muftuler, "Physical activity and perceptions of neighborhood walkability among Turkish women in low and high socio-economic environments: An Exploratory study," *Percept Mot Skills*, vol. 115, no. 2, pp. 661–675, Oct. 2012, doi: 10.2466/06.15.PMS.115.5.661-675.

[27] A. Yilmaz and E. Kurkcuoglu, "Multidimensional dynamics of pedestrian-environment interaction: a micromovement analysis in Istiklal Street, Istanbul*," *J Urban Des (Abingdon)*, 2024, doi: 10.1080/13574809.2024.2317813.

[28] N. Kesici and N. Ç. Erkan, "The Effect of Public Facade Characteristics On Changing Pedestrian Behaviors," *Journal of Architecture and Urbanism*, vol. 47, no. 1, pp. 68–76, Jan. 2023, doi: 10.3846/jau.2023.17688.

[29] Ö. C. Yıldırım and E. Çelik, "Understanding pedestrian behavior and spatial relations: A pedestrianized area in Besiktas, Istanbul," *Frontiers of Architectural Research*, vol. 12, no. 1, pp. 67–84, Feb. 2023, doi: 10.1016/j.foar.2022.06.009.

[30] Y. I. Demiroz, P. Onelcin, and Y. Alver, "Illegal road crossing behavior of pedestrians at overpass locations: Factors affecting gap acceptance, crossing times and overpass use," *Accid Anal Prev*, vol. 80, pp. 220–228, 2015, doi: 10.1016/j.aap.2015.04.018.

Urban Walkability Research in Turkey: Trends, Challenges, and Future Directions

[31] Y. Alver and P. Onelcin, "Gap acceptance of pedestrians at overpass locations," *Transp Res Part F Traffic Psychol Behav*, vol. 56, pp. 436–443, Jul. 2018, doi: 10.1016/j.trf.2018.05.010.

[32] G. Solmazer et al., "Cross-cultural differences in pedestrian behaviors in relation to values: A comparison of five countries," *Accid Anal Prev*, vol. 138, Apr. 2020, doi: 10.1016/j.aap.2020.105459.

[33] H. Tuydes-Yaman and P. Karatas, "Evaluation of walkability and Pedestrian Level of Service," in *Engineering Tools and Solutions for Sustainable Transportation Planning*, IGI Global, 2017, pp. 30–51. doi: 10.4018/978-1-5225-2116-7.ch002.

[34] P. Karatas and H. Tuydes-Yaman, "Variability in Sidewalk Pedestrian Level of Service Measures and Rating," *J Urban Plan Dev*, vol. 144, no. 4, 2018, doi: 10.1061/(ASCE).

ENHANCING SAFETY AND ACCESSIBILITY AT KARACHI'S BUS STOPS: ADDRESSING THE INTERSECTION OF URBAN DESIGN, CRIME PREVENTION, AND PUBLIC TRANSPORT

HUMAIRA NAZIR [a,*], ASIFA IQBAL [b]

[a] *Assistant Professor, Sir Syed University of Engineering and Technology Karachi, Department of Architecture and Environmental Design, ST-16 Main University Road, Block 5 Gulshan-e-Iqbal, Karachi, Karachi City, Sindh, Pakistan*
[b] *Assistant Professor, University of Gävle, Gävle, Sweden, Department of computer and Geospatial Sciences, Kungsbäcksvägen 47, 801 76 Gävle, Sweden*
* *corresponding author: hnazeer1991@gmail.com*

As Karachi grew into a megacity, its rapidly growing population made the public transport network an important part of daily life. However, transport infrastructure, like bus stops, became unsafe and inaccessible. The research aims to explore the relationship between crime, urban planning frameworks, and public transport infrastructure by focusing on the safety of commuters at bus stops in Karachi. The study will use and analyze urban planning frameworks, such as the design and layout of bus stops and their integration with urban environment, to identify the key risk factors that contribute to the safety or insecurity of bus stops in Karachi. This study will help urban planners, policymakers, and transport authorities develop targeted strategies for making bus stops safer and more secure, ultimately contributing to a more reliable and user-friendly public transport system in Karachi.

1. Introduction

Karachi, the world's 6th largest metropolitan city, with a significant population., is experiencing rapid expansion [1]. This rapid urbanization has significantly increased the number of vehicles on the road. However, the city's public transport sector is in disarray due to inadequate infrastructure, such as the lack of bus terminals, workshops, and facilities for drivers and conductors [2]. Buses frequently bypass designated stops, which are often obstructed by permanent and movable encroachments, as well as para-transit modes, rendering many stops unsafe and inaccessible [3]. Hence the placement, design and layout of bus stops should be considered important because bus stops are essential components of the public transport system, significantly enhancing its appeal through improved quality, accessibility, and safety and can greatly impact a bus user's perception of safety at the stop [4].

Research by [5] indicates that people may avoid certain bus stops, limit their use to daytime, or refrain from using public transit altogether if they fear harassment or victimization. The perception of safety while waiting at bus stops is as important as the safety experienced on the bus itself in influencing public transit use. [6] further emphasize that fear and anxiety about personal security can deter individuals from using public transit, significantly affecting ridership. A 2002 survey by the Department of Transport in United Kingdom found that improving public safety could increase travel by an additional 10.5 percent [7].

In addition, crime on public transportation is a significant issue in developing countries such as India, Pakistan, and China [8]. Research consistently underscores the crucial role of urban design in influencing crime rates and overall safety in public spaces. [9] highlighted that well-designed, visible, and accessible spaces can deter criminal activity by reducing opportunities for crime. Bus stops, often prime locations for criminal behavior, offer cover for individuals who may prey on unsuspecting victims while waiting unnoticed. Urban riders frequently express concerns about their safety at bus stops, feeling uneasy about individuals lingering behind them or being intimidated by homeless individuals who use bus stops as gathering places [10]. They often experience discomfort when waiting alone in areas with vacant buildings or fenced lots, where the absence of other people heightens their sense of vulnerability.

Harassment at bus stops is a prevalent issue, with many women reporting daily experiences of unwanted advances and verbal abuse from individuals in nearby cars or on the street [2]. In Karachi, the poorly designed and neglected bus stops, often situated on grimy street corners amidst concrete and speeding traffic, exacerbate commuters' feelings of insecurity and discomfort. Incidents such as the loss of personal belongings like wallets and mobile phones are also common at these locations [11]. There are many studies done on the bus stops and transportation system in Karachi such as [12, 13, 14, 15] however, there is a lack in exploring the buss stops infrastructure by focusing on the safety of commuters in Karachi. Futhermore, how can we determine the safety level of bus stops? While there is extensive literature on designing bus stops, research into assessing the safety of existing bus stops remains relatively underdeveloped [16]. The security and protection of lives and property rely heavily on the effective functioning of various infrastructure systems. The CPTED (Crime Prevention Through Environmental Design) concept offers a modern approach to reducing crime through thoughtful design. Applying CPTED principles to transport terminals can enhance safety and security by addressing environmental factors that contribute to criminal activity [17]. Therefore, this research will be analysing the design and layout of bus stops and their integration with urban environment, to identify the key risk factors that contribute to the safety or insecurity of bus stops in Karachi by using CPTED principles.
The principles of CPTED includes:

1. Surveillance includes both formal and natural surveillance. Closed-circuit television (CCTV) camera installation has been viewed as a surveillance tool and a potential social control instrument [18, 19].

2. Territoriality is the concept of how physical design may create a sense of ownership in particular regions [19]. It may be accomplished by ensuring that every location has a clear function [20]

3. Access control means restricting access to a property through gates, fences, and entrance points [20]

4. Activity support (which encourages relationships between users and locals, which deters crime) [21].

5. Image of the place- maintenance (It explains how an environment's aesthetic appeal may strengthen people's perception of its safety and prevent potential criminals by demonstrating that people are in charge of it) [20].

2. Materials and methods

This research uses a qualitative approach, incorporating comprehensive examination of various sources such as scientific journal articles, books on transportation systems, research reports, newspaper articles, and other media resources. To gain a more detailed understanding of bus stops a Crime prevention through environmental design (CPTED) checklist will be used. A total of ten busses stops will be selected across three areas varying socio economic characteristics to perform this inspection. The check list will be focused on five key principles, visibility and surveillance, access control, territorial reinforcement, image of the place, activity support [17].

3. Expected Results

Urban planning and transportation system design go hand in hand. In Karachi there are many different public departments that are responsible for this planning and work. The number of these departments has become a big issue in terms of inter-coordination [2]. Additionally, fear about personal security respectively a perceived sense of being unsafe in public space has the potential to discourage individuals from travelling [22]. From a Crime Prevention Through Environmental Design (CPTED) perspective, it is expected that bus stops in the city of Karachi are not safe due to poor visibility, no access, inadequate lighting, lack of surveillance, and insufficient design features that enhance safety and security. Furthermore, findings of this study may suggest that specific environmental features in the immediate vicinity of a bus stop can significantly influence the possibility of criminal activity.

4. Conclusions

Crimes at bus stops are often concentrated in those areas with high population density, and with inadequate infrastructure, poorly maintained public spaces . The higher crime potential of these locations can also be partially attributed to their social and compositional characteristics. However, within these high-crime areas, some bus stops are significantly more dangerous than others. The design and layout of the physical environment can either foster criminal activity or help mitigate opportunities for crime. This study identified several bus stops in three socio economic areas including historic core—a region known for its high crime potential—that experienced frequent criminal incidents, while others in the same area and along the same bus route remained relatively unaffected. Therefore, by incorporating the CPTED principle, safety of bus stops can be enhanced, like enhancing visibility through clear signage and removing obstacles. Surveillance can be increased by installing CCTV cameras, and natural surveillance can be enhanced by incorporating features that allow for clear sightlines and encourage the presence of passive observers, such as open spaces and transparent shelters. Proximity to active spaces like retailes and shops can also increases the possibility of natural surveillance and reduces opportunities for crime.

Further, preventing neglect and vandalism at the bus stop is possible by keeping bus stops clean and well-maintained that will help in making a positive image of the place. Access can be enhanced by making the bus stop universally accessible for all users, including handicapped, and by providing comfortable waiting areas, and access can be controled by defining entry and exists and clearly define boundaries. Activity support can be done through providing different activities like cafe, reading areas, public art, landscaping, or community information boards that can make the space more engaging and welcoming. Last but not least is the territorial reinforcement that can be achieved by creating a sense of ownership like use landscaping and other design elements to create a sense of ownership and pride in the bus stop area. Well-maintained areas signal that the space is cared for, which can discourage vandalism and other criminal activities.

References

[1] Hussaini, W., & Hussaini, S. G. (2023). Risks Of A Megacity. *Journal of Survey in Fisheries Science*s, 1576-158a8. https://doi.org/10.53555/sfs.v10i1.2414

[2] Heraa, N. (2013). Transportation system of Karachi, Pakistan. *PhD Diss., Faculty of the Graduate School of Asia.* https://ritsumei.repo.nii.ac.jp/?action=repository_action_common_download&item_id=11859&item_no=1&attribute_id=22&file_no=1

[3] Iqbal Rao, Z., Khan, K., Faraz Jafri, S., & Sheeraz, K. (2014). Public transportation improvement validation model for metropolitan city Karachi. *Engineering Journal*, *18*(1), 55–64. https://doi.org/10.4186/ej.2014.18.1.55

[4] Rossetti, S., & Tiboni, M. (2020). In field assessment of safety, security, comfort and accessibility of bus stops: A planning perspective. European *Transport - Trasporti Europei, 80*(6), 1–17. https://doi.org/10.48295/ET.2020.80.8

[5] Loukaitou-Sideris, A., & Fink, C. (2009). Addressing Women's Fear of Victimization in Transportation Settings: A Survey of U.S. Transit Agencies. *Urban Affairs Review, 44*(4), 554-587. https://doi.org/10.1177/1078087408322874

[6] Kheir-moghadam, G. (2015). *Perception of Safety at Transit Stops: A Case Study of Kingston. March*, 62. http://hdl.handle.net/1974/12799

[7] Carter, M. (2005). Gender differences in experience with and fear of crime in relation to public transport. *In Research on women's issues in transportation* (Conference proceedings 35, Vol. 2, p. 100). Washington, DC: Transportation Research Board.

[8] Lee, J., Mao, R., & Pervez, A. (2024). Perceived risk of crime on driverless public bus and ride-pooling services in China. *Travel Behaviour and Society*, 35(December 2023), 100730. https://doi.org/10.1016/j.tbs.2023.100730

[9] Jacobs, J. (1961). Jane jacobs. *The Death and Life of Great American Cities, 21*(1), 13-25.

[10]. Anastasia, L.-S., & Robin, L. (2000). On Bus-Stop Crime. *ACCESS Magazine*, 1(16).

[11] Nazir, H. (2018). An approach to improve local bus stops in the inner-city of Karachi. *Department of Architecture & Planning, NED University of Engineering & Technology, City Campus Maulana Din Muhammad Wafai Road, Karachi.*, 50.

[12] Mirza, S., Mirza, M., Chotani, H., & Luby, S. (1999). Risky behavior of bus commuters and bus drivers in Karachi, Pakistan. *Accident Analysis & Prevention*, 31(4), 329-333.

[13] Soomro, R., Memon, I. A., Pathan, A. F. H., Mahar, W. A., Sahito, N., & Lashari, Z. A. (2022). Factors that influence travelers' willingness to adopt bus rapid transit (Green Line) service in Karachi. *Sustainability, 14*(16), 10184. https://doi.org/10.3390/su141610184

[14] Muhammad, G., Rasheed, K., Qureshi, M. A., Ashraf, J., Irfan, M., & Fawad, M. (2019, November). An Android based ERP System for Karachi Bus Route Management. *2019 International Conference on Innovative Computing (ICIC),* Lahore, Pakistan, 2019, pp. 1-6. IEEE.10.1109/ICIC48496.2019.8966681

[15] Fatima, M., Khan, M. I., & Naqvi, S. K. A. (2022). Gauging the efficiency of public transport in karachi: an application of data envelopment analysis (DEA). *Pakistan Journal of Social Research, 4*(03), 607-616. https://doi.org/10.52567/pjsr.v4i03.750

[16] Barabino, B. (2018). Automatic recognition of "low-quality" vehicles and bus stops in bus services. Public Transport, 10(2), 257-289. 10.1007/s12469-018-0180-8

[17] Králová, K., Šoltés, V., & Kotalová, N. (2021). Protection of Transport Terminals through the Application of the CPTED Concept. *Transportation Research Procedia, 55*(July), 1593–1598. https://doi.org/10.1016/j.trpro.2021.07.148

[18] Moffat, R. (1983). Crime prevention through environmental design—A management perspective. *Canadian Journal of Criminology, 25*(4), 19–31.

[19] Reynald, D. M. (2015). Environmental design and crime events. *Journal of Contemporary Criminal Justice, 31*(1), 71-89. https://doi.org/10.1177/1043986214552618

[20] Iqbal, A., & Ceccato, V. (2016). Is CPTED useful to guide the inventory of safety in parks? A study case in Stockholm, Sweden. *International criminal justice review, 26*(2), 150-168. 10.1177/1057567716639353

[21] Saville, G., & Cleveland, B. (2018). Evaluating the impact of crime prevention through environmental design (CPTED) on residents' fear of crime in a high- poverty neighborhood. Journal of Urban Affairs, 40(3), 329-343. https://doi.org/10.1080/07352166.2017.1309618

[22] Stark, J., & Meschik, M. (2018). Women's everyday mobility: Frightening situations and their impacts on travel behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour, 54*, 311–323. https://doi.org/10.1016/j.trf.2018.02.017JFA, vol. 25, no. 2, pp. 71–97, 2008.

THE 15-MINUTE CITY: HOW BIG UTOPIA IS IT?

DENIS CHARALAMBIDIS *

Czech University of Life Sciences Prague (CZU), Faculty of Environmental Sciences, Kamýcká 129, 165 00 Prague 6 – Suchdol, Czechia
** corresponding author: charalambidis@fzp.czu.cz*

1. Introduction

Already in 20th century was as subject of city planning also determination of the basic amenities in a walkable distance. This topic was solved not only abroad [1], but also in our country [2]. Both models consider no more than a 5 minutes walk to basic amenities from each residence. Quite similar concept is the concept of a city of short distances which was popular especially in German-speaking countries at the turn of the 20th century. Since year 2016, when Carlos Moreno published his first article about 15-minute city [3], has been more often applied the concept of 15-minute city. This concept differs from the concept of a city of short distances mainly by the threshold value that is declared by the name of the concept, but also more specifically defined basic human needs and preferred modes of transport. The 15-minute city model comes with a much more ambitious idea of providing basic human needs compared to the models and concepts detailed above, because this model counts with more amenities available by walk or by bike and also with longer time to reach these facilities by preferred mode of transport. The 15-minute city model according to Carlos Moreno [4] is based on the availability of six basic human needs. These needs are housing (≈ living), (≈ work), food (often replaced by commerce), health (also confused with a more complex set of care ≈ care; of which health is a part), education and culture and leisure (often replaced by entertainment ≈ entertainment), which should be accessible within 15 minutes by walk or by bike. But is it this idea realistic?

2. Materials and methods

The research work builds on my diploma thesis, which theoretically and analytically dealt with the city of short distances. The follow-up works consist of the survey of theoretical concepts of the 15-minute city with focus to clarify each part of the basic definition. Due to the diversity of works and sub-themes in relation to the theme of the 15-minute city, a similar interpretation by two or more authors was considered theoretical agreement. The theoretical research was also supplemented by a hypothetical confrontation of the considered framework of the maximal airy distance of the 15-minute city and the standardized values of the summary research doc. Šindlerová, which were the basis of the methodology [5].

3. Results

Due to the time limitation of 15 minutes availability of basic human needs by walk or by bike, the authors [6, 7] conclude that the basic unit of the 15-minute city concept is a district/neighborhood with only a limited amount of amenities. Within this unit, it is only possible to consider a 15 minutes

bike ride would no longer be walking, because 15 minutes of cycling equals more than 15 minutes of walking, which is not in accordance with the maximum time limit. The range of this unit in meters corresponds to the lowest and highest detected average walking values. The lowest value found matches 3,6 km/h [6] – *generally the average walking speed of a person regardless of age, fitness and weather* (approx. 900 m) and the highest value found matches 5,15 km/h [7] - *during dry, summerlike, road conditions, the average walking speed of adults* (approx. 1300 m). Nevertheless, according to basic definition of the concept of 15-minute city is necessary to reflect the walking value of the slowest part of population, because within this concept it is necessary to ensure time availability for all their residents.

When we focus on individual daily needs, then there is a theoretical conformity [6, 8, 9, 10] about the unavailability of work and higher education within 30 minutes of travel, let alone the necessary 15 minutes. In the case of the remaining devices for basic human needs, their need is already based on the standardized values of the required physical availability. However, this required physical availability is often stricter than the considered 15 minutes limit. In many cases, the establishment of a given device is conditioned not only by the need for its physical availability, but also by other criteria. For example, Rogers [1] states that higher residential density provides greater amount of public amenities to be located within walking distance and conversely lower residential density will not disturb the required quantity. However, he adds that the optimal level of density is dependent on individual local conditions. If these criteria were not met, then the considered unit of 15 minutes of the city would not be covered by the required amount of the given amenities according to the relevant standardized values. It follows from the above that in such a case not all residents would be guaranteed the declared availability of all basic human needs.

4. Conclusions

The concept of a 15-minute city represents only a limited idea of providing basic human needs. However, even this limited idea is not uniformly graspable. Not all districts have sufficient conditions for all daily needs according to the concept of 15-minute city. In this case the concept of 15-minute city cannot be used as a flat rate. This conclusion was detected also in the diploma thesis [11]. The results of the analysis pointed to the fact that each of the locations fulfils different attributes of short-distance cities. In this regard, for precise clarification, he should focus primarily on commercial amenities, because these amenities are conditioned primarily by the economic need for efficiency. Furthermore, this primary focus should be narrowed down to equipment, which will always be needed given the socio-demographic situation, namely health and social care.

