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Assessing the Transformative Capacity Building for Sustainable Mobility Transitions in Cities:

A Case Study of Road Transport Decarbonisation in Vilnius, Lithuania

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["Change is inevitable, but transformation is by conscious choice."]

- Heather Ash Amara

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Abstract

43% of daily commuting trips in Vilnius, Lithuania, are made by car. Most of such vehicles are characterised by high dependency on fossil fuels which further contribute to ongoing GHGs increase across the transportation sector. At the same time, adverse health and well-being impacts arise, with transportation being the leading source of air pollution and accounting for almost half of PM2.5 and NOx emissions locally. These socio-environmental pressures call for transformative change within the city, particularly by shifting conventional transportation practices towards more sustainable modes of mobility. While studies are emerging in a local context to further understand the necessity of transport decarbonisation, most of such studies focus on micro-level and isolated changes with a lack of system-level assessment, especially for transformative capacity building. Hence, by conducting a case study in Vilnius city, this research explores how transformative capacities (TCs) are built and advanced in the transportation sector at the city (as a system) level to support road-transport decarbonisation pathways. The study is undertaken by adopting Wolfram's (2016) framework, which introduces eight interrelated elements that constitute capacity building for system-level transformations. 26 semi-structured interviews were conducted with local and national mobility and climate change experts and later supported by the complementary policy document analysis to investigate the signs of transformative capacity building. Research results show that all TCs are visible within the transportation system in Vilnius. However, the level of their manifestation differs significantly across the TC categories. The TCs representing *core development processes* (C4-C8) required for climate governance are embedded more firmly within the system, while the TCs displaying the *agency and interaction forms* (C1-C3) are characterised by weaker signs of implementation. Above all, study findings indicate that transformative capacity building (TCB) frameworks are valuable analytical tools for understanding institutional and socio-technical dynamics underpinning the existing mobility systems and could be utilised in practice to reinforce climate governance in cities. The study makes a valuable empirical contribution to transformative capacity and urban climate governance literature, as no similar research was conducted in Vilnius and other Baltic cities before. Finally, the study calls for future research on theoretical and practical TCB framework applications in the transportation sector and cross-sectoral contexts.

Keywords: Road-transport decarbonisation, transformative capacities (TC), transformative capacity building (TCB), sustainable urban mobility, urban climate governance

Executive Summary

Problem definition

Conventional transportation planning remains a visible barrier in climate change mitigation narratives in cities, with Vilnius, Lithuania being no exception. 43% of daily commuting trips in Vilnius are made by car, while most of such vehicles are fueled by petrol and diesel (Vilniaus Planas, 2018). This further results in ongoing sectoral GHGs increase that undermines sustainable urban governance ambitions. As a response, Vilnius city municipality has set new sustainable mobility targets to be met in the upcoming decade as part of the national and collective EU efforts. Such efforts are mostly targeted to alleviate the negative climate impacts linked to private vehicle uptake with road transport decarbonisation being a leading goal. Most importantly, the high road-based transportation dependency on fossil fuels marks a growing need to investigate novel and transformative mechanisms to dismantle the conventional transportation planning practices in Vilnius. Different types of capacities are needed in cities to orchestrate and sustain road transport decarbonisation. According to Wolfram et al. (2019, p. 31), such capacities could be defined as *"the collective ability of the stakeholders involved in urban development to conceive of, prepare for, initiate and perform path-deviant change"*.

Aim and Research Questions

Thus, this study aims to identify the existence or lack of potential transformative capacities (TCs) to support local transformation towards carbon neutrality in road transportation. By conducting a case study in Vilnius city, it was investigated what institutional and socio-technical dynamics underpin the existing conventional transportation system in Vilnius. Thus, exploring how local governance discources could be re-directed towards sustainability by reinforcing transformative capacity building (TCB). By doing so, this study recognises system areas where TCs show the most and least potential for guiding a visionary and holistic narrative towards road transport decarbonisation. Based on the research aim, one research question (RQ) with three sub-questions has been formulated to be answered in this thesis:

RQ: How are transformative capacities being built to advance local road transport decarbonisation in Vilnius, Lithuania?

RQa: How do transformative capacity elements manifest?
RQb: How are transformative capacity elements exercised by different actors/or by the municipality of Vilnius?
RQc: How could transformative capacity elements be reinforced locally?

Research Design

The framework by Wolfram (2016) was selected to assess 8 TCs (C1-C8) in the local context and to position the study within relevant theoretical conceptualisations of transformative urban change. To answer the RQ, a qualitative study incorporated interviews and document analysis to explore transformative capacity building (TCB) in a local context. More specifically, 26 semi-structured online interviews (n=26) were conducted with professionals in the mobility and sustainability-related spheres. Similarly, five local and national transportation and climate change policy documents were reviewed to support interview findings. The interviews were performed first and were a leading data collection method, while document analysis was used to cross-check and triangulate data.