References

[1] R. Rogers (ed.). *Towards an Urban Renaissance*. London: Crown Copyright, 1999. ISBN 1 85112 165 X

[2] J. Voženílek (ed.). *Stavba měst a vesnic. Urbanistická příručka*. Prague, Výzkumný ústav výstavby a architektury, 1957. D-572544

[3] C. Moreno. *La ville du quart d'heure : pour un nouveau chrono urbanisme*. Carlos Moreno. 2016. https://www.moreno-web.net/la-ville-du-quart-dheure-pour-un-nouveau-chrono-urbanisme/

[4] C. Moreno: *Definition of the 15-minute city*: *WHAT IS THE 15-MINUTE CITY?*, 2021. https://www.researchgate.net/publication/362839186_Definition_of_the_15-minute_city_WHAT_IS_THE_15-MINUTE_CITY

[5] K. Maier, V. Šindlerová, J. Vorel, V. Jetel, T. Peltan: *Standardy dostupnosti veřejné infrastruktury*. 2020. https://mmr.gov.cz/getmedia/172ef4fb-11fb-4647-bc0d-278110a20369/TB050MMR01-Standardy-dostupnosti-verejne-infrastruktury-aktualizace-2020-03.pdf.aspx?ext=.pdf

[6] A. L.Gaxiola-Beltrán, J. Narezo-Balzaretti, M. A.Ramírez-Moreno, B. L. Pérez-Henríquez, R. A. Ramírez-Mendoza, D. Krajzewicz, J. de-Jesús Lozoya-Santos,: *Assessing Urban Accessibility in Monterrey, Mexico: A Transferable Approach to Evaluate Access to Main Destinations at the Metropolitan and Local Levels*. Applied Sciences 11, 7519, 2021. https://doi.org/10.3390/app11167519

[7] E. Willberg, C. Fink, T. Toivonen: *The 15-minute city for all? – Measuring individual and temporal variations in walking accessibility*. Journal of Transport Geography 106, 103521, 2023. https://doi.org/10.1016/j.jtrangeo.2022.103521

[8] C. Birkenfeld, R. Victoriano-Habit, M. Alousi-Jones, A. Soliz,A. El-Geneidy: *Who is living a local lifestyle? Towards a better understanding of the 15-minute-city and 30-minute-city concepts from a behavioural perspective in Montréal, Canada*. Journal of Urban Mobility 3, 100048. 2023. https://doi.org/10.1016/j.urbmob.2023.100048

[9] O. R. Manifesty: *Case Study of a 15-Minute City Concept in Singapore's 2040 Land Transport Master Plan: 20-Minute Towns and a 45-Minute City*. International Journal of Sustainable Transportation Technology. 2022. https://www.academia.edu/101893591/A_Case_Study_of_a_15_Minute_City_Concept_in_Singapore_s_2040_Land_Transport_Master_Plan_20_Minute_Towns_and_a_45_Minute_City

[10] M. Wolański: *The Potential Role of Railway Stations and Public Transport Nodes in the Development of "15-Minute Cities."* Infrastructures 8, 141. 2023. https://doi.org/10.3390/infrastructures8100141

[11] D. Charalambidis: *Vyhodnocení vybraných pražských přestavbových území z hlediska konceptu měst krátkých vzdáleností*. Prague Czech University of Life Sciences Prague (CZU). 2023. https://theses.cz/id/qsaswp/

MULTI-SCALE ANALYSIS OF ACCESSIBILITY TO SHOPS, SERVICES AND GREEN SPACES IN THE RABAT-SALÉ CONURBATION IN MOROCCO

XAVIER LEHMANN [a, *], IKRAME LAADSSI [a, b]

[a] *Gustave Eiffel University, 5 Boulevard Descartes, 77420 Champs-sur-Marne, France*
[b] *National Institute of Planning and Urbanism (INAU), Avenue Allal El Fassi B.P 6215, Rabat, Morocco*
* *corresponding author: xavier.lehmann@enpc.fr*

1. Introduction

This study is part of two doctoral research projects: on the one hand, on planning through accessibility, to increase proximity to amenities and reduce the car's share of daily mobility, and on the other, on the daily travel experience of public transport users. This paper presents the results of a multi-scale analysis of accessibility in the Rabat-Salé area of Morocco. Several theoretical and methodological issues justify the choice of this study area and place it in the context of broader academic and operational research programmes. Firstly, this study draws on the concepts of the '15-minute City' and 'walkability' [1]. These approaches are still relatively unexplored in the context of Moroccan cities, and more broadly in that of North African cities. In many respects, urban planning in the Rabat-Salé conurbation is representative of the main cities in this geographical area: combating heat islands, managing dense informal housing, developing new towns on the outskirts, balancing the distribution of urban facilities in a context of strong urban and demographic growth, improving public transport infrastructure and promoting active modes of transport. Against this backdrop, the conurbation has embarked on drawing up a Sustainable Urban Mobility Plan (PMUD) to plan its mobility system for 2040 [2]. The core of the region's public transport offering is the tramway network, which has been in service since 2011. Two lines currently link the cities of Rabat and Salé, serving the main districts at the heart of the conurbation, and are set to be significantly extended to serve outlying areas by 2030. Our study therefore takes place in a context of major planning challenges, requiring a multi-scale approach due to the diversity of the urban areas concerned and the issues addressed. For this reason, a significant methodological contribution of our study lies in the use of Fractalopolis analysis software, currently under development. This software, based on the principles of fractal geometry, enables us to measure the accessibility of an area's amenities by taking into account the hierarchical and complementary organisation of its various centres [3]. While several studies have already been carried out using Fractalopolis on French and European cities, this is the first time the software's accessibility model has been applied in a non-European context. This study gives concrete expression to our thoughts on the software's adaptability to other cultural and socio-spatial contexts. The reproducibility of the methodology for the Rabat-Salé area has also been made possible by the emergence of global databases. Through this contribution, we hope to present a set of open data that will facilitate research into urban mobility and spatial planning for a wide range of areas.

Multi-Scale Analysis of Accessibility to Shops, Services, and Green Spaces
in the Rabat-Salé Conurbation in Morocco

2. Materials and methods

2.1. Methods

The study is based on two main stages of analysis, representing the multi-scale nature of our approach. The first stage involves an overall measurement of accessibility to amenities in the Rabat-Salé area, based on the organisation of its urban and commercial framework. The second stage is based on a more detailed understanding of accessibility indicators in the districts served by the tramway.

2.1.1. Global scale

Using the Fractalopolis methodology, we carry out an initial phase of diagnosing the area by measuring accessibility to amenities according to the organisation of the various urban centres. The first step is to understand the polycentric nature of the area and the spatial hierarchy that exists between the different polarities. Using the urban system we have constructed, we can identify the main areas of the conurbation from which we will measure levels of accessibility. This measure of accessibility is based on various indicators: the selection and classification of the different types of points of interest (POIs) used for the study, the choice of preferred access distances according to the type of POI and the frequency of use by the population. The POIs considered for this study are shops (grocery shops, supermarkets, coffee shops, pharmacies, etc.), services (nurseries, schools, sports facilities, health services, etc.) and green and leisure areas (parks, forests, beaches, etc.). With around thirty types of POI selected and geolocated in the form of points, the database used is particularly rich for this study area.

2.1.2. Local scale

As part of the preparation of the PMUD, we wanted to expand on existing knowledge of the urban characteristics of the areas served by the tramway and their integration with the rest of the Rabat-Salé conurbation. By focusing on the neighbourhoods around the tramway stations, the aim was to assess the level of walkability of these areas and their interactions with the public transport network. Our analysis therefore focused on a detailed analysis of accessibility to the POIs around the stations and in the rest of the city. We also focused on a number of indicators associated with the territorial design of these spaces (jobs, land use, pedestrian network, etc.). To calculate multimodal accessibility combining walking and trams, we used the open source tools OpenTripPlanner [4] and r5r [5], via the R environment. These tools can be used to calculate journey times and estimate accessibility to POIs via different types of location-based measures. This methodology required the use of GTFS (General Transit Feed Specification) data from the Rabat-Salé tramway network, which cross-references itineraries (organisation of routes and location of stops) and vehicle timetables.

2.2. Materials

The main GIS data used and their sources are shown in Table 1. The use of open and recent data has been favoured wherever possible, to facilitate the reproducibility of the methodology. Similarly, the preference for global spatial data may favour applications over a wide variety of territories. QGIS Desktop 3.32 software was used for GIS processing.

TYPE OF DATA	SOURCE	PERIOD
Building footprint	Google-Microsoft Open Buildings	2023
Building height	Global Human Settlement Layer - GHS-BUILT-HR2023A	2023
Population / Number of households	Population census (RGPH)	2014
Number of jobs	*Rabat Région Mobilité*	2022
Land Use	OpenStreetMap / geoportal of the Rabat Salé Urban Agency	2024
Shops and services	Google maps / geoportal of the Rabat Salé Urban Agency	2024
Green and leisure areas	OpenStreetMap	2024
Tram lines and stations	OpenStreetMap	2024
GTFS tramway	*Rabat Région Mobilité*	2022

Table 1. Principal data used in the study

3. Results

The first contribution of this study is the formalisation of Rabat-Salé's 'urban system', reflecting the multi-scale organisation of its urban and commercial frameworks. Accessibility levels to shops, services and green spaces were estimated and indexed according to the different urban polarities identified. There is a disparity in scores between neighbourhoods, particularly between the heart of the conurbation and non-regulated built areas. It is therefore possible to identify areas that are suitable for future development, taking into account these assessments and the PMUD's recommendations. A detailed analysis of the areas served by the tramway provides a precise diagnosis of the nature of urban development and the potential for walkability and multimodal accessibility in these areas. This paves the way for more in-depth studies on the relationship between urban planning and transport in the Rabat-Salé conurbation, particularly with regard to the future development of its mobility system.

4. Conclusions

The contributions of this study are important in several respects, both in terms of improving specific knowledges of the study area and in the wider development of new theoretical and methodological thinking on the measurement of urban accessibility. This is an interesting contribution to the application of the '15-minute City' concept in the urban and socio-cultural contexts of a North African metropolis. This application of Fractalopolis is also an important step in developing the

Multi-Scale Analysis of Accessibility to Shops, Services, and Green Spaces
in the Rabat-Salé Conurbation in Morocco

operationality of the software and the reproducibility of its methodology. Finally, we hope to contribute to the dissemination of the latest innovations in the field of existing open geographic data on a global scale.

Acknowledgements

We would like to thank *Rabat Région Mobilité* for its support in sharing the data required for this study, in particular the GTFS files for the tramway and the job and population data.

References

[1] B. Büttner, S. Seisenberger, B. McCormick, C.Silva, J. F. Teixeira, E. Papa, M. Cao. Mapping of 15-minute City Practices - Overview on strategies, policies and implementation in Europe and beyond, 2024. https://dutpartnership.eu/wp-content/uploads/2024/06/DUT_15mC-Mapping_digital_final.pdf

[2] PMUD Rabat-Salé-Skhirat-Témara. https://www.instagram.com/pmud_rabat_sale_skhirat_temara?igshid=ZDdkNTZiNTM%3D&fbclid=IwY2xjawFT5dtleHRuA2FlbQIxMAABHeTur6_1huPJTtrdTo8Qoh1RuEU1foKndsf3qcREbFHJ7Qhq9oJBtfwYw_aem_TIwVfL4DYvIayFfKbmjjXw, 2024.

[3] P. Frankhauser. Fractalopolis - A Fractal Concept for the Sustainable Development of Metropolitean Areas. *Complex Systems, Smart Territories and Mobility*. Understanding Complex Systems. Springer, Cham. 2021. https://doi.org/10.1007/978-3-030-59302-5_2

[4] M. Morgan, M. Young, R. Lovelace, L. Hama. OpenTripPlanner for R. *Journal of Open Source Software*, Vol. 4, n° 44, pp. 1926, 2019. https://doi.org/10.21105/joss.01926

[5] R. H. M. Pereira, M. Saraiva, D. Herszenhut, C. K. V. Braga, M. W. Conway. R5r: Rapid Realistic Routing on Multimodal Transport Networks with R5 in R. Findings, 2021. https://doi.org/10.32866/001c.21262

MEASURING THE 15-MINUTE CITY A META-STUDY ON THE CONCEPTUAL OPERATIONALISATION AND TECHNICAL APPROACHES TOWARDS MEASURING PROXIMITY-BASED ACCESSIBILITY IN NEIGHBOURHOODS, CITIES AND URBAN REGIONS.

ARNE MARKUSKE *

Technical University Munich (TUM), School of Engineering and Design, Chair of Sustainable Urbanism, Arcisstraße 21, 80333 München, Germany
** corresponding author: arne.markuske@tum.de*

1. Introduction

Since its introduction in 2016 [1], the 15-minute city (FMC) has become a popular model for urban planning and urban design [2]. The central idea is to provide people with all the essential amenities they need in their everyday-life within 15 minutes walking or cycling. This contributes to achieving several sustainability goals, especially *reducing greenhouse gas emissions, promoting active mobility and enhancing public life* [3].

As the concept aligns in many aspects with paradigms of contemporary and sustainable urban planning and urban design such as the *New Leipzig Charta, the C40 Cities Network* has declared the FMC concept a cornerstone for the sustainable transformation of urban regions according to United Nations' *Sustainable Development Goals* [4]. This raises the question how cities and urban regions can actually apply the concept or which policies they need to implement in order to become a 15-minute city or, more general speaking, a city of proximities.

Consequently, especially in recent years after COVID-19, numerous studies have been published investigating questions like *"Is [city] already a 15-minute city?" or "which parts of [city] can already be regarded as 15-minute neighbourhoods?"* or familiar questions. These studies assume that monitoring the alignment of urban regions, cities or neighbourhoods with the proximity-criteria of the FMC can be a first step towards its implementation into urban planning and urban design policies, as it can help to identify deficit areas which should be closer looked at or prioritised by further efforts.

It is important to notice that these studies interpret the FMC as a planning model pursuing proximity-centred accessibility [5] for active modes of mobility . For this reason several studies refer to the conceptual foundations as the 5 dimensions of accessibility introduced by Penchansky and Thomas [6]. However, when taking a closer look at these studies, it becomes obvious that, although continuously referring to Carlos Moreno's concept of the FMC, their operationalisations of the concept differ, as well as from the original concept as among each other substantially. That is why this meta-study compares the FMC definition and methodology of a random selection of 14 studies investigating the question if city X or neighbourhood Y already comply with the FMC concept.

A Meta-Study on the Conceptual Operationalisation and Technical Approaches Towards Measuring Proximity-Based Accessibility in Neighbourhoods, Cities, and Urban Regions

2. Materials and methods

In this meta-study 14 studies (see Table 1) published in scientific journals between 2021 and 2024 on measuring compliance of cities and urban regions with the FMC concept have been analysed regarding their specific conceptual operationalisation of the FMC (definition of accessibility) concept as well as their technical approaches to evaluating proximity-centred accessibility (methodology).

AUTHOR(S), YEAR	SUBJECT
Noworól et al., 2022 [4]	Geographical proximity of Services in Krakow
Abbiasov et al., 2024 [7]	The 15-minute city quantified using human mobility data
Birkenfeld et al., 2023 [8]	Behavioural perspective on 15- / 30-minute city in Montréal
Knap et al., 2023 [9]	Development of a composite cycling accessibility metric demonstrated in case study in Utrecht
Gaxiola-Beltrán et al., 2021 [10]	Assessing urban accessibility in Monterrey (Mexico) at the metropolitan and local levels
Ferrer-Ortiz et al., 2022 [11]	Mapping pedestrian accessibility in Barcelona
Gaglione et al., 2021 [12]	Comparison between 15-minute neighbourhood accessibility in Naples and London
Olivari et al., 2023 [13]	Are Italian Cities already 15-minute? Presenting the Next Proximity Index (NEXI)
Vale & Soares Lopes, 2023 [14]	Comparison of 15-minute pedestrian accessibility in European cities with 100,000 inhabitant or more
Logan et al., 2022 [15]	Evaluating x-minute accessibility in 500 cities in the US and 43 urban regions in New Zealand
Nicoletti, Sirenko & Verma, 2023 [16]	Evaluating the nature and distribution of spatial accessibility among 54 urban communities
Starrico, 2022 [17]	Accessibility to services in Turin
Baletto et al., 2021 [18]	15-minute approach to transforming disused public properties in Cagliari

Table 1. List of the 14 studies from the sample for the meta-study.

2.1. Definition of accessibility

An important precondition for measuring accessibility is to present a definition which operationalises the term for measurement. Therefore, the studies of the sample have been analysed and compared regarding the following questions:

- definition of active mobility (walking, cycling, public transport)
- time threshold for accessibility (5, 10, 15, 20, 30 minutes)
- definition of essential functions, especially if working is considered an essential function
- does the same time threshold apply to all functions or are there different levels of importance or rather urgency resulting in differentiated time thresholds

2.2. Methodology

Regarding the technical details of measuring accessibility, all studies of the sample chose a methodology based on the use of GIS- and statistics software, e.g. *QGIS* and *R*. The following technical details are of importance:

- How is the location of origin defined (e.g. point data of post-addresses, centroids of parcels, building blocks or census blocks, nodes of the street network)
- How is the catchment- or service-area calculated (e.g. Euclidian distance, network distance)
- Which speeds are assigned to the different modes of active mobility (walking, cycling, public transport)

3. Results

Comparing the studies from the sample, two general approaches can be identified: The first approach is to measure accessibility by analysing actual mobility data (n=1) [7] or by analysing mobility surveys (n=2) [8, 9]. The second approach is to analyse the topological proximity of residents to essential amenities (n=13). These numbers do not add up to 14, because Abbiasov et al. (2024) [7] and Knap et al. (2023) [9] combined both approaches and thus were counted in both categories.

3.1. Definition of accessibility

The majority of studies from the sample (11/14) considered only walking as active mobility and defined a 15 minutes time-threshold for their analysis (9/14). Only three studies considered working an essential amenity [8, 9, 10]. That is noteworthy, because in Moreno's original FMC concept working is one of the essential social urban functions. Concerning the other functions the picture is quite diverse. However there seems to be a broad consensus on the point, that supermarkets, primary schools, primary health facilities (11/14) and parks (10/14), kindergartens and playgrounds as well as pharmacies (9/14) are essential social urban functions whereas the status of sports facilities, places of worship and stops or stations of public transport (4/14) as wells as secondary schools (6/14) is more disputed. This is astonishing as the accessibility to public transport is a key issue of reaching destinations beyond the neighbourhood-scale without the use of a private car. Almost all studies applied the same accessibility threshold to all POIs. Only Ferrer Ortiz et al. (2022) [11] developed a more sophisticated model in which different amenities from one category have been assigned different time thresholds, for example five minutes for kindergartens and primary schools and ten minutes for secondary schools. Such differentiations can be an efficient way to mapping the complexity of mobility decisions and considering differing catchment areas of amenities.

3.2. Methodology

In general, two approaches can be distinguished whose methodology will be explained below: First, a supply-based approach (n=5) and, second, a demand-based approach (n=11). These numbers add up to more than fourteen, because some studies [9, 11] combined both approaches. Out of nine studies which applied a strictly demand-based approach – Knap et al. (2023) [9] and Gaglione et al. (2021) [11] excluded – six used centroids of cadastral parcels, urban blocks or census blocks as origins points for the calculation of their service areas, whereas two studies [13, 14] used the nodes of the pedestrian network. Only one study calculated the catchment-area of its service based on the Euclidian distance [4]. The overwhelming majority (13/14) calculated the catchment-area based on the pedestrian- or cycling-network assuming speeds between 3.6 and 5.0 km/h for walking and between 12 and 15 km/h for cycling.

3.2.1. Supply-based approach

Based on the locations of the amenities which shall be accessible within the time threshold using active mobility, the catchment areas of POIs (amenities considered essential by the specific definition of accessibility) are calculated. Depending on the definition of active mobility, only those areas where the catchment areas of all functions overlap are considered accessible or *proximity areas*. This methodology is for example used by Noworól et al. [4] to measure the accessibility in Krakow trying to find correlations with morphological features of different morphogenetic zones of the city.

3.2.2. Demand-based approach

Based on people's places of residence (origin), distances to POIs (destinations) are calculated (O-D). For each category only the distance to the nearest POI is relevant. Depending on the specific definition of active mobility, the largest value among the different POI-categories like, e.g. *education, healthcare, provisioning*, defines the accessibility value for this specific point. For example and according to Logan et al. (2022) [15], if accessibility is defined as being able to reach at least one kindergarten, one supermarket and one public park within 15 minutes walking from home and the next kindergarten is 8 minutes away, the nearest supermarket 14 minutes and the nearest public park only 5 minutes, then the value for this point is 14 minutes, because all needed amenities can be reached within 14 minutes walking from home.

Those accessibility values can then be aggregated to produce an accessibility index for a certain area, e.g. a city, a neighbourhood, or a census block. Depending on the research question it might be useful, if these areas matched with the spatial units in which other necessary data is provided, e.g. statistic cells or census blocks.

4. Conclusions

The meta-study shows that the when measuring the FMC it is generally operationalised as proximity-centred accessibility which can be measured by analysing real mobility behaviour or topological proximity of residents to services in a certain area. The absolute majority of studies from the sample measure accessibility as proximity of services defined as within 15 minutes walking from home, according to the original FMC concept. Whereas the list of amenities considered essential differs significantly among the studies, there is stark agreement on the significance of supermarkets, primary schools, primary health facilities, parks, kindergartens and playgrounds as well as pharmacies. Regarding the technical details of evaluating accessibility most studies opted for a demand-based approach measuring the network-distance from the centroids of census blocks to essential destinations. Several studies have combined their x-minute statistics with other information such as urban morphology, demographics or socio-economic data in order to identify possible correlations and approaches for development, transformation or intervention.

List of symbols

FMC 15-minute city

References

[1] C. Moreno, A. Zaheer, D. Chabaud, C. Gall, F. Pratlong. Introducing the '15-minute city': sustainability, resilience and place identity in future post-pandemic cities. *Smart Cities* 2021(4): 93-111, 2021. DOI: 10.3390/smartcities4010006

[2] G. Pozoukidou, Z. Chatziyiannaki. 15-Minute City: Decomposing the New Urban Planning Eutopia. *Sustainability* 2021(13, 928), 2022. DOI: 10.3390/su13020928

[3] Z. Allam, S. E. Bibri, D. Chabaud, C. Moreno. The '15-Minute City' concept can shape a net-zero urban future. *Humanities & Social Sciences Communications* 9(126): 1-5, 2022. DOI: 10.1057/s41599-022-01145-0

[4] A. Noworól, P. Kopycinsky, P. Hałat, J. Salamon, A. Hołuj. The 15-Minute City—The Geographical Proximity of Services in Krakow. *Sustainability* 2022(14, 7103), 2022. DOI: 10.3390/su14127103

[5] C. Silva, B. Büttner, S. Seisenberger, A. Rauli. Proximity-centred accessibility—A conceptual debate involving experts and planning practitioners. Journal of Urban Mobility 4(2023): 100060, 2023. DOI: 10.1016/j.urbmob.2023.100060

[6] R. Penchansky, W. Thomas. The concept of access: Definition and relationship to consumer satisfaction. *Medical Care* XIX(2): 127–140, 1981.

[7] T. Abbiasov, C. Heine, S. Sabouri, A. Salazar-Miranda, P. Santi, E. Glaeser, C. Ratti. The 15-minute city quantified using human mobility data. *Nature Human Behaviour* 8(2024): 445-455, 2024.

[8] C. Birkenfeld, R. Victoriano-Habit, M. Alousi-Jones, A. Soliz, A. El-Geneidy. Who is living a local lifestyle? Towards a better understanding of the 15-minute city and 30-minute city concepts from a behavioral perspective in Montréal, Canada. *Journal of Urban Mobility* 3(2023): 100048, 2023. DOI: 10.1016/j.urbmob.2023.100048

[9] E. Knap, M. Baran Ulak, K. T. Geurs, A. Mulders, S. van der Drift. A composite X-minute cycling accessibility metric and its role in assessing spatial and socioeconomic inequalities – A case study in Utrecht, the Netherlands. *Journal of Urban Mobility* 3(2023): 100043, 2023. DOI: 10.1016/j.urbmob.2022.100043

[10] A. L. Gaxiola-Beltrán, J. Narezo-Balzaretti, M. A. Ramírez-Moreno, B. L. Pérez-Henríquez, R. A. Ramírez-Mendoza, D. Krajzewicz, J. de-Jesús Lozoya-Santon. Assessing Urban Accessibility in Monterrey, Mexico: A Transferable Approach to Evaluate Access to Main Destinations at the Metropolitan and Local Levels. *Applied Sciences* 2021(11): 7519, 2021. DOI: 10.3390/app11167519

[11] C. Ferrer-Ortiz, O. Marquet, L. Mojica, G. Vich. Barcelona under the 15-Minute City Lens: Mapping the Accessibility and Proximity Potential Based on Pedestrian Travel Times. *Smart Cities* 2022(5): 146-161, 2022. DOI: 10.3390/smartcities5010010

[12] F. Gaglione, C. Gargiulo, F. Zucaro, C. Cottril. 15-minute neighbourhood accessibility: a comparison between Naples and London. *European Transport \ Transporti Europei* 2021(85): 5, 2021. DOI: 10.48295/ET.2021.85.5

[13] B. Olivari, P. Cipriano, M. Napolitano, L. Giovannini. Are Italian Cities already 15-minute? Presenting the Next Proximity Index: A novel and scalable way to measure it, based on open data. *Journal of Urban Mobility* 4(2023): 100057, 2023. DOI: 10.1016/j.urbmob.2023.100057

[14] D. Vale, A. Soares Lopes. Accessibility inequality across Europe: a comparison of 15-minute pedestrian accessibility in cities with 100,000 or more inhabitants. *npj Urban Sustainability* 3(2023):55, 2023. DOI: 10.1038/s42949-023-00133-w

[15] T. M. Logan, M. H. Hobbs, L. C. Conrow, N. L. Reid, R. A. Young, M. J. Anderson. The x-minute city: Measuring the 10, 15, 20-minute city and an evaluation of its use for sustainable urban design. *Cities* 131(2022): 103924, 2022. DOI: 10.1016/j.cities.2022.103924

[16] L. Nicoletti, M. Sirenko, T. Verma. Disadvantaged communities have lower access to urban infrastructure. *EPB: Urban Analytics and City Science* 50(3): 831-849, 2023. DOI: 10.1177/23998083221131044

[17] L. Starrico. 15-, 10- or 5-minute city? A focus on accessibility to services in Turin, Italy. *Journal of Urban Mobility* 2(2022): 100030, 2022. DOI: 10.1016/j.urbmob.2022.100030

[18] G. Baletto, M. Ladu, A. Milesi, G. Borruso. A Methodological Approach on Disused Public Properties in the 15-Minute City Perspective. *Sustainability* 2021(13): 593. DOI: 10.3390/su13020593

ALL IN ALL – IT'S JUST ANOTHER WALK TO THE SCHOOL: UNCOVERING THE LINK BETWEEN EDUCATIONAL ACCESS AND TRAVEL BEHAVIOUR ACROSS PRAGUE'S SUBURBAN AREAS

JAN BITTNER *

Czech Technical University in Prague, Jugoslávských partyzánů 1580/3, 160 00 Prague 6 – Dejvice, Czechia
* *Corresponding author: jan.bittner@cvut.cz*

1. Introduction

Residential car dependency is a significant challenge to achieving sustainable urban mobility, especially in suburban areas. Its negative impacts include energy consumption [1], land-use inefficiency [2], public health [3], deepening socio-economic polarization [4], all hindering the transition to resilient and inclusive urban mobility. This research focuses on Prague's suburban areas, specifically exploring the relationship between accessibility to primary educational amenities and parental transport behaviour, measured through both car dependency and public transport (PT) use frequency.

Urban planning concepts like the 15-minute city [5] or Transit-Oriented Development (TOD) [6] aim to address car dependency by improving access to essential services and amenities, but their real-world impact on transport behaviour, particularly in suburban environments, is still not fully understood. This study adds new insights by examining parental travel behaviour using travel diaries and regression models, focusing on how proximity to primary educational facilities correlates with both car and PT used in the Prague suburban area.

2. Materials and Methods

The dataset comprises geolocated travel diaries from parents living in Prague's suburban areas. The research applies three regression models to analyse parental transport behaviour, focusing on the following dependent variables:

a) Model A: **Car Use Frequency**: Measured on a 5-point scale (> 3 times per week, 1 - 3 times per week, 1 - 3 times per month, < 1 time per month, Never)
b) Model B: **Public Transport Use Frequency**: Measured on the same scale as car use frequency.
c) Model C: ***Ratio between Car and PT Use Frequency***: A matrix-based ratio derived from the car use and PT use scales. See the matrix below.

	PT > 3 TIMES PER WEEK	PT 1 - 3 TIMES PER WEEK	PT 1 - 3 TIMES PER MONTH	PT < 1 TIME PER MONTH	PT NEVER
CAR > 3 TIMES PER WEEK	0.50	0.67	0.90	0.97	0.97
CAR 1 - 3 TIMES PER WEEK	0.33	0.50	0.81	0.94	0.97
CAR 1 - 3 TIMES PER MONTH	0.10	0.19	0.50	0.80	0.97
CAR < 1 TIME PER MONTH	0.03	0.06	0.20	0.50	0.97
CAR NEVER	0.03	0.03	0.03	0.03	NA

Table 1 – Car and PT Use Ratio Matrix

The independent variables across the three models include [1]:

- **Sex** (dummy 1=female)
- **Driving licence possession** (dummy 1=yes)
- **Number of cars in the household**
- **House characteristics** – latent variable based on house type and size
- **Municipal suburban category** – according to suburbanisation zones defined by Ouředníček [7]
- Accessibility ratios for regional centres (PT/car) – latent variable based on accessibility to regional centres defined by the Central Bohemian Regional Plan [8]
- **Accessibility ratios for local centres (PT/car)** – latent variable based on accessibility to local centres defined by the Central Bohemian Regional Plan [8]
- **Respondent workplace accessibility ratio (PT/car)**
- **Municipal population density** – inhabitants per hectare
- **Walk time to the nearest primary educational facility** – categories for walk times ⩽6 minutes, 7–15 minutes, and ⩾16 minutes (base category).

The models (model A, model B, model C) were run for two subsamples: all parents (N=247) and a subsample of parents with known "off-house" workplaces (N=152). This allows for a comparative analysis between general parental travel behaviour and known workplaces.

[1] Other socio-economic variables were also considered (respondent education, age, household income, etc .); however, none of them showed significance in any model.

All in All – It's Just Another Walk to the School: Uncovering the Link Between Educational Access and Travel Behaviour Across Prague's Suburban Areas

3. Results

The results from the three models collectively highlight key factors that shape parental transport behaviour. Several variables consistently influence both car dependency and public transport (PT) use.

In **Model A** (Car Use Frequency), men are more likely to use cars than women, with an estimate of 0.6 for women ($p < 0.01$), indicating a notable gender difference in car use patterns. Having a driving licence strongly increases car dependency, with highly significant estimates of -4.593 ($p < 0.001$) for all parents and -7.426 ($p < 0.001$) for parents with known workplaces, suggesting that possessing a licence is a major determinant of car reliance. The number of cars in a household is another strong predictor of car use frequency, with estimates of -1.123 ($p < 0.001$) for all parents and -0.94 ($p = 0.013$) for parents with a known workplace, reinforcing the idea that car ownership directly correlates with higher car usage. House characteristics, such as size and type, are significant only for parents with known workplaces, with an estimate of -0.5 ($p < 0.1$), indicating that larger or more detached homes may increase car use. The accessibility ratio (PT/car) to regional and local centres also plays a critical role, with estimates of -0.45 ($p = 0.04$) and -0.38 ($p = 0.02$) in the full sample, showing that better public transport access to these centres reduces car dependency. Municipal population density becomes significant when combined with the workplace accessibility ratio (PT/car), reducing car use by an estimated -0.03 ($p < 0.05$). Finally, proximity to educational facilities significantly decreases car use, with estimates of around 1.4 ($p < 0.05$) for both short (<6 minutes) and moderate (7 – 15 minutes) walk times, emphasising the role of school accessibility in reducing car reliance.

In **Model B** (Public Transport Use Frequency), similar patterns emerge. Parents with a driving licence are less likely to use public transport, with estimates of 1.944 ($p = 0.005$) for all parents and 2.492 ($p = 0.006$) for those with known workplaces. The number of cars in a household remains a strong predictor of PT use, with an estimate of 0.44 ($p = 0.005$) for both samples, indicating that more cars lead to less PT usage. Living in more distant suburban areas correlates with lower PT use, with significant estimates of 0.288 ($p < 0.001$) for all parents and 0.195 ($p = 0.04$) for working parents. Interestingly, the regional centre accessibility ratio (PT/car) becomes significant only for the total sample, with an estimated 0.268 ($p = 0.054$). Conversely, municipal population density is significant only for parents with a known workplace, reducing car use by an estimated -0.017 ($p = 0.007$), indicating that denser areas promote public transport use. The workplace accessibility ratio (PT/car) is also important (estimate = 0.278, $p = 0.004$). Educational facility accessibility is essential for parents with known workplaces, where a 7–15 minute walk time has a significant estimate of -0.79 ($p = 0.041$), further supporting the idea that proximity to schools encourages public transport use.

In **Model C** (Car/PT Use Ratio), which focuses on the balance between car and PT use, several findings align with the previous models. Women are more likely to use PT relative to cars, with an estimate of -0.17 ($p < 0.1$) in both subsamples. Having a driving licence increases car use relative to PT, with significant estimates of 2.116 ($p < 0.001$) for all parents and 2.592 ($p < 0.001$) for working parents. Similarly, more cars in a household increase car use relative to PT, with estimates of 0.333 ($p < 0.001$) for all parents and 0.257 ($p = 0.01$) for parents with a known workplace. Suburban living is associated with a higher car/PT use ratio, with an estimate of 0.132 ($p = 0.003$) for all parents, though this effect is not significant for parents with known workplaces. Regional centre accessibility shows the same significance as in Model A, reducing the car/PT use ratio with an estimated 0.15 ($p < 0.001$) for all parents. Municipal population density significantly reduces car

dependency, with an estimate of -0.005 (p = 0.085) for all parents. Finally, workplace accessibility ratio (PT/car) significantly reduces car use relative to PT, with an estimate of 0.125 (p = 0.01), and proximity to schools is crucial in lowering the car/PT use ratio. A 7–15 minute walk time significantly reduces car use relative to PT, with estimates of -0.32 (p = 0.067) and -0.507 (p = 0.02), suggesting that moderate proximity to schools encourages parents to rely more on public transport.

In models B and C, a notable pattern emerged: only the 7–15 minute walk time to educational facilities was significant, while the 0–6 minute category was not. This may suggest that parents living within closer proximity to schools may not need to adjust their transport behaviour, as children residing within a short walking distance (0–6 minutes) are likely permitted to travel independently, thus negating the need for a car journey or public transport accompaniment.

Overall, these results demonstrate the strong correlation of socio-economic factors, built environment characteristics, and educational facility accessibility with parental transport choices.

4. Discussion

The results indicate that educational facility accessibility significantly correlates (along with other built environment variables) with lower car dependency and higher public transport use. However, several limitations should be considered when interpreting these findings. The sample size is relatively small (N=247 and N=152), which may affect the generalizability of the results. Furthermore, while the focus is on educational facilities, the proximity of other amenities, such as shops or healthcare services, could also influence transport behaviour. The categories for car and public transport use frequency in the analysis are broad and not equally spaced, potentially limiting the precision in capturing nuanced transport behaviours. Additionally, this study only considers car and public transport use, excluding other travel modes such as cycling or walking, which could offer further insights into suburban transport behaviour. Finally, the research identifies correlations rather than causal relationships, meaning that other factors, such as individual attitudes or the availability of other amenities, may also be contributing to the observed patterns. Future studies should aim to address these limitations better to understand the complex dynamics between accessibility and transport behaviour.

5. Conclusion

This research proves that proximity to primary educational facilities significantly correlates with parental transport behaviour, reducing car dependency and increasing public transport use. These findings support the integration of educational accessibility into urban planning strategies aimed at promoting sustainable mobility, particularly in suburban areas where car dependency is more prevalent. By addressing both socioeconomic factors and built environment characteristics, cities can create more resilient and inclusive mobility patterns that align with the principles of urban sustainability.

All in All – It's Just Another Walk to the School: Uncovering the Link Between Educational Access and Travel Behaviour Across Prague's Suburban Areas

References

[1] MINDALI, Orit, Adi RAVEH a Ilan SALOMON. Urban density and energy consumption: a new look at old statistics. *Transportation Research Part A: Policy and Practice* [online]. 2004, ***38***(2), 143–162. ISSN 09658564. Dostupné z: doi:10.1016/j.tra.2003.10.004

[2] EUROPEAN ENVIRONMENT AGENCY. a SWISS FEDERAL OFFICE FOR THE ENVIRONMENT (FOEN). *Urban sprawl in Europe: joint EEA FOEN report*. [online]. LU: Publications Office, 2016 [vid. 2023-07-08]. Dostupné z: https://data.europa.eu/doi/10.2800/143470

[3] EWING, Reid, Richard A SCHIEBER a Charles V ZEGEER. Urban Sprawl as a Risk Factor in Motor Vehicle Occupant and Pedestrian Fatalities. *American Journal of Public Health*. 2003, **93**(9).

[4] DE BOER, Enne. *Transport Sociology: Social Aspects of Transport Planning*. Burlington: Elsevier Science, 2013. ISBN 978-1-4831-6060-3.

[5] POZOUKIDOU, Georgia a Zoi CHATZIYIANNAKI. 15-Minute City: Decomposing the New Urban Planning Eutopia. *Sustainability* [online]. 2021, **13**(2), 928. ISSN 2071-1050. Dostupné z: doi:10.3390/su13020928

[6] POJANI, Dorina a Dominic STEAD. Past, Present and Future of Transit-Oriented Development in Three European Capital City-Regions. In: *Advances in Transport Policy and Planning* [online]. B.m.: Elsevier, 2018 [vid. 2023-07-08], s. 93–118. ISBN 978-0-12-815294-2. Dostupné z: doi:10.1016/bs.atpp.2018.07.003

[7] OUŘEDNÍČEK, Martin. *Zones of residential suburbanisation 2016* [online]. [map]. 2016. Dostupné z: https://www.atlasobyvatelstva.cz/cs/zony-2016

[8] *Central Bohemian Regional Plan (Zásady územního rozvoje)* [online]. [map]. B.m.: Středočeský kraj. 2023. Dostupné z: https://kr-stredocesky.cz/web/uzemni-planovani/10.-aktualizace-zasad-uzemniho-rozvoje-stredoceskeho-kraje

BRIDGING CITIES, FOSTERING MOBILITY, SAFEGUARDING NATURE: THE ROLE OF ENVIRONMENTAL MONITORING IN INFRASTRUCTURE PROJECTS

DAVIDE VETTORE *

University of Bergamo, Department of Engineering and Applied Sciences, Viale Marconi, 5, 24044 Dalmine (BG), Italy
** Correspondence: davide.vettore@unibg.it*

1. Introduction

Infrastructure projects are pivotal in enhancing connectivity between cities and people, thereby driving economic growth but also fostering social development and improving urban mobility systems [1, 2, 3]. However, these infrastructure projects can also pose significant environmental risks [4]. This is where the role of Environmental Impact Assessment (EIA) becomes crucial, with environmental monitoring serving as a cornerstone of this process [5]. In the context of modern infrastructure development, environmental monitoring has become a critical tool for ensuring sustainable growth [6]. Environmental monitoring, articulated in, pre-operam, in-operam and post-operam, plays a crucial role in the sustainable management of infrastructure projects ensuring that environmental impacts are not only continuously monitored but also mitigated with implementing actions throughout the entire lifecycle of the project [7].

This research delves into the role of environmental monitoring in infrastructure projects by analyzing three case studies from the SEW-Line Project, an inter-university research initiative involving research units from the Universities of Padua, Bergamo and Rome. In alignment with European directives, the project aims to develop a model that adopts a holistic approach, which is replicable and applicable on various scales, to propose the adaptation, as well as a more suitable planning, of infrastructures [8].

The principal issue addressed in this research is the challenge of balancing infrastructure development with environmental sustainability and urban mobility [9]. Infrastructure projects, especially large-scale ones, inherently lead to environmental changes even if they implement mobility system [4]. However, through rigorous environmental monitoring, it is possible to minimize negative impacts and ensure that projects contribute positively to regional development [7, 10]. The aim is to explore how environmental monitoring has been implemented in the infrastructure projects, evaluate its effectiveness, and find elements for improvement and innovation.

The methodology involves a thorough review of the existing literature, the consultation of project reports, environmental assessment documents and national regulations. These data were used for developing a comparative analysis to evaluate the effectiveness of the monitoring process. The focus has been on identifying recommendations to emphasize a continuous evolution of monitoring technologies and methodologies to further enhance the sustainability of large infrastructure projects.

Bridging Cities, Fostering Mobility, Safeguarding Nature:
The Role of Environmental Monitoring in Infrastructure Projects

2. Discussion and methods

The challenge of balancing infrastructure system and sustainability goals has been analyzed with a comparative analysis of three case studies in urban mobility, highlighting both similarities and differences in the topic of environmental monitoring. These cases were selected based on specific characteristics, such as the project size, the purpose of the project and the different stage of development, to better define an analysis that could compare a wide range of infrastructure projects. Each case has been briefly analyzed, focusing on crucial aspects of the monitoring phase of the during and post-operam phase, like monitoring actions, tools used, environmental parameters measured, results obtained, but it also sought to highlight some strengths, weaknesses, and potential innovations. The data from the pre-operam phase were not considered because they provided the state of the environment and estimated some possible qualitative effects of the project. This study has provided an initial overview of environmental monitoring practices, offering valuable insights to enhance the sustainability of infrastructure projects.

2.1. Case Study 1: BreBeMi A35 Highway

The A35, an alternative route to the A4 Highway, was opened to traffic in 2014 to connect the cities of Brescia, Bergamo, and Milan, from which the name "BreBeMi" originates. It represents a significant infrastructure project aimed at improving regional connectivity [11]. Despite these benefits, the construction and operation of the expressway introduced several environmental challenges, particularly in terms of air quality, noise pollution, and potential soil contamination [12]. To address these concerns, the environmental monitoring plan was implemented and was conducted under the supervision of ARPA Lombardia with the Environmental Observatory, focusing on various environmental factors such as air quality, noise levels, soil and water contamination, fauna, and flora. In Table 1 are reported the overall considerations emerged by this initial analysis.

ASPECTS	DETAILS
Monitoring Actions	Continuous monitoring of air quality, noise pollution and impacts on local ecosystems.
Tools Used	Real-time sensors for detecting NO_X, CO, PM10, and acoustic sensors for noise.
Parameters Measured	Air quality, noise levels, soil and water contamination, fauna, and flora.
Strengths	Real-time data collection, allowing prompt responses to emerging environmental issues.
Weaknesses	Limited biodiversity monitoring; potential underestimation of long-term ecosystem impacts.
Potential Innovations	Development of a more extensive biodiversity monitoring system; integration of new technologies for ecosystem management.

Table 1. Aspects analysed from the BreBeMi environmental monitoring

An interesting aspect was the attention to historical and archaeological pre-existing elements, along with the preliminary risk assessment. It has conducted a preventive investigation to verify these pre-existing elements, then retrieved during the construction process and now preserved in the M.A.G.O museum of Pagazzano, located in the province of Bergamo [13].

The monitoring stations were deployed along the route to continuously collect and register data. The results, as stated from the report [14], indicated that while the highway facilitated faster

travel times and reduced congestion on the A4, air quality remained within acceptable limits, noise levels near residential areas occasionally exceeded the threshold. The overall results of the monitoring will be available when the post-operam monitoring will be completed, and so it will be possible to make more valuable considerations.

2.2. Case Study 2: Mestre A4 Highway Bypass

The Mestre Bypass, opened to traffic in 2009, is one of Veneto's key infrastructures, designed to reduce congestion on the Mestre ring road and separate local traffic from through traffic. [15]

The environmental monitoring plan was conducted by ARPA Veneto coordinated by the Soil and Remediation Observatory Service, focusing on various environmental factors.

Among the different factors, the water quality monitoring was notable for its use of bioindicators to assess the impact on nearby water bodies. In Table 2 are reported the overall considerations emerged by this initial analysis.

ASPECTS	DETAILS
Monitoring Actions	Monitoring of air, water, soil quality, noise levels and biodiversity along the route.
Tools Used	Fixed and mobile monitoring units; use of bioindicators for water quality.
Parameters Measured	Air pollution (NOx, PM), water quality (bioindicators), soil contamination, noise levels.
Strengths	Holistic approach to environmental monitoring; broad coverage of environmental parameters.
Weaknesses	Complex management of soil contamination; need for more effective soil protection strategies.
Potential Innovations	Implementation of integrated soil protection strategies; development of advanced technologies for contaminant monitoring.

Table 2. Aspects analysed from the Mestre Bypass environmental monitoring.

The project was one of the first cases of wildlife monitoring application for the control of large- scale infrastructure construction. It focused on vertebrate species in ecologically valuable areas to assess biodiversity and ensure compliance with European and national environmental laws. During construction, monitoring controlled target populations, while post-construction, it evaluated the effectiveness of mitigation measures [16].

The general results, as stated from the report [17], demonstrated a broad improvement in traffic flow and a reduction in vehicle emissions in the urban area, although some localized increases in soil contamination were observed due to construction activities.

2.3. Case Study 3: Verona-Padova High-Speed/High-Capacity Railway section

The Verona-Padova railway section (1st subsection completed, 2nd ongoing, and 3rd in design phase) is part of the Turin-Milan-Venice railway line, a component of the Mediterranean corridor of the trans-European transport network (TEN-T core network) that will link Spain and Ukraine. The project aims in 2026 to quadruple the railway line, while also relocating the old line where the two tracks come close to each other [18].

The environmental monitoring for this project focused heavily on noise and vibration impacts due to the proximity of the railway to urban centers [19, 20]. Advanced monitoring technologies,

including remote sensing and GIS-based tools, were employed to assess these impacts along the railway corridor. In Table 3 are reported the overall considerations emerged.

ASPECTS	DETAILS
Monitoring Actions	Monitoring of water, soil quality, vibrations and noise levels, and biodiversity along the route.
Tools Used	GIS tools, remote sensors, advanced vibration monitoring technologies.
Parameters Measured	Noise and vibration levels, impacts on urban centers and nearby green areas.
Strengths	Use of innovative monitoring technologies; detailed spatial analysis of environmental impacts.
Weaknesses	Limited monitoring of wildlife impacts; potential underestimation of long-term effects.
Potential Innovations	Introduction of more extensive biodiversity and wildlife monitoring; development of new techniques for vibration management.

Table 3. Aspects analysed from the Verona-Padova Railway section environmental monitoring.

The monitoring for the pre-operam phase, estimated, among other factors, the reduced travel times and improved logistic efficiency. Although, there were reported challenges in managing noise levels, particularly in densely populated areas, but there will be a clearer scenario when the 3rd subsection will be finished, and the monitoring completed.

3. Results and Conclusions

The comparative analysis of these three case studies underscores the pivotal role of environmental monitoring in infrastructure projects. Although each project has made significant strides in mitigating environmental impacts, the analysis reveals areas where improvements and innovations are needed. By addressing these deficiencies and integrating advanced monitoring tools and

RECOMMENDATIONS	DETAILS
Invest in advanced monitoring technologies	Infrastructure projects should invest in the latest monitoring technologies, such as real-time sensors and predictive models, to ensure accurate and timely data collection. (e.g. use of drones and IoT sensors for a more detailed and efficient monitoring)
Implement adaptive management strategies	Projects should adopt adaptive management strategies that allow for adjustments in monitoring and mitigation measures based on real-time data. (e.g. implementation of AI systems on the monitoring program)
Engage local communities	Transparent communication and active engagement with local communities are essential for building trust and ensuring the success of environmental monitoring efforts. (e.g. use of apps for reporting environmental anomalies)
Promote continuous learning	Encourage continuous learning and improvement in monitoring methodologies by staying updated with the latest scientific research and technological advancements. (e.g. public workshop for citizens to explain updates on the monitoring program of a project)

Table 4. Recommendations for environmental monitoring in infrastructure projects.

methodologies, future infrastructure projects could achieve a more balanced development approach, ensuring both environmental sustainability and advancements in urban mobility.

This analysis establishes an initial framework for enhancing environmental monitoring practices. The subsequent step involves planning additional case studies to further advance the goal of sustainable infrastructure development. The findings presented in Table 4 suggest that future infrastructure projects would benefit from adopting more comprehensive monitoring practices, which should include a broader range of environmental parameters such as biodiversity and long-term ecosystem health. Furthermore, the potential for innovation in monitoring technologies – such as the development of sophisticated systems for managing vibrations and soil contaminants – offers a promising avenue for improving the effectiveness of environmental assessments.

In conclusion, while the analyzed projects have effectively enhanced connectivity and fostered socio-economic growth, they also reveal areas where environmental monitoring could be strengthened. By leveraging insights from these case studies, future infrastructure development can achieve a more sustainable balance between economic advancement and environmental conservation, ultimately contributing to a more resilient mobility system.

References

[1] D. Banister, Y. Berechman. Transport investment and the promotion of economic growth. *Journal of Transport Geography* 9(3):209-218, 2001. https://doi.org/10.1016/S0966-6923(01)00013-8

[2] A. Gospodini. Urban development, redevelopment and regeneration encouraged by transport infrastructure projects: The case study of 12 European cities. Eu*ropean Planning Studies* 13(7): 1083–1111, 2007. https://doi.org/10.1080/09654310500242121

[3] E. Cigu, D.T. Agheorghiesei, A.F. Gavriluță, E. Toader. Transport Infrastructure Development, Public Performance and Long-Run Economic Growth: A Case Study for the Eu-28 Countries. *Sustainability* 11(1) 67, 2019. https://doi.org/10.3390/su11010067

[4] W. F. Laurance et al. Reducing the global environmental impacts of rapid infrastructure expansion. *Current Biology* 25(7): R259-R262, 2015. https://doi.org/10.1016/j.cub.2015.02.050

[5] J. Wilson, S. Hinz, J. Coston-Guarini, C. Mazé, J-M. Guarini, L. Chauvaud. System-Based Assessments - Improving the Confidence in the EIA Process. *Environments* 4(4):95, 2017. https://doi.org/10.3390/environments4040095

[6] A.J. Soria-Lara, M.R. Arce-Ruiz, A. Arranz-López, A. Ariza-Álvarez. Chapter Eight - Environmental Impact Assessment for transport projects: A review of technical and process-related issues. *Advances in Transport Policy and Planning* vol 6, pp. 255-285, Academic Press, 2020. https://doi.org/10.1016/bs.atpp.2020.07.002

[7] H. Mollenhauer, M. Kasner, P. Haase, J. Peterseil, C. Wohner, M. Frenzel, M. Mirtl, R. Schima, J. Bumberger, S. Zacharias. Long-term environmental monitoring infrastructures in Europe: observations, measurements, scales, and socio-ecological representativeness. *Science of The Total Environment* vol. 624, pp. 968-978, 2018. https://doi.org/10.1016/j.scitotenv.2017.12.095

[8] C. Dezio, A. Lei, M. Paris. SEW Line. Socio-Ecological Way for a Holistic Mobility Infrastructure Planning in Periurban and Rural Landscape, presentation given at the conference *Motorway Architecture and Landscape Retrospectives and Perspectives between Critique and Design* held at the Politecnico di Milano, pp. 88-89, 2024. https://hdl.handle.net/11573/1707685

Bridging Cities, Fostering Mobility, Safeguarding Nature:
The Role of Environmental Monitoring in Infrastructure Projects

[9] C. Cucuzzella & S. Goubran S. Infrastructure as a Deeply Integrated Sustainable Urban Project. *Journal of Sustainability Research*, vol. 1:e190005, 2019. https://doi.org/10.20900/jsr20190005

[10] R. Bhateria. EIA Procedure - Mitigation and Impact Management. *Environmental Impact Assessment* 47-60. Springer, Cham. 2024. https://doi.org/10.1007/978-3-031-66797-8_5

[11] A. Garzella, M. Perotti. *Analisi dei benefici diretti e indiretti dell'autostrada A35 Brebemi.* Agici Finanza d'Impresa, 2019.

[12] L. Martinelli L. La Brebemi non funziona: il bilancio insostenibile dell'autostrada mangia-suolo, *Altreconomia*. 2022. https://altreconomia.it/la-brebemi-non-funziona-il-bilancio-insostenibile-dellauto-strada-mangia-suolo/

[13] M. Fortunati, C. Giostra. *I Longobardi Del Ducato Di Bergamo*. Soc. Archeologica, 2019.

[14] BreBeMi S.p.a. and CAL S.p.a. *Piano di monitoraggio ambientale*: A35 BreBeMi, 2008.

[15] M. Basso. Nuove infrastrutture e governo degli interessi localizzativi: quale ruolo per la pianificazione? Il caso del Passante autostradale di Mestre, in Veneto. Proceedings of the 15th SIU National Conference *The Changing Urban Planning: Risks and Values*. Planum, The Journal of Urbanism n.25, vol. 2, 2012. https://issuu.com/planumnet/docs/xv_conferenza_siu_by_planum_n.25-2012_atelier_5

[16] P. Turin, S. Tioli, M. Zanetti, A. Lalli. Fauna e monitoraggio delle grandi opere: l'esperienza del Passante di Mestre. *Biologia Ambientale* 27(2), pp. 56-68, 2013. http://www.cisba.eu/images/rivista/biologia_ambientale/Ba2013-2Completo.pdf#page=59

[17] ANAS S.p.a. and CAV S.p.a. *Piano di monitoraggio ambientale: Autostrada A4, variante di Mestre - Il passante Autostradale*, 2006.

[18] T. Cini & G. Siciliano, L'innovazione nei trasporti. I servizi ferroviari ad Alta Velocità/Alta Capacità. *Economia dei Servizi, Mercati, Istituzioni, Management* 1/2008, pp. 85-98, 2008. https://www.rivisteweb.it/doi/10.2382/26333

[19] Consorzio IRICAV DUE, and Italferr S.p.A. *Piano di monitoraggio ambientale: Linea AV/AC Verona-Padova, sub tratta Verona-Vicenza, 1° sub lotto Verona-Montebello Vicentino*, 2015.

[20] Consorzio IRICAV DUE, and Italferr S.p.A. *Piano di monitoraggio ambientale: Linea AV/AC Verona-Padova, sub tratta Verona-Vicenza, 2° sub lotto Montebello Vicentino-Bivio Vicenza*, 2015.

MOBILITY CORRIDORS AND LOGISTICS CLUSTERS IN SUPRA-MUNICIPAL PLANNING: CASE STUDIES ON THE A4 AND A35 MOTORWAYS IN THE PROVINCE OF BERGAMO

EDMONDO PIETRANGELI *

University of Bergamo, Department of Engineering and Applied Sciences,
Viale Marconi, 5, 24044 Dalmine (BG), Italy
**corresponding author: edmondo.pietrangeli@unibg.it*

1. Introduction

This study is part of the research project "SEW Line: Socio-Ecological Way for a Holistic Mobility Infrastructure Planning in Periurban and Rural Landscapes", which seeks to establish a holistic approach for the design of large-scale linear infrastructures in agricultural and periurban landscapes [1]. Within this broader framework, the present study focuses on the development dynamics of integrated land-use functions associated with motorway corridors, particularly in relation to the Logistics System.

This contribution aims to analyse the dynamics of logistics platform development near motorway corridors by examining two distinct case studies that differ significantly in terms of development period, geographical location, and scale. The first case is the logistics cluster surrounding Bergamo – Orio al Serio airport, covering an area of approximately 16 km², which benefits from its proximity to the A4 motorway (Turin – Trieste). In this peri-urban area near Bergamo, industrial and commercial expansion was already well-established between the 1980s and 1990s. The second case is the logistics cluster that has emerged along the A35 "Brebemi" motorway (Brescia – Milan) in the southern part of the Province of Bergamo, in the upper Po Plain. This cluster spans a much larger area, approximately 265 km², and has seen rapid development, particularly since 2015, following the opening of the A35 motorway. This more recent growth has taken place in a period marked by greater awareness of environmental and landscape concerns, as well as within the context of a renewed urban planning vision focused on sustainable spatial management. In contrast, the airport area experienced logistical developments much earlier, within a broader framework that included industrial zones, at a time when socioeconomic paradigms were significantly different from today.

Logistics functions usually tend to form clusters, but the two cases presented here were selected for their distinct reasons for agglomeration. The Cluster Aeroporto, strategically located near the A4 motorway – a key section of two major European routes, the E55 and E70, crucial for continental connections – and to one of Italy's primary airports in terms of freight handling, focuses on both continental and intercontinental traffic while maintaining strong ties with local companies. In contrast, the Cluster Brebemi is more detached from the local business network, prioritizing and servicing long-range routes, and this can also be seen in the differentiation of the types of logistics established.

1.1. Body

In recent decades, rural areas have undergone significant changes due to evolving consumption habits and lifestyles, leading to urban expansion and new forms of urbanization. This has highlighted the need to differentiate between urban and non-urban spaces, with a focus on defining "rural" areas. Current views challenge the traditional urban-rural divide, recognizing these peri-urban areas as "operational landscapes" [2,3] that provide essential services like resource extraction, energy supply, waste management, and logistics, despite not fitting typical urban definitions.

Since the 1980s, the traditional conception of "logistics" has undergone significant transformation due to industrial decentralization and the global division of labor, which has diminished the importance of local production in favor of a globally interconnected network of logistics nodes [4]. Today, logistics encompasses a complex system that manages the production, storage, and transportation of goods on a global scale [5], and that relies heavily on integrated and efficient mobility infrastructures.

The logistics system is structured around mobility infrastructure, logistics nodes such as ports and airports, and goods distribution and management activities, including e-commerce and reverse logistics technologies [6]. This system plays a crucial role in enhancing territorial competitiveness, which is often linked to the logistical attractiveness of a region [7].

Moreover, the expansion of logistics activities presents significant environmental and landscape challenges. Logistics sprawl, particularly in suburban areas, has led to issues such as soil sealing and increased traffic-related pollution. Therefore, a balanced approach to spatial planning that integrates the needs of the logistics sector with environmental and social considerations is essential. Today, logistics can be viewed in a broader context, incorporating services such as goods recycling and other activities that provide environmental benefits [8].

Last-mile logistics, driven by the rise of e-commerce, significantly contributes to urban pollution through increased traffic and CO^2 emissions in city centers. This underscores the growing complexity of logistics and its impact on urban life.

The examination of this topic within the context of the Province of Bergamo has revealed that, despite decades of rapid growth and evolution, the logistics sector faces a significant regulatory gap. This gap exists both in legislation and in urban and territorial planning instruments across all administrative levels, even though the Lombardy Region has recently enacted a law regulating logistics settlements of supra-municipal importance [9]. The location decisions of logistics infrastructures are influenced by municipal choices regarding territorial planning, determining where these facilities can be situated. Each type of logistics infrastructure has specific requirements based on the activities it supports. As logistics infrastructures play a key role in contemporary suburban areas, the decisions made by urban planners will significantly shape the future economic and social geographies of the territory [10].

Given this regulatory void, it is essential to begin with an analysis of existing conditions. The foundation for this study is a report by the Centro Studi sul Territorio (CST) 'Lelio Pagani' of the University of Bergamo [11], which aims to establish a comprehensive framework of knowledge on the logistics system in the Bergamo provincial area.

2. Materials and methods

The methodology employed in this study to analyse logistics and related topics is based on a multidisciplinary approach. Initially, scientific literature review was conducted to familiarize with existing theories and studies on the subject. A foundational database was compiled by data from the above-mentioned report by CST, complemented during an internship at the Territorial Planning and Urban Planning Service of the Province of Bergamo.

To construct a regulatory framework and understand the relevant urban and territorial planning instruments, databases of the Lombardy Region's laws, the Gazzetta Ufficiale of the Italian Republic, and the Official Journal of the European Union were utilized. Furthermore, the Metropolitan Territorial Plan of the Metropolitan City of Milan and the Regole di Piano (Planning Rules) of the Provincial Coordination Territorial Plan of the Province of Bergamo were reviewed.

In addition to this initial data, the study was further developed through detailed cartographic analyses performed using GIS, with databases sourced from the of the Lombardy Region Geoportal. Field surveys were also conducted in the areas under investigation to identify issues related to the integration of different functions and assess the quality of structures. Additionally, dimensional parameters of logistics buildings were recorded, contributing to a hierarchical analysis of spatial dimensions.

3. Results

Logistics geographies in the Province of Bergamo have been categorized by type (Figures 1, 2, and Table 1). Of the 1,016 logistics units, the majority are freight forwarders and hauliers (733 units, 72.1%). Other categories include 164 third-party logistics platforms and warehouses (16.1%), 77 distribution centers (7.6%), 27 postal operators (2.7%), and 15 couriers (1.5%).

In the "Aeroporto" and "Brebemi" clusters, while freight forwarders and hauliers remain dominant (32 units or 57.1% in Aeroporto; 91 units or 69.5% in Brebemi), there are notable differences. The Cluster Aeroporto has a significant number of courier and postal operators, benefiting from proximity to the airport. Conversely, the Cluster Brebemi, situated in a more agricultural area of the upper Po Plain, features a higher concentration of distribution centers, reflecting its more dispersed and less congested space compared to the historically industrialized Cluster Aeroporto.

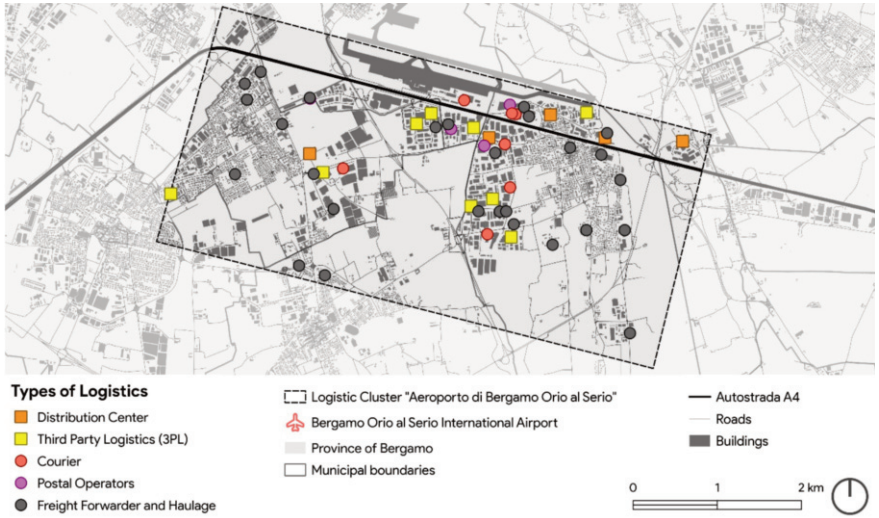


Figure 1. Types of Logistics in Logistic Cluster "Aeroporto di Bergamo-Orio al Serio"

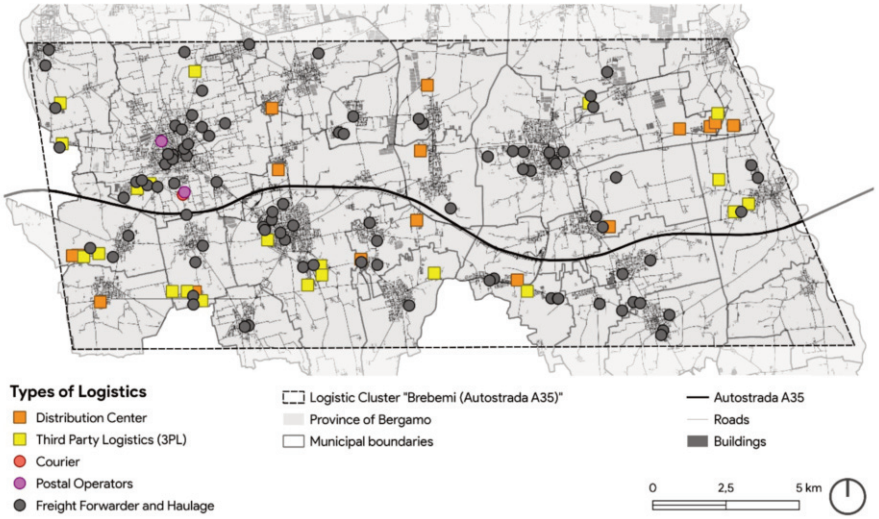


Figure 2. Types of Logistics in Logistic Cluster "Aeroporto di Bergamo-Orio al Serio"

	PROVINCE OF BERGAMO		CLUSTER AEROPORTO		CLUSTER BREBEMI	
	Units	%	Units	%	Units	%
DISTRIBUTION CENTER	77	7,6 %	4	7,1%	16	12,2%
THIRD PARTY LOGISTICS	164	16,1%	9	16,2%	21	16%
COURIER	15	1,5%	7	12,5%	1	0,8%
POSTAL OPERATORS	27	2,7%	4	7,1%	2	1,5%
FREIGHT FORWARDER & HAULAGE	733	72,1%	32	57,1%	91	69,5%
TOTALE	1.016	100%	56	100%	131	100%

Table 1. Number of units of the different types of logistics in the Province of Bergamo and in the clusters Aeroporto and Brebemi..

To better define the territorial framework and assess the impacts of logistics expansion, the land use of the study areas was analysed using the most recent version of the DUSAF database from the Lombardy Region, updated to 2021 (Figures 3, 4, 5).

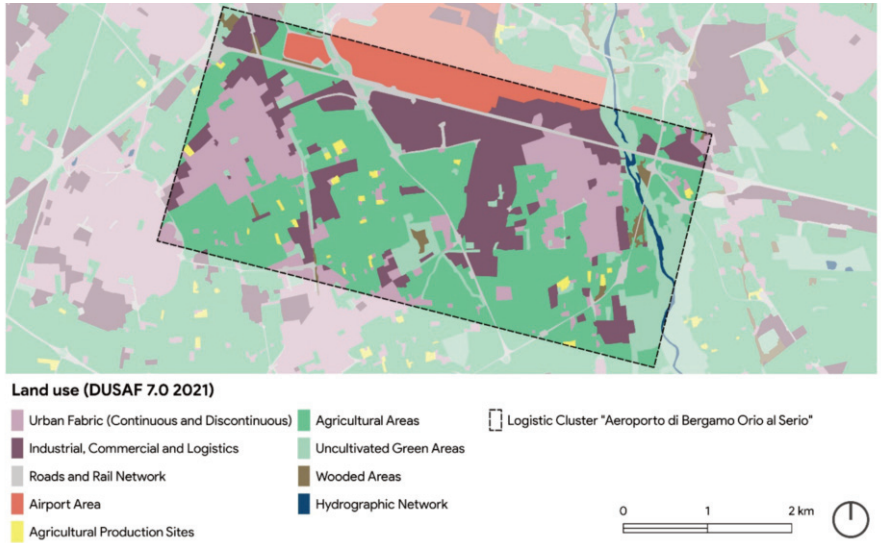


Figure 3. Land Use in Cluster Aeroporto

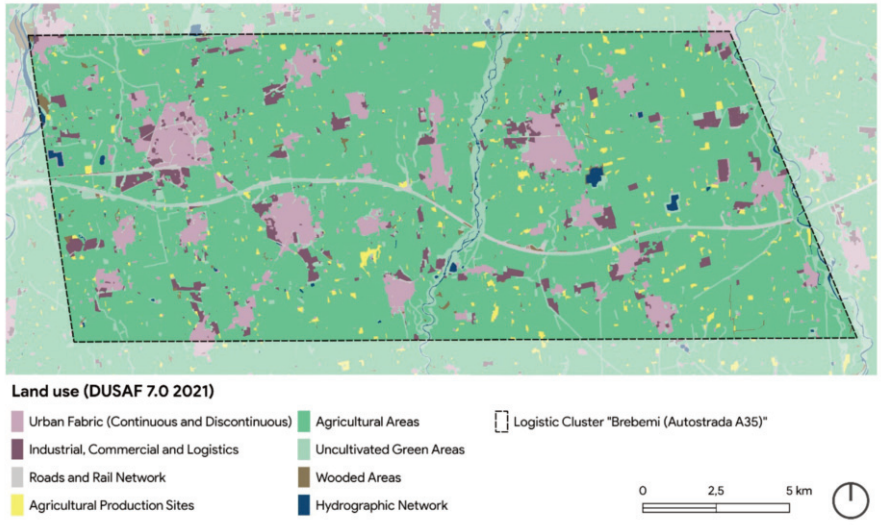


Figure 4. Land Use in Cluster Brebemi

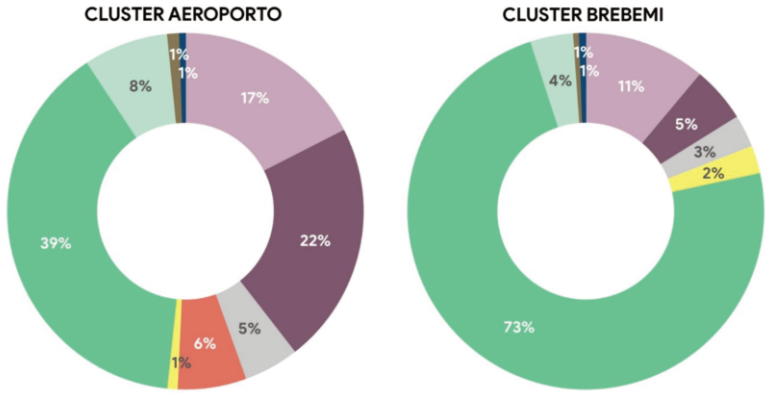


Figure 5. Charts showing land use percentage in the two clusters.

Direct comparison between the two clusters is challenging due to significant differences. However, there is a notable variation in the proportion of green areas (both cultivated and uncultivated) relative to industrial, commercial, and logistics areas, which highlights their locational distinctions. Historical analysis shows an expansion of "purple" areas from 1990, when the A35 motorway project was initiated, through 2015, a year after its operation began, with this expansion continuing to the present.

Additionally, an analysis classifies logistics settlements based on the size of their operational buildings. This hierarchical analysis aims to provide a comprehensive understanding of the significance and functionality of logistics structures according to their scale, offering insights into logistics organization and its territorial impact. The size of the buildings is a crucial indicator for differentiating between various logistics types, such as large-scale platforms and last-mile logistics.

4. Conclusions

Extending this analysis to encompass all logistics clusters within the Lombardy Region could significantly contribute to the knowledge base required to support the new regional legislation on logistics settlements of supra-municipal importance. Specifically, Article 1, paragraph 5, and Article 3, paragraph 1, letter h of the law, emphasize the need for Provinces and Metropolitan City of Milan to provide and update a comprehensive knowledge framework to define suitable areas for logistics location. This analytical approach would not only support the effective application of these legal provisions but would also facilitate the strategic identification of key areas for logistics development. This would ultimately strengthen regional planning efforts, promoting informed decision-making that addresses both current logistical demands and future growth opportunities.

References

[1] M. Paris, C. Dezio, S. Marchesini, E. Pietrangeli. *Linear Infrastructures and Rural Spaces. Pressures, Impacts, and a No-Remedial Design Approaches*. Game Changer? Planning for just and sustainable urban regions AESOP Annual Conference Book of abstracts, 2024. https://hdl.handle.net/10446/275629.

[2] N. Brenner, C. Schmid. Planetary Urbanization. In Implosions / Explosions: Towards a Study of Planetary Urbanization, chap. 11. Jovis, Berlin, 2013. DOI: https://doi.org/10.1515/9783868598933-012.

[3] N. Brenner, C. Schmid. The 'Urban Age' in Question. *International Journal of Urban and Regional Research* 3, 731-755, 2014. DOI: https://doi.org/10.1111/1468-2427.12115.

[4] M. Tadini. Locale e globale nella logistica: effetti economici, necessità infrastrutturali e riflessi territoriali. In *Logistica, intermodalità e territorio. Scenari e prospettive di sviluppo del Piemonte orientale*, pages 19-32. Franco Angeli, Milano, 2013.

[5] C. Cabodi. *Logistica e territorio. I nodi logistici nelle trasformazioni territoriali e nello sviluppo locale dell'area padana*. IRES Piemonte, Torino, 2001.

[6] F. Bosacci. *La nuova logistica. Una industria in formazione tra territorio, ambiente e Sistema economico*. Egea, Milano, 2003.

[7] S. Bologna. Trasporti e logistica come fattori di competitività di una regione. In *Neoregionalismo. L'economia archipelago*, pages 152-186. Bollati Boringhieri, 1998.

[8] G. Aguiari. Che cosa intendiamo per logistica sostenibile? *In Logistica sostenibile: un'occasione di sviluppo e innovazione*, pages 17-27. Franco Angeli, Milano, 2013.

[9] Legge Regionale 8 agosto 2024, n. 15, Disciplina degli insediamenti logistici di rilevanza sovracomunale. [2024-09-02], https://normelombardia.consiglio.regione.lombardia.it/normelombardia/accessibile/main.aspx?view=showdoc&iddoc=lr002024080800015

[10] A. Khalid, R. G. Thompson. Impacts of logistics sprawl on the urban environment and logistics: Taxonomy and review of literature. *Journal of Transport Geography* 57, 255-263, 2016. DOI: https://doi.org/10.1016/j.jtrangeo.2016.08.009.

[11] Centro Studi sul Territorio 'Lelio Pagani'. *Logistica e territorio. Geografie, governance territoriale e strumenti di regolazione/pianificazione. Rapporto finale*. Università degli studi di Bergamo, Bergamo, 2023.

THE IMPACT ON THE LANDSCAPE: LARGE INFRASTRUCTURE CONSTRUCTION SITES AS OPPORTUNITIES FOR TERRITORIAL COHESION

SILVIA MARCHESINI [a,*], CATHERINE DEZIO [a]

[a] *Università degli Studi di Padova, TESAF Department, Agripolis, Viale dell'Università, 16, Legnaro, Padova, Italy*
* *corresponding author: silvia.marchesini.1@phd.unipd.it*

1. Introduction

The research presented, still in development, is part of a project called Sew-Line, coordinated by the University of Padua, along with the University of Bergamo and the University of Rome La Sapienza [1]. The Sew-Line project aims to identify a holistic methodology for the design of large linear infrastructures in agricultural and peri-urban landscapes. Large infrastructures deeply influence landscape perception [2; 3], often appearing disconnected from the landscape, as if they had been placed there without establishing any relationship with it (ibid.).

The study in question concerns one of the case studies of the Sew-Line project: the high-speed/highcapacity line under construction between Verona and Montebello Vicentino[1]. The 44 km stretch between Verona Porta Vescovo and Montebello Vicentino, construction of which began in 2020, traverses an already critical landscape marked by the presence of other transport infrastructures such as the A4 motorway, the historic Milan-Venice railway line, and the Porcilana road. The landscape crossed, characterized by pronounced fragmentation, retains a clear agricultural vocation.

The initiated research focuses on the impact of construction sites on this type of landscape. Construction sites are a strongly impactful feature on landscape perception [4], configuring themselves as marginal, transitional spaces. Their activities have a significant impact from both environmental and social perspectives. Despite their temporary nature, they play a crucial role concerning land consumption, soil quality loss [5], landscape perception [6], and residents' quality of life [7].

The ongoing study aims to develop a design methodology that can leverage the potential for territorial change inherent in construction sites, transforming them from a line of disruption to a line of conversion.

1 The line between Verona and Montebello Vicentino is the first segment of the Verona-Padua and is part of a national and continental strategic context aimed at optimizing rail traffic of people and goods. It is part of the European infrastructure corridors system, TEN-T, with the goal of connecting the most significant logistics and settlement hubs in the European Union by rail (EU Regulation 2024/1979)

2. Body

The study of landscape is a discipline at the intersection of academic research and design research [8] as the landscape itself is a highly mutable element [9], responding to the increasingly rapid changes of the real world [10].

The study begins with the definition of the term "landscape," here understood as the synthesis of human activities on a territory [11; 12]. We considered it important to define the scope within which the landscape fits to delineate the breadth of landscape research. To address the issues related to the multi-sectorality imposed by the meaning of landscape, the research methodology we decided to adopt is Research by Design. This research method is based on the premise that both project and research assume the same elements: awareness, articulation, and acceptance of a problem [13; 14].

First, we formulated the research question: Can a construction site, with its highly disintegrative character, become an element of cohesion and landscape connection?

To answer this, it is necessary to evaluate its impacts, study similar cases, and identify a design strategy that allows for assessing the specific requirements demanded by the broad disciplinary scope of the intervention.

We identified Research by Design as an effective method for managing information from multiple disciplines [15], synthesizing it into a design process that begins with a question, develops with the tools of architects for spatial understanding (data collection, analysis, drawings, mapping, site inspection, scientific literature review, and case studies collection), and aims to conclude, in this case, with a design methodology that manifests as projections of possible future scenarios responding to the initial question [16]. Indeed, design research creates new relationships, possibilities, and, in some ways, new realities [17].

The first step of our research was to analyze and evaluate the extent of soil consumption caused by the construction sites. The assessment of soil type loss is a proxy for identifying the loss of Ecosystem Services, as soil quality and land use are two fundamental indicators for the provision of ES [19].

2.1 Impact Assessment

First, we analyzed the Environmental Impact Assessment documents presented to the Ministry of Environment by IRICAV2 and contacted IRICAV2 and RFI (Italian Rail Network) to access the design drawings, which were provided to us.

We then gathered territorial data related to the project. From the Geoportal of the Veneto Region website, we obtained data on provincial boundaries, buildings, types of agricultural landscapes, and connectivity elements (roads and railways).

We downloaded land use data from Corine Land Cover, in the latest available edition, that of 2018. Finally, using the Google Satellite QGIS layer, we expanded the analysis with data provided by the Satellite Orthophoto.

The data were processed using the QGIS mapping management program to complete the mapping of the construction areas and identify portions of the construction site not accounted for in the Environmental Impact Assessment.

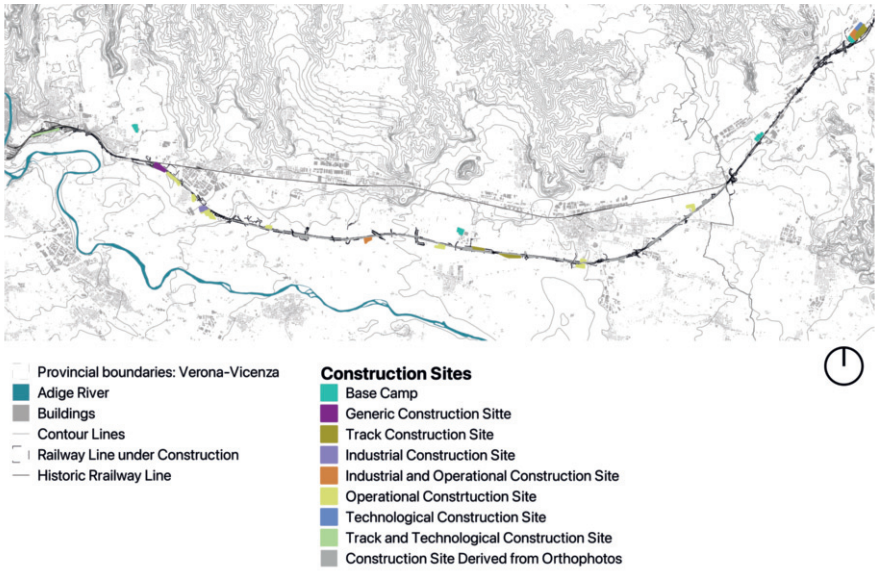
Additionally, we had the opportunity to conduct two site visits to the construction sites under study as part of a Workshop organized by the Sew-Line research in Verona at the end of April 2024. The act of walking is a methodological analysis tool [18] that allowed us to practically identify the impact of construction sites on the territory, soil degradation, and its consumption.

SITE	TYPE OF CONSTRUCTION SITE	AREA (m²)	DURATION (months)	WORK PROCESSES	USE OF LAND	MITIGATION	RESTORATION
Loc. Mattaranetta, Vr	Base Camp	41000	80	-	Agricolo	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of agricultural land
Loc. Campagnetta, Vr	Truck Construction Site	160340	72	AC Railway Line Trucking Construction	Arable Land in Irrigated Areas	Grass-covered dune (2m high) along the perimeter of the construction sitelato nord-est	Restoration of agricultural land
Loc. Campagnetta, Vr	Technological Construction Site	26820	80	Technology Platforms; Substations	Arable Land in Irrigated Areas	Mitigations outside the construction site area. Grass-covered dune along the project line	Restoration of agricultural land
Loc. Campalto, Vr	Operational Construction Site	37439	66	Railway Trench; RRailway; Interferences Management; Tunnel; Extension Manholes e Underpass; Buildings; Deviazioni strade; Retention Baisins	Grass-Covered Areas: Non-Rotational Grasses	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of uncultivated land
Loc. Campalto, Vr	Industrial Construction Site	39758	66	Interferences Management; Tunnel; Extension; Manholes e Underpass; Buildings; Retention Baisins; Railway Overpass; Viaduct	Grass-Covered Areas: Non-Rotational Grasses	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of uncultivated land
Loc. La Funanella, Zevio (Vr)	Operational Construction Site	25580	66	Viaduct; Railway Embankment; Railway Overpass; Manholes; Underpass; Bridge	Arable Land in Irrigated Areas. Fruit trees	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of agricultural land (fruit tree)
Loc. C.Nova, Belfiore (Vr)	Industrial Construction Site	33670	66	Manhole; Railway Overpass; Bridge; Viaduct; Underpass	Arable Land in Irrigated Areas. Vineyards	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of agricultural land(vineyard)
Loc. Castelletto, Belfiore (Vr)	Base Camp	41857	80	-	Area awaiting use designation. Currently uncultivated - fallow land	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of uncultivated land
Loc. La Tacchetta, Belfiore (Vr)	Operational Construction Site	43260	66	Railway Embankment; Railway Overpass; Manhole; Underpass; Bridge; Road Diversions; Restoration of traffic routes; Viaduct	Arable Land in Irrigated Areas	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of agricultural land
Loc. Fossa Bassa, San. Bonifacio (Vr)	Operational Construction Site	51524	66	Viaduct; Deviazione stradale; Underpass; Railway Embankment; Manhole	Arable Land in Irrigated Areas. Vineyards	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of agricultural land(vineyard)
Loc. Fossa Bassa, San Bonifacio (Vr)	Industrial Construction Site	36210	66	Viaduct; Underpass; Manhole; Railway Overpass; Extension Underpass; Station; Retention Baisin	Arable Land in Non-Irrigated Areas.	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of agricultural land
Loc. Corte Bosco, San Bonifacio (Vr)	Operational Construction Site	43680	66	Railway Embankment; Underpass; Manhole; Railway Overpass; Extension Underpass; Station; Retention Baisin; Underpass	Arable Land in Non-Irrigated Areas.	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of agricultural land
Loc. Ca' Bandita, Lonigo (Vi)	Base Camp	45130	80	-	Arable Land in Non-Irrigated Areas.	Grass-covered dune (2m high) along the perimeter of the construction site	Restoration of agricultural land

Table 1: type of construction sites according to the project documents

2.2. Results & Discussion

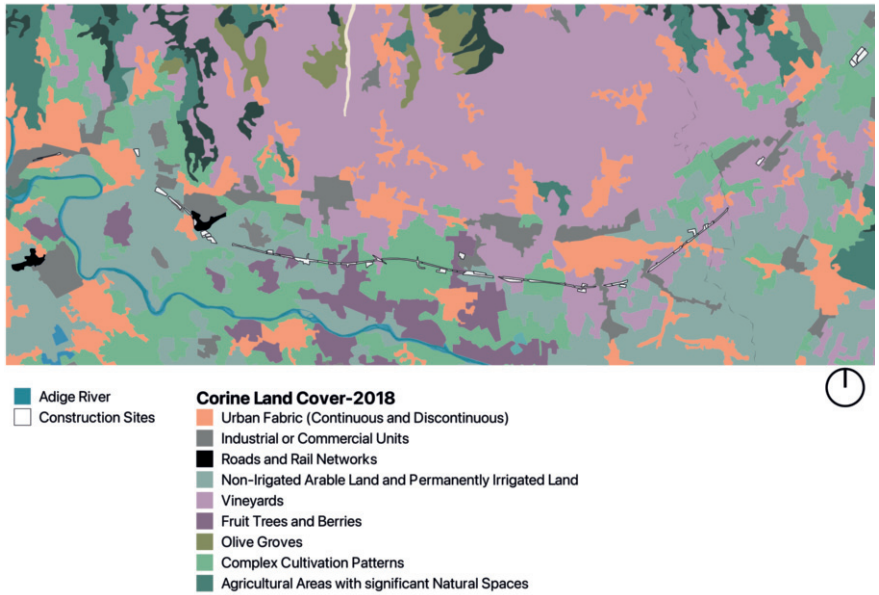
From the study of the documents and design drawings, a discrepancy was found between the project documents and the drawings. The number of construction sites classified in the documents and design drawings (Table 1) is lower than the number of sites mapped from the orthophotos (Map 1). A related issue is the lack of mitigation strategies: the construction sites declared in the project documents are indeed accompanied by an environmental mitigation strategy, which does not appear to be present for those mapped by the research.



Map 1: Mapping of Construction Site

The map is an analysis conducted using QGIS to represent the construction areas of the section. The colored fills represent those derived from the project documents; in gray, instead, are the construction sites inferred and traced from the Google Satellite layer. The territorial data (the historic railway line, contour lines, provincial boundaries, and the course of the Adige River) are sourced from the Veneto Region Geoportal.

We then analyzed and quantified the type of Land Cover affected (Map 2; Chart 1). The majority of the consumed land is agricultural, with a prevalence of non-irrigated arable land and vineyards.



Map 2: Land Cover Types Affected by Construction Sites

The map is an analysis conducted using QGIS to evaluate the types of land cover impacted by the construction sites. The data are sourced from CORINE LAND COVER 2018.

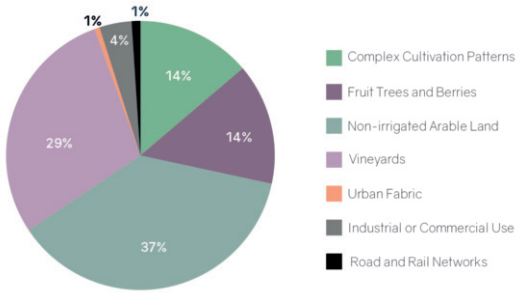


Chart 1: Construction Site Land Consumption based on Land Cover (CORINE 2018)

Processing of territorial data derived from the map: Land Cover Types Affected by Construction Sites.

Out of a total of 2,582,525 m² of construction areas, 66% was determined from the processing and overlay of satellite data, resulting in an increased actual land consumption.

The site visits allowed us to qualitatively assess the impact of the construction sites on the territory, particularly in terms of their disintegrative effect on the land, as well as soil degradation [18] (Images 1 and 2). The visited construction sites appeared as expanses of bare earth where existing trees had been uprooted, separated from the surrounding landscape by orange nets. Soil compaction is a well-known problem concerning soil quality maintenance [19; 20].

Thus, the construction site proved to be a disturbing element from both a perceptual and ecological standpoint.

Figure 1: Construction Site, photograph by the author

Figure 2: Construction Site, photograph by the author

Figure 3: Construction Site, photograph by the author

Figure 4: Construction Site, photograph by the author

The results show that the agricultural land consumption caused by construction activities is a significant factor in the overall impact assessment of the infrastructure. The construction sites affect an agricultural area for 96% of their extent. Land consumption proves to be a problem from many perspectives. Firstly, for the provision of ecosystem services [21], and secondly, for the loss of soil quality. Indeed, agricultural areas are extremely important vectors for providing ecosystem services, especially those related to maintaining ecological integrity [22;23].

Unfortunately, the proposed compensation measures do not seem adequate to offset the damage (Table 1). The mitigation measures presented in the Environmental Impact Assessment do not cover all construction areas, as there are discrepancies between the actual areas and the planned areas, leading to a severe crisis regarding the maintenance of ecological and landscape integrity.

From the site visit to the two construction sites, it was also possible to qualitatively assess their impact on the territory. It is interesting to note how the construction sites indeed function as a buffer zone completely disconnected from the traversed territory. According to the project documents, the previous state will be restored once the sites are decommissioned. However, it will take a significant amount of time for the landscape to return to providing the ecosystem services and environmental, social, and productive functions that were disrupted by the presence of the construction site.

A limitation of the collected results is the partial update of the data, especially those from Google Satellite: the different satellite cells are not all from the same period, so they do not all have the same level of update.

3. Summary

The ongoing study of the AV/AC line construction sites between Verona and Montebello Vicentino, part of the Sew-Line project, highlights the importance of a holistic approach in designing and managing construction sites for large-scale infrastructure. The research reveals a significant impact on the landscape, with 96% of the affected areas being agricultural land. This leads to a loss of productive and environmental functions, contributing to territorial degradation.

A key issue identified is the discrepancy between the construction areas planned in official documents and those observed on-site, which results in inadequate mitigation strategies for some regions. This lack of proper planning threatens ecological integrity and the provision of essential ecosystem services. Site visits provided qualitative insights, showing that construction zones often exist as disconnected marginal spaces, further fragmenting the landscape.

The study calls for a design approach that integrates construction site management into the broader process of territorial transformation. By treating construction sites not merely as temporary disruptions but as opportunities for landscape cohesion and ecological restoration, the negative impacts can be minimized, fostering greater resilience in the affected regions. This proactive strategy could transform construction sites into instruments of territorial regeneration rather than fragmentation.

References

[1] Dezio C., Lei A., Paris M., in pubblication phase, “SEW Line. Socio-Ecological Way for a Holistic Mobility Infrastructure Planning in Periurban and Rural Landscape”, pp. 88-89, intervento presentato al convegno Motorway Architecture and Landscape Retrospectives and Perspectives between Critique and Design tenutosi al Politecnico di Milano;

[2] Shannon K. & Smets M.(2010) Landscape of Contemporary Infrastructure, NaI Publishers. Rotterdam

[3] Morelli, E , 2007, Disegnare linee nel paesaggio. Metodologie di progettazione paesistica delle grandi infrastrutture viarie in "Paesaggio: didattica, ricerche e progetti: 1997-2007. - (Luoghi e paesaggi / Dottorato di ricerca in progettazione paesistica, Università degli studi di Firenze ; 4) -Firenze : Firenze University Press, Firenze;

[4] Arioli A. (2013) Paesaggi in transizione : da vuoto informe a sedime : il progetto dello spazio residuale per la riqualificazione dei contesti di margine, Maggioli, Santarcangelo di Romagna (RN)

[5] Munafò, M. (a cura di), 2022. Consumo di suolo, dinamiche territoriali e servizi ecosistemici. Edizione 2022. Re- port SNPA 32/22;

[6] Ghersi, D., Metodologia per la didattica: l'analisi del paesaggio come fondamento del progetto, in Incontri con il Paesaggio, Genova 2001-2010, Paola Sabbion (a cura di), 2021, Genova University Press; pp. 17-24;

[7] Henningsson, M., Blicharska, M., Antonson, H., Mikusiński, G., Göransson, G., Angelstam, P., Jönsson, S., Perceived landscape values and public participation in a road-planning process – a case study in Sweden, 2014, in *Journal of Environmental Planning and Managemen*t, *58*(4), pp. 631–653, https://doi.org/10.1080/09640568.2013.876391;

[8] Strauf S, Walser M., New Ways through the Alps The New Gotthard Base Tunnel - Impact of a Big Construction Site on a Small Mountain Village, 2005, in 45th Congress of the European Regional Science Association: "Land Use and Water Management in a Sustainable Network Society", 23-27 August 2005, Amsterdam, The Netherlands, European Regional Science Association (ERSA), Louvain-la-Neuve;

[9] Tischer, S., Formazione o sensibilizzazione? Tematizzare il "paesaggio" e "l'architettura del paesaggio", in Studi sul Progetto di Paesaggio, 2010, Franco Angeli, pp. 29-36;

[10] Deming, M. E., & Swaffield, S., Landscape Architecture Research: Inquiry, Strategy, Design, 2011, John Wiley & Sons, Ltd;

[11] Turri, E., Antropologia del paesaggio, 2008, Marsilio Editore;

[12] European Landscape Convention, 2000, Florence;

[13] Steenbergen, C., Mihl, H. and Reh, W., 'Introduction: Design research, research by design', in Steenbergen, C., Mihl, H., Reh, W. and Aerts, FA.M.F., eds. Architectural Design and Composition, 2002, Bussum: THOTH, pp. 12-25;

[14] Koberg. D., J. Bagnall, The all new universal traveler. A soft systems guide to creativity, problem solving, and the process of design, 1976, Rev. ed. Los Altos, CA: W. Kaufans;

[15] Hauberg, J., Research by Design - a research strategy, 2011, AE... Revista Lusófona de Architectura e Educacao, pp. 46-56;

[16] Lenzholzer, S., Duchhart, I. and Koh, J., "Research through designing" in landscape architecture', 2013, Landscape and Urban Planning, 113, pp. 120-127,

[17] Deming, M. E., & Swaffield, S., Landscape Architecture Research: Inquiry, Strategy, Design, 2011, John Wiley & Sons, Ltd;

[18] Schultz, H., van Etteger, R., Walking, in Research in Landscape Architecture: methods and methodology, van den Brink, A., Bruns, D., Tobi, H., Bell, S. (ed), New York, Routledge, 2017, Chapter 11, pp. 179-193

[19] Eigenbrod, F., Armsworth, P. R. , Anderson, B. J., Heinemeyer, A., Gillings, S., Roy, D. B., Thomas, C. D., Gaston, K. J., The impact of proxy-based methods on mapping the distribution of ecosystem services, Journal of Applied Ecology 2010, 4, pp. 377–385, doi: 10.1111/j.1365-2664.2010.01777.x

[20] Randrup, T.B., Dralle, K., Influence of planning and design on soil compaction in construction sites, in Landscape and Urban Planning, Volume 38, Issues 1–2, 1997, pp. 87-92;

[21] Alberty, C.A., Pellett, H.M., Taylor, D.H., Characterization of Soil Compaction at Construction Sites and Woody Plant Response, 1984, J. Environ. Hart. 2 (2), pp. 48-53;

[22] Pfieffer, C.A., Wott, J.A., Clark, J.R., Analyses of Landscape Design and Maintenance Requirements in Urban Parking Lots, 1987, J. Environ. Hart. 5, 41, pp. 188-192;

[23] Munafò, M. (ed.), Land consumption, territorial dynamics, and ecosystem services. 2022 Edition, 2022, SNPA Report 32/22;

[24] Burkhard, B., Kroll, F., Müller, F., Windhorst, W., Landscapes' Capacities to Provide Ecosystem Services – a Concept for Land-Cover Based Assessments, 2009, in Landscape Online 15(1), pp. 1-12, DOI. 10.3097/LO.200915;

[25] Koschke, L., Fürst, C., Lorz, C., Frank, S., Makeschin, F., Using a multi-criteria approach to fit the evaluation basis of the modified 2-D cellular automaton Pimp Your Landscape, 2010, In: Azevedo, J.C. (Ed.), Forest Landscapes and Global Change- New Frontiers in Management, Conservation and Restoration. Proceedings of the IUFRO Landscape Ecology Working Group International. Braganc¸a, Portugal, p. 104

PUBLIC PRIVATE PARTNERSHIPS & FRAGMENTATION OF PUBLIC TRANSIT SERVICES: LESSONS ON GOVERNANCE CHALLENGES & SOLUTIONS TO IMPLEMENTING INTEGRATION MECHANISMS

DAVID WEINREICH [a, *], KAREL MARTENS [a, b]

[a] *Faculty of Social Sciences, University of Bergen in Bergen, Postbox 7802, 5020 Bergen, Norway*
[*] *corresponding author: david.weinreich@uib.no*
[a, b] *Faculty of Architecture and Town Planning, Technion-Israel Institute of Technology, Israel*

1. Introduction

A high level of integration of public transport services in terms of scheduling, ticketing, and cross-operator data provision and others is crucial to provide a high level of service to potential users. Transport integration issues are a growing need as transport providers consider low cost ways of increasing ridership following the travel pattern disruptions exacerbated by the recent pandemic, along with the equity and accessibility barriers created by poorly-integrated transit systems.

Particularly in Europe, there has been increasing privatization of services, which are tendered to private operators that bid in a competitive process, though public authorities often retain the power to define such services [1]. This has created operator fragmentation [1], and requires further research on cross-operator service integration. Previous scholarship has found that larger tenders and more integrated tenders should, over time, facilitate further cooperation [2], but more research is needed on the process for developing such tenders, how its ability to overcome transport fragmentation is influenced by the centralization of the process and the centralization of government decision making [3]. Israel presents a case with a highly centralized transport decision making process that will add to existing literature on tendering and transport fragmentation.

The challenge of delivering an integrated system has increased over the past decades, due to the (gradual) privatization of public transport services over multiple private public transport providers in many countries. Israel is one of the countries that have followed this path since the early 2000s, with the public tendering process resulting in the fragmentation of services from merely 2 into 17 bus operators.

In this paper, we study the tendering reforms in Israel and their cross-operator integration policies to learn from how they addressed operational barriers to coordination created by the increase in operators; and the institutional factors that facilitated or hindered service integration through managed competition. The Israeli case is compelling for this analysis because it involved a national tendering process in multiple metro regions, including intercity buses. The lack of strong local transit agencies illustrates the possibilities for a fully integrated tendering system, though strong local governance in other countries would make certain accomplishments more difficult.

We argue these policies should be of interest in other countries, but Israel's governance structure facilitated their implementation.

2. Materials and Methods

In this paper, we use document analysis as well as interviews with key members of the national government, private consultants, private operators and municipalities, to understand how the Israeli tendering process fragmented services into 17 operators, but also developed ways to integrate them. The study uses this information to understand the role of formal institutions in coordinating schedules, integration of fares and fare cards, shared use of terminals, and cross-operator data sharing across the country. We identify a number of ways integration was enhanced in each category, with the national government making use of its strong leverage over private operators. We also highlight the limitations of this approach due to the separate management of bus and rail services within the national government. The study closes with findings that Israel has achieved coordination despite a large amount of private ownership and fragmentation across operators. Flexibility over time has helped to refine this coordination with each new tender. However the results have been confined to the bus system, with poor coordination across modes (bus/rail), and results that are unsatisfactory to local municipalities, which are often not included in the decision making process. In this case, the use of a higher level of government to effect coordination has been effective, though it has also impeded their ability to adapt to local needs.

We followed standard research methodology for qualitative interviews outlined by Yin [4]. Interviews were conducted from 2022-2023. The interviews were semi-structured and followed a standard interview guide. Most interviews lasted between 1-2 hours. All were recorded and transcribed with the interviewees' permission, and anonymized. Interviewees included agency directors in the national government, private operators, consultant companies hired to write tenders for the government, municipal elected officials, and NGOs advocating for public transit riders. Interview findings were coded by topic area and compared with information from official government decisions and a state comptroller report auditing the tenders, their impacts and implementation [5].

3. Results and Conclusions

This paper identifies integration methods that were seen as necessary and possible to integrate private services regulated by a public-private partnership through a national tendering program. These included 1) *de facto* schedule coordination through high frequency of services; 2) fare equalization progressively expanding across clusters and nationally; 3) terminal sharing including regulation of private terminals and development of public transit terminals ; and 4) cross-operator data sharing, which provided the foundation for national fare equalization policies, universal national bus arrival signage and other means of relaying integrated multi-operator real time information to riders. The national regulatory structure clearly facilitated the level of integration, and indicates the possibilities for integration of multiple operators in a centrally-managed tendering process. We could surely imagine such integration happening at the state/provincial or regional level in a country with stronger local authorities, though the process would be more complex.

Some examples of this appear even in the centralized system we examined. We find limits to integration at the fault lines in Israel's governance structure: Bus operators did not follow the schedule without sufficient monitoring and schedule coordination did not encompass bus and rail (managed by a separate corporation). Rail joined the fare card last, and rail was not included in the

fare equalization reforms. The failure to include Israel Railways in the tendering program is an example of how separate government agencies make it difficult to integrate tenders across them, just as [6] found was the case in Copenhagen.

By contrast, the tendering process facilitated service integration by giving the Ministry of Transport and the Ministry of Finance significant and progressively increasing leverage over private operators. This paper confirms the hypothesis from [6] that larger tenders at higher levels of government (e.g. regional, provincial/state or national) provide advantages for integration of services. We might imagine it would be very difficult for a local government to accomplish strong integration, for example. Higher levels of government provide more leverage on operational subsidies and regulation to require universal standards on fares and fare media, terminals, and information, making questions of hierarchy or rigidity of the power structure between the Public Transport Authority and private operators less of a concern than in the cases studied by [6], due to the Israeli national government's significant leverage.

With regard to management at higher levels of government, specifically, we find here that there were two important benefits to managing integration at the national or state level: 1) Since higher level management captures most travel, the share of traffic crossing a jurisdictional border is rather limited. The share of trips that cross jurisdictional lines would increase as we go down the levels of government. 2) Higher levels of government have the most authority to set rules for private providers including rules requiring integration, while local or regional governments have to act according to those rules. Implementation of these rules is strengthened by higher levels of government and their greater ability to collect taxes, subsidize services, and use those subsidies as leverage to require policy changes in the tenders, including cross-operator integration. However the important drawback is the lack of ability to tune decisions to local needs, which may make the national level, as we saw in Israel, too high a level for most places, though it offers a number of lessons on strategies and types of multi-operator integration that lower levels could strive for.

A continuing theme was the importance of gaining leverage in order to effect integration policies that may be undesirable or unprofitable for a single operator to perform independently, but were beneficial to ridership when implemented by all operators.

Acknowledgements

Dr. Weinreich's work was supported by a Fulbright Postdoctoral Research Fellowship at Technion-Israel Institute of Technology, and by the Centre for Climate and Energy Transformation at the University of Bergen. We would also like to thank the Fulbright Israel program for its support and assistance. We thank Felix Shakhman of Netivei Ayalon Ltd. for generously sharing data on public transport ridership. We also thank Gil Yaacov, Ya'ara Tsairi and Saadi Diana for helping reach out to key contacts.

Public Private Partnerships & Fragmentation of Public Transit Services:
Lessons on Governance Challenges & Solutions to Implementing Integration Mechanisms

References

[1] Pettersson, F., & Hrelja, R. (2020). How to create functioning collaboration in theory and in practice–practical experiences of collaboration when planning public transport systems. *International Journal of Sustainable Transportation*, 14(1), 1-13. https://doi.org/10.1080/15568318.2018.1517842

[2] Veeneman, W., & Van de Velde, D. (2014). Developments in public transport governance in the Netherlands: A brief history and recent developments. *Research in Transportation Economics*, 48, 41-47. https://doi.org/10.1016/j.retrec.2014.09.030

[3] Veeneman, W., & Mulley, C. (2018). Multi-level governance in public transport: Governmental layering and its influence on public transport service solutions. *Research in Transportation Economics*, 69, pp. 430-437.

[4] Yin, R. K. (2009). *Case Study Research: Design and Methods* (Vol. 5). Sage.

[5] State Comptroller and Public Complaints Commission, March 13, 2019, "Promotion of public transportation services in buses: Special report the public transport crisis." https://www.mevaker.gov.il/sites/DigitalLibrary/Documents/special/2019-Transport/2019-Transport-400-Otobusim.pdf

[6] Veeneman, W. (2002). Mind the Gap: *Bridging the Theories and Practice for the Organisation of Metropolitan Public Transport*. Delft University Press.

CRISES AND SUSTAINABLE URBAN TRANSPORTATION: SYSTEMATIC LITERATURE REVIEW

SOGOLOV ILYA [a, *], OSMA BLANCO DIANA FERNANDA

[a] *Technische Universität Berlin, Zentrum Technik und Gesellschaft, Kaiserin-Augusta-Allee 104, 10553 – Berlin, Germany*
* *corresponding author: sogolov@ztg.tu-berlin.de*

1. Introduction

The recent COVID-19 pandemic, and the economic crisis of 2008 are some of the more recent examples of major disruption on a global scale. Mobility practices are often rooted in habits or routines rather than a rational decision-making process and are usually resistant to change [1]. External events such as strikes and protests or natural hazards may disrupt them and represent a window of opportunity for change. The purpose of this paper is to review the literature published on the possible long-term impacts of crises on mobility. It examines 47 peer-reviewed journal articles, 3 non-refereed reports, and other grey literature sources that were published between the years 2009 and 2024 covering two major crises, namely the economic crisis of 2008 onward and the COVID-19 pandemic and touches on the ongoing war in Ukraine. The short-term effects of a crisis are reviewed, and more importantly, the long-term effects after the presumed end of the crisis are addressed. In the final analysis, the main reasons for a long-term change in mobility patterns or the lack thereof will be discussed.

2. Literature and background

Crisis, as an interdisciplinary concept, can be encapsulated by "temporality, spatiality, and scale" [2]. Therefore, it is bound to a specific time and space. Thus the 2008 economic crisis and the COVID-19 pandemic are counted as crises. Both events had an impact on mobility on a global scale, forcing individuals and communities to adapt. Both crises emphasized existing inequalities and while being different across most parameters mark the vastest global crisis of the current century with the exclusion of the ongoing climate crisis. The beginning of the pandemic and its end are marked by decisions of the World Health Organization [3] for the purpose of this study. The 2008 economic crash was marked by a series of economic events and its boundaries are defined by data from the European Parliament [4].

Sustainable modes such as cycling have been shown to increase the resilience of urban populations in various crises. This is demonstrated in the case of plummeting petroleum prices [5]. During the 2020-21 pandemic, bike sharing contributed to the resilience of local mobility in cities such as Lisbon [6], Brussels [7], New York [8], and enhanced the resistance of transport systems in the case of the shutdown of major public transport systems [9]. Thus, promoting active mobility in times of relative calm may prove beneficial during harsher times.

The long-term effects of crises on mobility behavior have been researched several times in the past [10, 11]. The economic crisis of 2008 is a well-studied case though not from a mobility

perspective. Before the end of the 2020 pandemic, such attempts had not been made systematically and covered only the pandemic itself [7]. Comparisons of the effects of various crises on mobility are also nowhere to be found in the literature. This work is an attempt to systematize such phenomena and draw conclusions leading toward better crisis adaptation and goal-oriented reconstruction efforts in crisis-stricken areas.

2.1. Research question

The systematic review is set to aggregate the main findings in the literature on the long-term impact of economic crises on sustainable urban transportation systems.

- Which modes of urban transportation are most affected by each crisis?
- What insights can be inferred from the literature regarding the lessons learned and best practices of crises and their impact on sustainable urban transportation?
- How have crises influenced sustainable transportation initiatives in urban areas?
- What are the key differences and similarities in the individual and collective response to each type of crisis (economic crisis and pandemic)?
- What are the gaps in the literature on crises and sustainable urban transportation?
- **Did any mobility changes that accrued during crises persist after it was over and why?**

3. Materials and methods

An initial and a complimentary search were conducted in 2023 and 2024 respectively. The initial search yielded 847 papers and was reduced to 508 unique entries after the removal of duplicates. Next, the titles were screened to exclude papers unrelated to mobility or crisis, resulting in 53 relevant items. This process was repeated in 2024. Screening by title resulted in 97 papers from this search, and 84 articles after the results of both searches were merged.

During the screening process, some of these 84 were excluded based on their abstracts, while others required full-text screening. Ultimately, 50 relevant articles were identified, with 47 from database searches and 3 from other sources. Figure 1 details the PRISMA protocol [12] followed for the selection of peer-reviewed articles and the exclusion criteria.

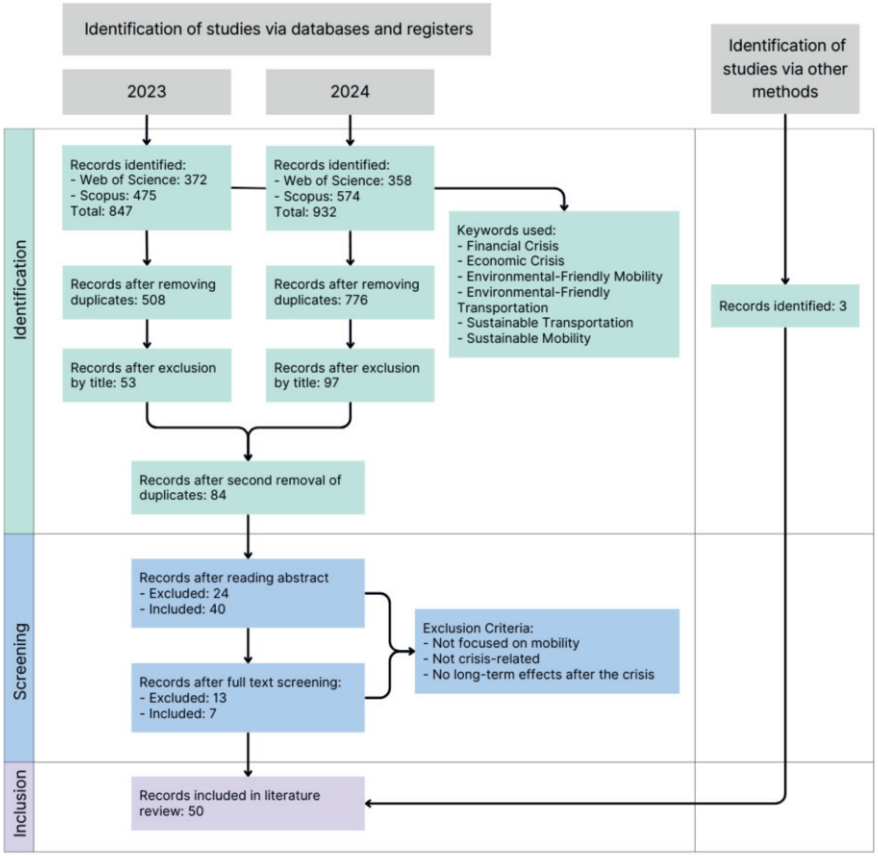


Figure 1. PRISMA diagram on the protocol of the systematic literature review

4. Preliminary Results

This literature review shows mobility changes occurring after and during the economic crisis of 2008 and the COVID-19 pandemic. Both crises lasted around two years and had a great variation of impact between countries and regions. The articles examined in the review were published between 2009 and 2024. Changes in all modes are examined in each crisis separately, however, special attention is given to changes in sustainable modes. The studies cover a worldwide sample. Europe and North America are the most frequently studied locations in the selected literature. Papers also include studies from Australia and Latin America.

Around 50% of the reviewed studies deal with the consequences of the economic crisis and 40% discuss the pandemic. Another 10% of the articles feature both crises. The methodologies employed exhibit a wide range of approaches including Empirical Case Studies, Quantitative Modeling, Systematic Literature Reviews and Documentary Analysis, Forecasting and Demand Analysis, Policy Review and Analysis and Survey-Based Analysis.

Around 60% of the studies directly measure or predict mobility changes as the goal of their research and the rest mention long-term mobility changes as part of general findings or as the new status quo. Only 25% of the studies present direct results of measurements for permanent mobility changes while the others provide predictions and projections of long-term mobility changes based on surveys conducted during or after the crisis or on synthesis of their findings.

As the COVID-19 pandemic had more vivid long-term effects on everyday life these are also reflected in mobility changes during and after the crisis. The pandemic was also better scrutinized by studies of mobility and by systematic reviews. Thus a comparison of post-crisis changes between the economic crisis of 2008 and the recent pandemic is fascinating despite being asymmetric as during the pandemic more explicit mobility policies were introduced, having the potential to support a long-term change.

An overall increase in cycling in many cities [7], and a clear increase in remote work (5 percentage points in the EU [13, 14]) was found. The COVID-19 crisis also provided communities with an opportunity to expand cycling infrastructure as streets were devoid of cars. This includes major cities in Australia [15], major metropolitan areas in the Philippines [16], and a wide selection of European and North American cities [7, 17, 18]. Such infrastructure improvements included the opening of new bike lanes and the widening and enhancement of the safety of existing ones. Rail transportation has been severely hit during the pandemic however it experienced a steady recovery of 16.6% in 2021 compared to 2020, and 2022. Much of the recovery was attributed to active policies by France [19] and Germany [20].

4.1. Key findings and themes identified

The effects of crises on mobility, as examined in the literature, reveal significant shifts in travel behavior, modal choices, urban planning strategies, as well as budget constraints and resource allocation. The economic crisis resulted in reduced trips and a modal shift to cycling and public transport in some regions [10]. However, the mobility shift only lasted as long as the crisis [10]. In both types of crises, public transportation suffered for different reasons. Remote work and changes in urban form are especially prominent after the pandemic. Some studies note that the changes in mobility behavior during crises might dissipate as the economy recovers, while others suggest these shifts may indicate longer-term trends toward more sustainable transportation. The long-term effects that have outlasted the crises have yet to be fully reviewed. More conclusive results of this review will be ready to present at the upcoming conference in November. The next steps in the research include full-text reading and the extraction of relevant post-crisis effects and the circumstances leading to them.

5. Preliminary Conclusions

Mobility changes during the crisis have a nature of emergency responses and reflect the type of crisis at hand. After the crisis has subsided a return to normality is often the most expected outcome. However, under certain circumstances, new habits and behaviors formed as crisis behavior are consolidated and carried on to the new normality. Such changes are unlikely to consolidate on their own. They rather appear with the help of new policies and developments. Pop-up bike lanes during the pandemic [21] and street interventions [22] are the best examples of such helping measures. Understanding the factors leading to long-lasting changes in favor of sustainable mobility will serve policy management for the mitigation and recovery from future crises.

Acknowledgements

This work was supported by the Elsa Neumann Scholarship. The author would like to thank Professor Hans-Luidger Dienel for his supervision and the Zentrum Technik und Gesellschaft (TU Berlin) for hosting the author as an affiliated researcher.

References

[1] K. Marechal. Recasting the Understanding of Habits for Behaviour-Oriented Policies in Transportation. Sustainability 10, no. 4 (2018): 899. https://doi.org/10.3390/su10040899.

[2] A. Bergman-Rosamond, T. Gammeltoft-Hansen, M. Hamza, J. Hearn, V. Ramasar, H. Rydstrom. The Case for Interdisciplinary Crisis Studies. *Global Discourse* 12 (March 13, 2020). https://doi.org/10.1332/204378920X15802967811683.

[3] World Health Organization. Coronavirus Disease (COVID-19) Pandemic. Overview, 2024. https://www.who.int/europe/emergencies/situations/covid-19.

[4] European Parliament. A Decade on from the Crisis: Main Responses and Remaining Challenges, October 2019. https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/642253/EPRS_BRI%282019%29642253_EN.pdf.

[5] M. S. Smith, G. Kauermann. Bicycle Commuting in Melbourne during the 2000s Energy Crisis: A Semiparametric Analysis of Intraday Volumes. *Transportation Research Part B: Methodological* 45, no. 10 (2011): 1846–62. https://doi.org/10.1016/j.trb.2011.07.003.

[6] J. F. Teixeira, C. Silva, F. Moura e Sá. The Strengths and Weaknesses of Bike Sharing as an Alternative Mode during Disruptive Public Health Crisis: A Qualitative Analysis on the Users' Motivations during COVID-19. Transport Policy 129 (December 1, 2022): 24–37. https://doi.org/10.1016/j.tranpol.2022.09.026.

[7] R. Buehler, J. Pucher. Cycling through the COVID-19 Pandemic to a More Sustainable Transport Future: Evidence from Case Studies of 14 Large Bicycle-Friendly Cities in Europe and North America. Sustainability 14, no. 12 (June 14, 2022): 7293. https://doi.org/10.3390/su14127293.

[8] H. Wang, R. B. Noland. Bikeshare and Subway Ridership Changes during the COVID-19 Pandemic in New York City. Transport Policy 106 (June 1, 2021): 262–70. https://doi.org/10.1016/j.tranpol.2021.04.004.

[9] S. Shen, C.-X. Lv, H. Zhu, L.-J. Sun, R.-C. Wang. Potentials and Prospects of Bicycle Sharing System in Smart Cities: A Review. IEEE Sensors Journal 22, no. 8 (April 2022): 7519–33. https://doi.org/10.1109/JSEN.2022.3160178

.

[10] A. Papagiannakis, I. Baraklianos, A. Spyridonidou. Urban Travel Behaviour and Household Income in Times of Economic Crisis: Challenges and Perspectives for Sustainable Mobility. Transport Policy, Household transport costs, economic stress and energy vulnerability, 65 (July 1, 2018): 51–60. https://doi.org/10.1016/j.tranpol.2016.12.006.

[11] Y. Lee, G. Circella, P. L. Mokhtarian, S. Guhathakurta. Are Millennials More Multimodal? A Latent-Class Cluster Analysis with Attitudes and Preferences among Millennial and Generation X Commuters in California. Transportation 47, no. 5 (October 1,2020): 2505–28. https://doi.org/10.1007/s11116-019-10026-6.

[12] S. Pahlevan-Sharif, P. Mura, S. N. R. Wijesinghe. A Systematic Review of Systematic Reviews in Tourism. Journal of Hospitality and Tourism Management 39 (June 1, 2019): 158–65. https://doi.org/10.1016/j.jhtm.2019.04.001.

[13] Eurostat. Working from Home across EU Regions in 2020, September 23, 2021. https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210923-1.

[14] Eurostat. Employed Persons Working from Home as a Percentage of the Total Employment, by Sex, Age and Professional Status (%). Statistics, June 13, 2024. https://ec.europa.eu/eurostat/databrowser/view/lfsa_ehomp/default/table?lang=en.

[15] Infrastructure Australia. Infrastructure beyond COVID-19, 2020. https://www.infrastructureaustralia.gov.au/publications/Infrastructure-beyond-COVID.

[16] V. Sunio, I. Mateo-Babiano. Pandemics as 'Windows of Opportunity': Transitioning towards More Sustainable and Resilient Transport Systems. Transport Policy 116 (February 1, 2022): 175–87. https://doi.org/10.1016/j.tranpol.2021.12.004.

[17] S. Kraus, N. Koch. Provisional COVID-19 Infrastructure Induces Large, Rapid Increases in Cycling. Proceedings of the National Academy of Sciences 118 (April 13, 2021): e2024399118. https://doi.org/10.1073/pnas.2024399118.

[18] B. Lin, T. C. Y. Chan, S. Saxe. The Impact of COVID-19 Cycling Infrastructure on Low-Stress Cycling Accessibility: A Case Study in the City of Toronto. Findings, February 11, 2021. https://doi.org/10.32866/001c.19069.

[19] Eurostat. Railway Passenger Transport Statistics - Quarterly and Annual Data. Eurostat, November 29, 2023. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Railway_passenger_transport_statistics_-_quarterly_and_annual_data.

[20] Bundesregierung. Deutschlandticket: Fragen Und Antworten | Bundesregierung. Die Bundesregierung informiert | Startseite, July 17, 2024. https://www.bundesregierung.de/breg-de/aktuelles/deutschlandticket-2134074.

[21] S. Becker, D. von Schneidemesser, A. Caseiro, K. Götting, S. Schmitz, E. von Schneidemesser. Pop-up Cycling Infrastructure as a Niche Innovation for Sustainable Transportation in European Cities: An Inter- and Transdisciplinary Case Study of Berlin. Sustainable Cities and Society 87 (2022): 104168. https://doi.org/10.1016/j.scs.2022.104168.

[22] K. Gregg, P. Hess, J. Brody, A. James. North American Street Design for the Coronavirus Pandemic: A Typology of Emerging Interventions. Journal of Urbanism: International Research on Placemaking and Urban Sustainability, May 17, 2022, 1–19. https://doi.org/10.1080/17549175.2022.2071970.

LEGAL FRAMEWORK FOR THE INTEGRATION OF ALTERNATIVE MOBILITY SERVICES INTO HOUSING IN AUSTRIA

OLIVER PECK *

TU Wien, Institute of Spatial Planning, Research Unit Law, Karlsgasse 13, 1010 Wien, Austria
** corresponding author: oliver.peck@tuwien.ac.at*

1. Introduction

Alternative mobility services such as car-, bicycle- and E-scooter sharing, carpooling or on-demand microtransit services are considered to have great potential to make a significant contribution to the mobility transition. Although numerous different services have been provided by various operators in Austria for quite some time, they have not yet become established on the market on a broad and comprehensive scale. Therefore, according to recent strategies adopted by the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, their integration into the public transport system, but also into sectors relevant to mobility as for example residential housing should be driven forward [1]. Since the mobility services available in the residential area play a key role in determining mobility behaviour, the planning of new urban development areas and housing projects, but also the transformation of the existing building stock offer the opportunity to implement sustainable mobility concepts, including alternative mobility services like car- or bike-sharing in the residential environment.

For the successful implementation of an integrative approach that combines housing and the mobility needs of residents in an appropriate way from the perspective of sustainable mobility, a reasonable legal framework is considered a key factor. However, just as alternative mobility services in general are hardly regulated in Austrian administrative law, which leads to a number of legal uncertainties [2], by now, the legal basis for the integration of alternative mobility services into housing projects in Austria often remains unclear. This paper examines the relevant legal framework in Austria, starting from an analysis of the status quo and addresses open questions, needs for action and possible new approaches.

2. Methodology

In a first step the central issues of the existing legal framework in Austria for alternative mobility services and their integration into housing were recorded and systematised by conducting a legal-dogmatic analysis of the relevant applicable legal provisions. At the same time, selected case studies were analysed, for which guideline-based expert interviews were conducted in order to record experiences and problem areas relevant to practice. Based on the analysis of the legal framework and the evaluation of the results of the expert interviews, as well as a supplementary literature analysis, problem areas were identified and the need for action pointed out.

Legal Framework for the Integration of Alternative Mobility Services into Housing in Austria

3. Results

The relevant legal framework in relation to the linking of housing and mobility is laid down in the building and spatial planning regulations of the federal states and currently consists primarily of regulations regarding the construction of car parking spaces for residential buildings (so-called parking space obligation). The aim of the regulations is to ensure that sufficient parking spaces are available for residents' cars and bicycle parking spaces are provided, alternative mobility services are usually not taken into account [3].

A legal obligation to provide alternative mobility options (such as car sharing services) has not yet been laid down in law. However, the integration of alternative mobility services in residential buildings is occasionally provided for as an option to deviate from the number of mandatory car parking spaces. Whether and under what conditions the number of car parking spaces can be reduced in favour of alternative mobility options is primarily in the hands of the administration. Only in Vienna, a recent revision of the building code introduced the option, that by establishing a car-sharing service as a "compensatory measure", the number of compulsory parking spaces is reduced [4, 5].

Therefore, the use of the parking space obligation as a starting point or control mechanism for the promotion of shared mobility services is currently mainly carried out via instruments under private law. Municipalities conclude contracts with property developers – so called Urban Development Contracts or „Mobility Contracts", as for example in the city of Graz [6]. Property developers undertake a contractual obligation to implement alternative mobility solutions (for example provision of bicycle parking spaces, charging facilities for e-vehicles, car-sharing services, bike-sharing, public transport passes for tenants, bicycle service stations, mobility counselling services, etc.). In return, the municipality agrees to reduce the mandatory number of parking spaces.

However, the use of such contracts has also some disadvantages. The contents of the contracts are legally only guided by the objectives set in the spatial planning laws, which are very vague in this respect [7]. Also, there is no obligation to make the contracts accessible to the public. Furthermore, the long-term financing of the operation of sharing services is not secured in most cases, as the property developers undertake to provide only temporary financing for the first few years. Later on, the sharing services are supposed to be economically self-sustaining, but in practice this is often not the case, which is why they are then discontinued. Finally, the possibilities for use of urban development contracts in existing buildings in refurbishment projects are limited.

Due to these shortcomings of the currently used legal instruments, changes in the legal framework and new approaches are being discussed to push the integration of alternative mobility services in residential housing. For example, the obligation to provide parking spaces could generally be (partly) replaced by the obligation to implement a sustainable mobility concept, consisting of various measures, including for example car sharing. Examples for this model can be found in Germany (e.g. Bremen's Mobility for New Buildings Bylaw) [8]. Another option could be that property developers could be legally obliged to contribute to a special "mobility fund", which is set up to finance the implementation of mobility concepts for housing projects in urban development areas and managed either by the public authorities or privately. In Austria, one "mobility fund" has already been set up in Vienna [9].

4. Conclusions

A suitable legal framework is a key factor for a successful integration of alternative mobility services into housing projects, which contributes to shared mobility services becoming a decisive factor in changing mobility behaviour and achieving the goals set for the mobility transition. In view of the shortcomings of the current regulatory system in Austria, still mainly focusing on the obligation to build parking spaces for cars, it is assumed that corresponding regulations in the building and spatial planning laws have to be adopted. Therefore, new instruments for the integration of alternative mobility services into housing still have to be examined more closely with regard to their possible legal implementation.

References

[1] 1. Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology. Austria's 2030 Mobility Master Plan. [2024-09-10] https://www.bmk.gv.at/dam/jcr:eaf9808b-b7f9-43d0-9faf-df28c202ce31/BMK_Mobilitaetsmasterplan2030_EN_UA.pdf

[2] D. Damjanovic, O. Peck. Der rechtliche Rahmen für alternative Mobilitätsdienstleistungen – offene Fragen und Handlungsbedarf. *Zeitschrift für Verwaltung* 2023 (4): 285-296.

[3] H. Frey, T. Brezina, G. Emberger. Mobilität. In *APCC Special Report: Strukturen für ein klimafreundliches Leben*, chap. 6. Springer Spektrum, Berlin/Heidelberg, 2023.

[4] § 50b Wiener Garagengesetz, LGBl 46/2010 in the version of LGBl 37/2023.

[5] S. Cejka. Die Energie- und Mobilitätswende in den Bauordnungsnovellen 2023. *Recht der Umwelt* 2024 (02): 53-57.

[6] EU Urban Mobility Observatory. Graz Mobility Contracts for sustainable mobility in new developments. [2024-09-10] https://urban-mobility-observatory.transport.ec.europa.eu/resources/case-studies/graz-mobility-contracts-sustainable-mobility-new-developments_en?prefLang=en

[7] A. Schüßler-Datler. *Städtebauliche Verträge*. Verlag Österreich, Wien, 2020. 207p.

[8] Freie Hansestadt Bremen. Providing innovative mobility management rather than car parking spaces. [2024-08-27] https://www.sharenorth2.eu/wp-content/uploads/2024/06/MobBauOG-Broschure_ENGLISH.pdf

[9] Stadt Wien. Der Mobilitätsfonds Wien im Überblick. [2024-07-12] https://www.wien.gv.at/verkehr/mobilitaetsfonds/ziele-und-organisation.html

TECHNOCRACY, INSTINCT OF WORKMANSHIP AND AUTHORITY OF PROCEDURES IN THE RESTORATION OF PRAGUE'S TROLLEYBUSES.

EGOR MULEEV *

Leibniz Institute for Regional Geography, Schnongauerstr. 9, 04328 Leipzig, Germany
** corresponding author: e_muleev@leibniz-ifl.de*

1. Introduction

The research for this contribution was prompted by the following question. If the management of public transport relies on technical knowledge, does it deserve to be called technocratic? For the tekhne, I draw on Thorsten Veblen's theoretical justification of the difference between engineers and financiers. For the kratos, I attract the anarchist critique of authority. This contribution argues that the epistemic superiority of a particular knowledge lies in the procedures of bureaucratically organised knowledge production. Empirical observations from the reopening of the trolleybus system in Prague show that the decision-making process was influenced by more than a century of tradition in building and maintaining transport systems and was supported by the available procedures.

2. Technocracy

The earliest documented use of the term "technocracy" clearly refers to issues of industrial management [1], while its contemporary understanding tends to avoid it. This term has a very straightforward definition nowadays, understood as the power of experts. It means that the knowledge produced by experts has an epistemic superiority over other types of approaches to the same questions. In two very recent publications on the issue, Andres Esmark [2] claims that technocracy manifests a specific type of rationality, while Jeffrey Friedman [3] takes a less straightforward position. He introduces "citizen technocrats" and argues that government-friendly experts share the same esoteric type of knowledge. Neither thinker, however, went very far into the question of technical control over the industry and the question of authority, even though it is the combination of these two words that defines the term.

3. Technology

Veblen's perspective on technical control over the industry is primarily based on three theoretical arguments [4; 5]. The first one posits that curiosity and creativity are integral and inextricable aspects of human nature. Technological development and progress can be seen as an outcome of this intrinsic feature. This perspective enables Veblen to regard technology as a public good rather than as a privately owned commodity.

The second argument presents a clear anti-capitalist excitement. The understanding of efficiency as a commercial success contaminates the process of industrial production. It substitutes the need and ability to satisfy the demand of the general public with the peculiar gain of "captains of industry." Consequently, the potential of technology to foster prosperity is significantly constrained. The technical understanding of efficiency suggests the liberation of the engineer's logic in the mechanical organisation of production.

The third argument put forth is the necessity for collective decision-making. Veblen argued for the Soviet of technicians, the voluntary union of "competent" people. Some authors [6] contend that Veblen was sympathetic to the anarcho-syndicalist movement, which espouses a non-authoritarian and horizontal type of industrial management.

4. Power

As Mariya Rakhmaninova [7] notes, the justification of power in Western knowledge can be traced back to ancient and Christian metaphysical traditions. Michael Huemer [8] presents a more straightforward argument, suggesting that the authority of government is ultimately an illusion because the available explanations are insufficient to explain it.

A left-wing intersectional approach reveals the expressions of privileges situated within specific contexts, disseminated according to the inherited institutions of hierarchically organised societies. Privileges, frames of reference, patterns of daily living and associated forms of epistemic superiority are expressed in hierarchies [7]. Metaphysical illusions, stereotypes and assumptions can thus be seen as expressions of fantasies that are structured by executive mechanisms. There are a plethora of ways to conceptualise the future. However, a clear distinction is often made between one particular style of conduct and all others.

The methods employed to address social concerns tend to be characterised by a high degree of bureaucracy. Bureaucracy is understood as a technical approach to money redistribution through the set of procedures. Bureaucracy is responsible for designing markets and establishing the principles that regulate the implementation of specific agendas. Epistemic superiority lies therefore in the bureaucratically sanctioned procedures of knowledge production which constitute the ability to dream about the future. Ultimately, esoteric epistocracy [3], the metaphysics of authority [7] and the animistic contamination of instincts [6] demonstrate that contemporary experts occupy a comparable position in society to that of shamans and oracles during the era of savagery.

5. Fieldwork

The fieldwork conducted Prague in spring 2024 aims to answer the question of the knowledge used to implement the decision on the restoration of trolleybus service. I spent 16 days in the city, riding buses, visiting transport museums, and talking to public transport professionals, activists, planners, industry representatives, and academics. An empirical argument is that the reopening has its roots in the tradition (of workmanship) of Czech electrical engineering, which has been carefully maintained in the course of decades.

The production of electrical infrastructure and planning capabilities have been inherited and successfully preserved in the Czech Republic since the middle of XIX century. After the Velvet Revolution there has been a notable absence of infrastructure development that would facilitate the use of cars and simultaneously the development of public transport. One potential explanation of such an unusual actions is that the reforms were "right-wing in rhetoric with left-wing practice" [9]. Secondly, the governance reform of public transport did not result in the transfer of all responsibilities for service provision from operator company DPP to the contractor PID. Also the

establishment of self-governance in 56 districts across the city helped DPP to celebrate a city-wide influence. A third aspect is the stance mentioned by numerous respondents with whom I spoke. The trolleybus was dismantled by the communist regime; therefore, it is imperative that it be rebuilt.

Electrification of a bus fleet in Prague initiated from the internally financed experimentation. The DPP possessed the requisite capabilities to plan, construct, and operate the system independently and after test rides, they applied for the external finding with a very clear understanding what kind of technical specifications they demand. Success of the test operation was not the type of marketing research, but rather the technical one, aiming to get the maximum out of the existing infrastructure.

The tradition of over a century in the production of various vehicles and the management of public transport had a great influence on the restoration of the trolleybus system in Prague. Furthermore, despite the political and social changes that have occurred over the course of decades, there has been a continuity in engineering knowledge tradition. The organisational structure and procedures are also of relevance in this context, namely the structure of governance, finance, and distribution of responsibilities.

6. Conclusions

The objective of these epistemic properties is to construct a future and implement measures to make it a reality. Technocracy, as a response to social problems and as a fundamentally epistemic project [3], is inextricably linked to the bureaucratic structures of execution and imagination associated with this vision. The restoration of trolleybuses in Prague demonstrates that the implementation of established procedures does not necessarily result in the exclusive manifestation of the executive power of accountants. Furthermore, there is room for manoeuvre for engineers.

The main reason for Prague's trolleybus restoration is that the fantasies of engineers celebrate the availability of procedures that make the dream come true. Therefore, the restoration can be considered a matter of maintaining tradition. It can be argued that care is the most crucial component in ensuring the continuity of such an incentive.

From this perspective, sustainability can be conceptualised as a bottom-up phenomenon, constituted by local knowledge, tradition and, arguably, aspirations for the future. It is therefore evident that the capacity for workmanship is inherent to each individual within a community, and the mobilisation of this capacity represents a pivotal step in the direction of enhancing publicly-owned transport systems on a global scale.

Acknowledgements

This article presents research conducted as part of the CoMoDe project, which received funding from the Leibniz Competition research and innovation programme of the Leibniz Association (grant number J86/2019).

References

[1] D. R. Stabile. Veblen and the Political Economy of the Engineer: The Radical Thinker and Engineering Leaders Came to Technocratic Ideas at the Same Time. *The American Journal of Economics* and Sociology, 45(1): 41-52, 1986.

[2] A. Esmark. *The New Technocracy*. Bristol University Press, 2020.

[3] J. Friedman. *Power without knowledge*. Oxford University Press, 2019.

[4] T. Veblen. *The instinct of workmanship and the state of industrial arts*. Transaction Publishers, 1990.

[5] T. Veblen. *The Engineers and the Price System*. Batoche Books, 2001.

[6] M. Perelman. Thorstein Veblen: An American Economic Perspective. In M. Hudson & A. Öncü (Eds.), *Absentee Ownership and its Discontents*, 1-19, Islet, 2016.

[7] M. Rakhmaninova. *Vlast' i Telo*. Radikalnaya Teoriya i Praktika, 2020.

[8] M. Huemer. *The Problem of Political Authority*. Palgrave Macmillan, 2012

[9] Ž. Libor. *From central planning to the market. The transformation of the Czech economy, 1989-2004*. CEU Press, 2017.

AI-POWERED TRANSFORMATION: REVOLUTIONIZING SUSTAINABLE TRANSPORTATION SYSTEMS FOR THE FUTURE

ENGY FARRAG *

Assistant Professor at Delta University for Science and Technology, Egypt
* *corresponding author: engy.m.farrag@gmail.com*

Artificial Intelligence (AI) stands at the forefront of revolutionizing the transportation sector, heralding a new era of innovation, efficiency, and sustainability. This paper examines the transformative influence of AI on the future of transportation, with a specific focus on enhancing sustainable transportation systems. By leveraging AI technologies, transportation systems are being reimagined and optimized to address key challenges such as congestion, emissions, and resource utilization, ultimately paving the way towards a more sustainable and efficient mobility landscape.

AI is driving a paradigm shift in transportation by enabling intelligent decision-making processes, predictive analytics, and automation across various facets of the sector. Through machine learning algorithms and data analytics, AI empowers transportation systems to analyse vast amounts of data in real-time, optimize routes, and predict traffic patterns with unprecedented accuracy[1]. Such capabilities are instrumental in reducing congestion, improving traffic flow, and enhancing the overall efficiency of transportation networks.

One of the most notable applications of AI in transportation is the development of autonomous vehicles. These self-driving cars leverage AI algorithms to perceive their surroundings, make split-second decisions, and navigate complex road scenarios autonomously. By reducing human error and optimizing driving behaviours, autonomous vehicles have the potential to significantly enhance road safety, reduce accidents, and improve overall traffic management [2]. Furthermore, AI-driven autonomous fleets offer the promise of shared mobility services that can revolutionize urban transportation models and reduce the need for private car ownership.

In addition to autonomous vehicles, AI is reshaping the public transportation landscape by optimizing scheduling, routing, and capacity management. Intelligent systems powered by AI algorithms can dynamically adjust bus and train schedules based on real-time demand, optimize transit routes, and improve the overall efficiency of public transportation services. By enhancing the reliability and accessibility of public transit options, AI contributes to reducing reliance on private vehicles, lowering emissions, and promoting sustainable urban mobility [3].

Moreover, AI plays a pivotal role in promoting sustainable transportation practices by optimizing energy consumption, reducing emissions, and encouraging the adoption of ecofriendly modes of transport [4]. AI-powered traffic management systems can optimize traffic flow to minimize fuel consumption and emissions, while predictive maintenance solutions can enhance the efficiency of vehicles and infrastructure, reducing waste and promoting longevity.

Furthermore, AI-driven mobility services such as ride-sharing and on-demand transit contribut to reducing the environmental impact of transportation by promoting shared mobility options and minimizing empty vehicle miles.

The integration of AI in transportation not only enhances operational efficiency and sustainability but also transforms the passenger experience and promotes user-centric transportation services. AI-powered navigation systems provide personalized travel recommendations, real-time updates, and seamless trip planning experiences, enhancing user satisfaction and convenience. By leveraging AI technologies to deliver tailored transportation solutions, service providers can create more inclusive, efficient, and user-friendly mobility experiences that cater to diverse passenger needs.

In conclusion, the transformative power of AI is reshaping the future of transportation and driving the evolution of sustainable transportation systems. By harnessing the capabilities of AI technologies, transportation stakeholders have the opportunity to optimize operations, improve efficiency, and reduce environmental impact while enhancing the overall mobility experience for individuals and communities. The integration of AI in transportation holds immense potential to create a more sustainable, accessible, and interconnected transportation ecosystem that addresses the evolving needs of society and fosters a greener, more efficient future of mobility.

References

[1] D. Garikapati,, & S. Shetiya,. *Autonomous Vehicles: Evolution of Artificial Intelligence and the Current Industry Landscape. Big Data and Cognitive Computing*, 8(4), 42. (2024). https://doi.org/10.3390/bdcc8040042

[2] M. Yifang, Z.Wang, H.Yang and L.Yang, "Artificial Intelligence Applications in the Development of Autonomous Vehicles: A Survey," *IEEE/CAA J. Autom. Sinica*, vol. 7, no. 2, pp. 315-329, Mar. 2020. doi: 10.1109/JAS.2020.1003021

[3] The Impact of AI on Transportation and Mobility Report. *Authored by Cambridge Consultants & ITS America in 2023. Retrieved from* https://itsa.org/wpcontent/uploads/2023/12/Lit-R-018-v0.3-2023-ITSA-AI-report.pdf

[4] J. Bharadiya. Artificial Intelligence in Transportation Systems A Critical Review. Vol. 6: American Journal of Computing and Engineering, Doi :10.47672/ajce.1487.

VISUAL POLLUTION IN CZECHIA: WHY ARE TRANSPORTATION ENGINEERS PART OF IT AND WHAT CAN THEY DO BETTER?

MARTIN MAREK *

Czech Technical University in Prague, Czechia
** Corresponding author: marek@citytraffic.cz*

1. Introduction

City planning is often seen as the domain of urban planners and architects, but in Czechia, it's transportation and civil engineers who play a more significant role. While the layout of towns and cities is largely in place due to mild population changes [1], it is constantly evolving to address mobility issues. [2] [3] [4] Streets are designed to balance car lanes, parking, sidewalks, cycle paths, and tram tracks, along with traffic control systems like signs and signals. [5] [6]

Although necessary, traffic signs contribute to visual pollution. The design and meaning of road signs are established by the Vienna Convention on Road Signs and Signals [7] [8], yet their practical application differs across Europe. How are transportation engineers in Czechia deciding their placement, and are they as effective as intended? This abstract provides an empirical analysis of traffic sign usage in Czechia and their impact on urban visual pollution, drawing from six years of professional and eight years of academic experience.

2. Background and objectives

Urban space is limited, requiring compromises in street design. In Czechia, the road network was unprepared for the post-communist surge in car use [9], leading to congestion and unsafe conditions for all road users. Since major construction is slow and costly, temporary solutions like traffic signs and speed bumps are often used to manage traffic. However, this has led to another issue: visual pollution. An excess of signs not only detracts from the street's appearance but can overwhelm drivers with too much information. [10]

Figure 1: Excessive use of traffic signs.

3. Legal framework

Traffic sings and road markings are defined by Czech regulation no. 294/2015 [6], the highway code is law no. 361/2000 [5]. The design of roadways in Czechia is governed by technical standards. The most important standards related to transportation include:

- ČSN 73 6101: Design of roads and highways [1] [11],
- ČSN 73 6102: Design of intersections [2] [12],
- ČSN 73 6110: Design of urban roads [13],
- ČSN 73 4001: Accessibility and barrier-free use [14].

These standards ensure the basic requirements for safe traffic operation. Additionally, several topics are expanded upon in documents called "Technické podmínky" (abbreviated as TP) issued by the Ministry of Transportation. These documents provide more detailed explanations, approaches, and possible solutions for various topics. TP 65 [10] extensively addresses the use cases and placement of traffic signs, TP 133 [15] focuses on road markings, and TP 131 [16] outlines principles for marking traffic situations on roads using both signs and markings.

None of these Czech standards are binding unless explicitly mandated by law, which is rarely the case in transportation design and planning. Nonetheless, both the standards and the TPs are widely used by transportation engineers and officials.

4. Main objectives

4.1. Identified issues

Nowadays, there are many traffic signs along the streets despite the main document TP 65 stating that traffic signs are meant to be used only when necessary for safety reasons since too many traffic signs lowers its respectability. [10] Few main reasons were identified as causes of traffic signs (over)use contributing to visual pollution:

- Size of traffic signs,
- Unnecessary use of (another) traffic sign,
- Lack of law enforcement,
- Low-cost changes,
- Traffic lights,
- Standalone poles.

4.1.1. Size of traffic signs

Traffic signs in Czechia are generally larger compared to countries like the Netherlands or Switzerland, with smaller versions allowed only on minor roads. The same large signs are used regardless of speed limits, creating disproportionate visual clutter.

[1] The official English name *"Design of highways and motorways"* is misleading, as the standard encompasses all types of roads.
[2] The official English name *"Design of intersections on highways"* is misleading, as it does not reflect that the standard addresses all types of intersections.

Figure 2: Comparison of smaller and standard lane sign sizes on arterial road.

This is particularly problematic for lane arrangement signs, where large, detailed signs are required, even though in other countries (e.g., France, Norway, the Netherlands), smaller or no signs are used, relying on visual cues like coloured bike lanes.

Figure 3: Visual pollution on every bike-friendly road in Czechia.

Figure 4: Smaller and simpler sign used in Norway

Figure 5: No sign used in the Netherlands due to coloured bike lane.

Figure 6: 4-lane arrangement in the Netherlands with no erected traffic sign.

The Czech practice is to place these signs at every junction, see Figure 2. The description of traffic sign IP 19 states it "displays the lane arrangement in front of a junction," [6] [10] but this should be interpreted as a description, not an order. Other signs, such as those marking hotels or restaurants, also use descriptive language without being mandated everywhere.

Conversely, signage for cyclist and pedestrian pathways should be utilized in a smaller size as specified by TP 65 [10]; however, this is rarely observed as shown in Figure 7.

Figure 7: Standard sized cycle track signs.

4.1.2. Unnecessary use of (another) traffic sign

Unnecessary use primarily involves danger warning signs. In urban areas, these signs often warn of hazards that drivers should expect. For example, a danger sign for a pedestrian crossing is often placed in a village where the crossing is clearly visible and marked by a zebra stripe and a standard traffic sign. The use of a warning sign, especially with a fluorescent background, seems redundant when TP 65 already mandates signs to be visible from 50 meters [10] and braking distance from city limit 50 kph is 34 meters. [11]

Figure 8: Warning signs placed in close proximity to the “danger”

This overuse of warning signs extends to other situations like traffic lights and roundabouts, where signs are placed despite the visibility and predictability of the hazard. It also encompasses various other situations and traffic signs as illustrated in the following figures.

Figure 9: Unnecessary parking signs at clearly designated parking spaces.

Figure 10: Anomalous and irrelevant use of overtaking signs in built-up area

Figure 11: Redundant additional plates showing standard intersection diagram.

Figure 12: Unnecessary give way signs at the end of a home zone.

4.1.3. Lack of law enforcement

A general lack of law enforcement in the Czech Republic contributes to traffic violations. Part of this problem stems from historical factors, but the absence of consequences also plays a major role. For example, bus stops often feature multiple signs and markings indicating a no-stopping zone, in addition to prohibition set by the highway code [5], but drivers frequently ignore these rules (see Figure 13), affecting mainly public transport users. Temporary traffic signs are another example, particularly during street cleaning in spring and fall, when signs are placed even where there are permanent parking bans, as shown in Figure 14. These signs serve as reminders that "today you really shouldn't park here."

Figure 13: 3 traffic signs and 2 road markings fail to prevent drivers from stopping.

Figure 14: Disregard for both permanent and temporary no parking signs.

Another common issue is drivers parking wherever they can, even when it contradicts the highway code or common sense, e.g. on sidewalks, grass as illustrated in Figure 15. This behaviour is often enabled by poor street design, and rule-breaking often requires a physical barrier like a concrete block (ironically called "city block"; see Figure 16) to prevent parking.

Figure 15: Illegal parking on sidewalks and greenery.

Figure 16: Prohibited parking in purposeless stripe of a street.

4.1.4. Low-cost changes

Low-cost traffic modifications are a significant source of visual pollution. While construction projects take years and require building permits, adding road markings and traffic signs is faster, simpler, and cheaper. This approach is common at intersections, where streets converted to one-way for parking leave wide pedestrian crossings, although the lane used is only about 3 meters wide. Often, plastic bollards are added to prevent parking, making the crossings and intersections unsightly as shown in Figure 17. Another example is the spread of parking spaces, where sidewalks are repurposed for parking, requiring additional signs to indicate allowed parking (see Figure 18).

Figure 17: Reducing intersection size with road markings and bollards.

Figure 18: Parking on sidewalks requires an erected traffic sign.

A similar problem arises on main roads passing through built-up areas. Instead of constructing safety islands, excess road width is simply narrowed to the actual lanes, see Figures 19 and 20. While this might meet technical standards, it does little for pedestrian safety or traffic calming. [17] [18] All these changes are not meant to be temporary, but they often look like quick fixes rather than permanent solutions without any long-term plan for improvement.

Figure 19: Permanent shortening of pedestrian crossing using temporary measures.

Figure 20: Missed opportunities to build a pedestrian crossing island.

4.1.5. Traffic lights

Traffic lights are useful when applied correctly, particularly at busy intersections, but they often hinder traffic flow when used on roads with normal or light traffic. For example, signalized pedestrian crossings on two-lane roads often create unnecessary delays, as heavier traffic occurs only 3 to 6 hours a day during rush hours. A pedestrian crosses the road in 4 to 5 seconds after a necessary 5-second wait to get a green light, but traffic is halted for at least 15 to 20 seconds [19], causing delays for both pedestrians and vehicles. Excessive use of traffic lights not only adds to visual pollution but also leads to air, light, and noise pollution in the area. The safety benefits are questionable, as pedestrians often jaywalk.

Figure 21: Visual pollution from excessive signage and railings near a traffic light.

Figure 22: Railings: frequent accessories for traffic lights.

Additionally, intersections with traffic lights require more lanes, signs, and road markings, further increasing their footprint, and surrounded by railings increasing visual pollution [20]. In many cases, traffic lights cannot simply be turned off due to overly wide crossings, caused by multiple lanes or a lack of safety islands. Fixing this issue would require a complete redesign of the intersection, which is a frequent reason for maintaining the current status quo unsuitable for all users.

4.1.6. Standalone poles

Traffic signs need to be placed somewhere, but even when streetlamps are available, separate poles are often used to avoid dealing with third parties. This leads to a clutter of poles, with some placed very close to existing vertical elements (see Figure 23). Traffic signs can also be mounted on buildings or walls, which avoids adding obstacles to narrow or busy sidewalks. However, this more aesthetically pleasing option is rarely used despite its benefits.

Figure 23: Standalone poles next to vertical elements and signs mounted on a building (right).

4.2. Mitigation

There are many factors contributing to the issues outlined above, some of which may be specific to certain countries. However, two overarching causes stand out: the separation of responsibilities and limited resources. Road administrators tend to focus solely on their own network, lacking a broader perspective that integrates all modes of transport. Municipalities, which should provide this oversight, often lack the knowledge, authority, or manpower to influence outcomes effectively. This is further compounded by low salaries on all included sides leading to a reactive rather than proactive approach. As a result, there is little time or capacity for strategic thinking.

A key solution lies in education. By equipping municipalities with the knowledge to demand and implement better, more integrated solutions, we can improve traffic systems and make streets livable. [21] These solutions should prioritize sustainable modes of transportation while also considering the aesthetic quality of streets. [3] [4] The encouraging news is that these changes can be made within the existing legal framework, without requiring alterations to Czech laws or standards.

Ultimately, the core issue is the lack of planning and long-term vision in road construction. Street layout is the most significant factor in shaping how drivers behave and perceive their environment. [22] While traffic signs and road markings can provide guidance, they cannot substitute for a well-designed street layout. [18] Thoughtful, comprehensive road design encourages safe driving and reduces the reliance on signs for speed regulation and risk assessment. [23]

In addition, the increased use of road markings can help define space distribution more effectively [18], see Figures 24 and 25. The latter road with cycle lanes is 0.7 meters wider, yet it appears otherwise due to the road markings.

Figure 24: 7.0 m wide road without road markings

Figure 25: 7.7 m wide road with protective cycle lanes

All of the above must be supported by law enforcement from the municipal police, which is responsible for addressing most driving offenses. The police established by the town often face political pressure that limits its ability to address offenses to avoid unpopularity, which could impact the town's political leadership. However, effective law enforcement is crucial for ensuring compliance, as drivers are unlikely to change their behaviour if violations are tolerated. [24] The municipalities and other agencies should work to eliminate the underlying causes of rule violations, which often implies changes in street and road design. [25]

5. Conclusions

Traffic signs are often viewed as a solution for driver behaviour and enhanced safety, but the design of the road itself plays a far more important role in influencing how drivers perceive speed and assess risk. This empirical analysis identifies six major causes of visual pollution caused by traffic signs in Czechia, all of which can be effectively mitigated through a more integrated approach to street design.

While the tools and frameworks needed for more thoughtful design already exist, they are often underutilized because they require additional effort. Transportation engineers, focused on completing their tasks efficiently, may default to simple solutions, which are not always the best ones. Only municipalities and agencies, as the project investors, are in a unique position to push for more thoughtful and comprehensive designs; however, they often lack the necessary knowledge and strategic approach nowadays.

References

[1] Počet a pohyb obyvatel v Českých zemích (roční údaje). [Dataset]. In *Dlouhodobé časové řady*. Český statistický úřad, 2024. [2024-09-09], https://vdb.czso.cz/vdbvo2/faces/index.jsf?page=vystup-objekt&z=T&f=TABULKA&ds=ds1057&pvo=DEMDCR1&skupId=4791&katalog=33157&str=v1056

[2] Dopravní politika České republiky pro období 2021 – 2027 s výhledem do roku 2050. Ministerstvo dopravy České republiky, 2021. [2024-09-09], https://www.mdcr.cz/getattachment/Dokumenty/Strategie/Dopravni-politika-a-MFDI/Dopravni-politika-CR-pro-obdobi-2014-2020-s-vyhled/Dopravni_Politika_CR_CZ.pdf.aspx-

[3] Strategický rámec Česká republika 2030. Úřad vlády České republiky, 2017. ISBN 978-80-7440-188-6 [2024-09-09], https://www.cr2030.cz/wp-content/uploads/2023/01/Strategický-rámec-ČR-2030.pdf

[4] Strategie regionálního rozvoje ČR 2021+. Ministerstvo pro místní rozvoj ČR, 2019. [2024-09-09], https://mmr.gov.cz/getmedia/58c57a22-202d-4374-af5d-cbd8f9454adb/SRR21.pdf

[5] Zákon č. 361/2000 Sb.: Zákon o provozu na pozemních komunikacích a o změnách některých zákonů (zákon o silničním provozu) (59th ed.). Zákony pro lidi. [2024-09-09], https://www.zakonyprolidi.cz/cs/2000-361

[6] Vyhláška č. 294/2015 Sb.: Vyhláška, kterou se provádějí pravidla provozu na pozemních komunikacích (4th ed.). Zákony pro lidi. [2024-09-09], https://www.zakonyprolidi.cz/cs/2015-294

[7] United Nations. *Convention on Road Signs and Signals, of 8 November 1968 (amended version)* (E/CONF.56/17/Rev.1/Amend.1). United Nations Economic Commission for Europe, 1995. [2024-09-09], https://unece.org/DAM/trans/conventn/signalse.pdf

[8] United Nations. *Convention on Road Signs and Signals of 8 November 1968 (amended version): Annex 2*. United Nations Economic Commission for Europe, 1995. [2024-09-09], https://unece.org/DAM/trans/conventn/signalsa2.pdf

[9] Dvořák, M. Vozový park v obcích ČR: První část série "Prostorové aspekty dopravy" Statutární město Brno, 2023-09-01. [2024-09-09], https://storymaps.arcgis.com/stories/6cd02a1229f5435d9753ada7c7ab2e71

[10] TP 65: Zásady pro dopravní značení na pozemních komunikacích. Ministerstvo dopravy ČR, 2013. [2024-09-09], https://pjpk.rsd.cz/data/USR_001_2_8_TP/TP_65.pdf

[11] ČSN 73 6101: Design of highways and motorways (No. 505692). Česká agentura pro standardizaci, 2018. [2024-09-09]

[12] ČSN 73 6102: Design of intersections on highways (No. 90469). Česká agentura pro standardizaci, 2012. [2024-09-09]

[13] ČSN 73 6110: Design of urban roads (No. 74506). Česká agentura pro standardizaci, 2006. [2024-09-09]

[14] ČSN 73 4001: Accessibility and barrier-free use (No. 519660). Česká agentura pro standardizaci, 2024. [2024-09-09]

[15] TP 133: Zásady pro vodorovné dopravní značení na PK. Ministerstvo dopravy ČR, 2013. [2024-09-09], https://pjpk.rsd.cz/data/USR_001_2_8_TP/TP_133.pdf

[16] TP 169: Zásady pro označování dopravních situací na pozemních komunikacích. Ministerstvo dopravy ČR, 2005. [2024-09-09], https://pjpk.rsd.cz/data/USR_001_2_8_TP/TP169.pdf

[17] TP 131: Zásady pro úpravy silnic včetně průtahů obcemi. Ministerstvo dopravy ČR, 2000. [2024-09-11], https://pjpk.rsd.cz/data/USR_001_2_8_TP/TP_131.pdf

[18] TP 145: Zásady pro navrhování úprav průtahů silnic obcemi. Ministerstvo dopravy ČR, 2001. [2024-09-11], https://pjpk.rsd.cz/data/USR_001_2_8_TP/TP_145.pdf

[19] TP 81: Navrhování světelných signalizačních zařízení pro řízení provozu na pozemních komunikacích, 2015. [2024-09-11], https://pjpk.rsd.cz/data/USR_001_2_8_TP/TP_81.pdf

[20] TP 186: Zábradlí na pozemních komunikacích, 2007. [2024-09-11], https://pjpk.rsd.cz/data/USR_001_2_8_TP/TP_186.pdf

[21] Bruce, N., & Appleyard, D. (2020). Tools, rules, and techniques: Planning, engineering, and design approaches to creating complete and livable streets and neighborhoods. In *Elsevier eBooks* (pp. 379–455). https://doi.org/10.1016/b978-0-12-816028-2.00020-4

[22] Ambros, J., Turek, R., Šragová, E., Petr, K., Šucha, M., & Frič, J. (2021). How fast would you (or should you) drive here? Investigation of relationships between official speed limit, perceived speed limit, and preferred speed. *Transportation Research Part F Traffic Psychology and Behaviour*, 83, 164–178. https://doi.org/10.1016/j.trf.2021.09.003

[23] Tranter, P., & Tolley, R. (2020). Hit the brakes: slowing existing motorised traffic. In *Elsevier eBooks* (pp. 235–272). https://doi.org/10.1016/b978-0-12-815316-1.00008-3

[24] Urie, Y., Velaga, N. R., & Maji, A. (2016). Cross-sectional study of road accidents and related law enforcement efficiency for 10 countries: A gap coherence analysis. *Traffic Injury Prevention*, 17(7), 686–691. https://doi.org/10.1080/15389588.2016.1146823

[25] Agerholm, N., Knudsen, D., & Variyeswaran, K. (2016). Speed-calming measures and their effect on driving speed – Test of a new technique measuring speeds based on GNSS data. *Transportation Research Part F Traffic Psychology and Behaviour*, 46, 263–270. https://doi.org/10.1016/j.trf.2016.06.022