Research Results & Conclusions

RQa: How do transformative capacity elements manifest?

All reviewed TC elements in the Vilnius transportation system are manifested through strategic governing and more practical initiatives. Nevertheless, the utilisation level of different TCs within the system varies greatly. For instance, such capacities as *system awareness & memory (C4)* and *sustainability foresight (C5)* are well established and positioned to support the transition from fossil-fueled transportation to more sustainable mobility forms. The capacity of *innovation embedding and coupling (C7)* is clearly noticeable and encouraged within the system. However, its practical realisation and contribution to transport decarbonisation is less clear than in other more developed capacities. On the other hand, the capacities of *transformative leadership (C2)* and *autonomous communities of practice (C3)* are scarcely embedded, with only limited signs of their presence to encourage the system's decarbonisation. Interestingly, all the remaining capacities, including *urban experimentation with disruptive solutions (C6), inclusive & multiform governance (C1) and reflexivity and social learning (C8)*, are moderately displayed in the system. Yet, they are not actively supported to push road transport decarbonisation forward and receive some considerable resistance. Specialists perceived these capacities as 'emerging'.

RQb: How transformative capacity elements are advanced by different actors/or by the city of Vilnius?

Most TC elements, which are actively reflected within the system *(C4 - system awareness & memory, C5 - sustainability foresight)*, are directly advanced by the Vilnius city municipality and its subordinate institutions and supported by national governing bodies. In addition, *innovation embedding and coupling (C7)* capacity is being promptly improved by the local municipality, its subordinate institutions and higher-level governing bodies (e.g., ministries). The capacities of *inclusive & multiform governance (C1), reflexivity and social learning (C8) and urban experimentation with disruptive solutions (C6*) are similarly advanced by local and national governing bodies. However, their utilisation is less straightforward. The remaining capacities, including *transformative leadership (C2) and autonomous communities of practice (C3)*, are only infrequently exercised by the governing bodies or other stakeholders. Overall, the facilitation of TCs primarily emerges from the local municipality and national government initiatives, while bottom-up governance for accelerating TCs is yet mostly submerged.

RQc: How transformative capacity elements could be reinforced?

The most frequently mentioned measures to reinforce the existing TC elements are concerned with 1) strengthening collaboration between different stakeholder groups, 2) raising public awareness towards sustainable mobility, and 3) making sustainable modes of transportation competitive enough to become alternatives to convenient transportation. More specifically, the capacities of *inclusive & multiform governance (C1), transformative leadership (C2),* and *autonomous communities of practice (C3)* would particularly benefit from establishing a firmer dialogue with the public. S*ystem awareness & memory (C4)* and *sustainability foresight (C5)* capacities could be improved by better transportation policy alignment between local-national levels and more aligned priorities and procedures for a collective vision towards transport decarbonisation. Moreover, the capacities of *urban experimentation with disruptive solutions (C6)* and *innovation embedding and coupling (C7)* could be mainly enhanced by removing financial, infrastructural, and market-related barriers or by utilising external EU resources to enhance their local applicability. Finally, reflexivity and *social learning (C8)* could be supported by establishing clear strategic guidelines for self-evaluation procedures at municipality level.

Futher recommendations

In addition to study results, an extensive list of recommendations is provided for Vilnius municipality and local practitioners to enhance local transport decarbonisation processes alongside further recommendations for similar research in the future (65-68 pages). A few recommendations from the list for Vilnius City Municipality are: 1) improve self-reflection and system-monitoring practices, 2) consider the potential implications (social, economic,

distributional) of transport decarbonisation measures on different societal groups, 3) recognise and align fragmented interests and visions within and between local and national government bodies, 4) re-define and reinforce stakeholder collaboration networks. A few recommendations from the list for local practitioners are: 1) enhance local business engagement in decarbonisation, both practical (in terms of strategic prioritisation) and collaborative (with other stakeholders), 2) build a local climate change narrative to align decarbonisation visions between stakeholders and increase public support/engagement, 3) encourage practical learning between sustainable mobility practitioners to stimulate commonly shared 'how-to' knowledge. Finally, a few recommendations from the list for future research are: 1) adopt a similar research design to investigate TC utilisation in other *geographical* or *sectoral* contexts, 2) investigate the *relational* TCs (C9-C10), which were presented by Wolfram (2016) but were out of scope of this research. The main study findings are visually summarised in Figure 0-1.

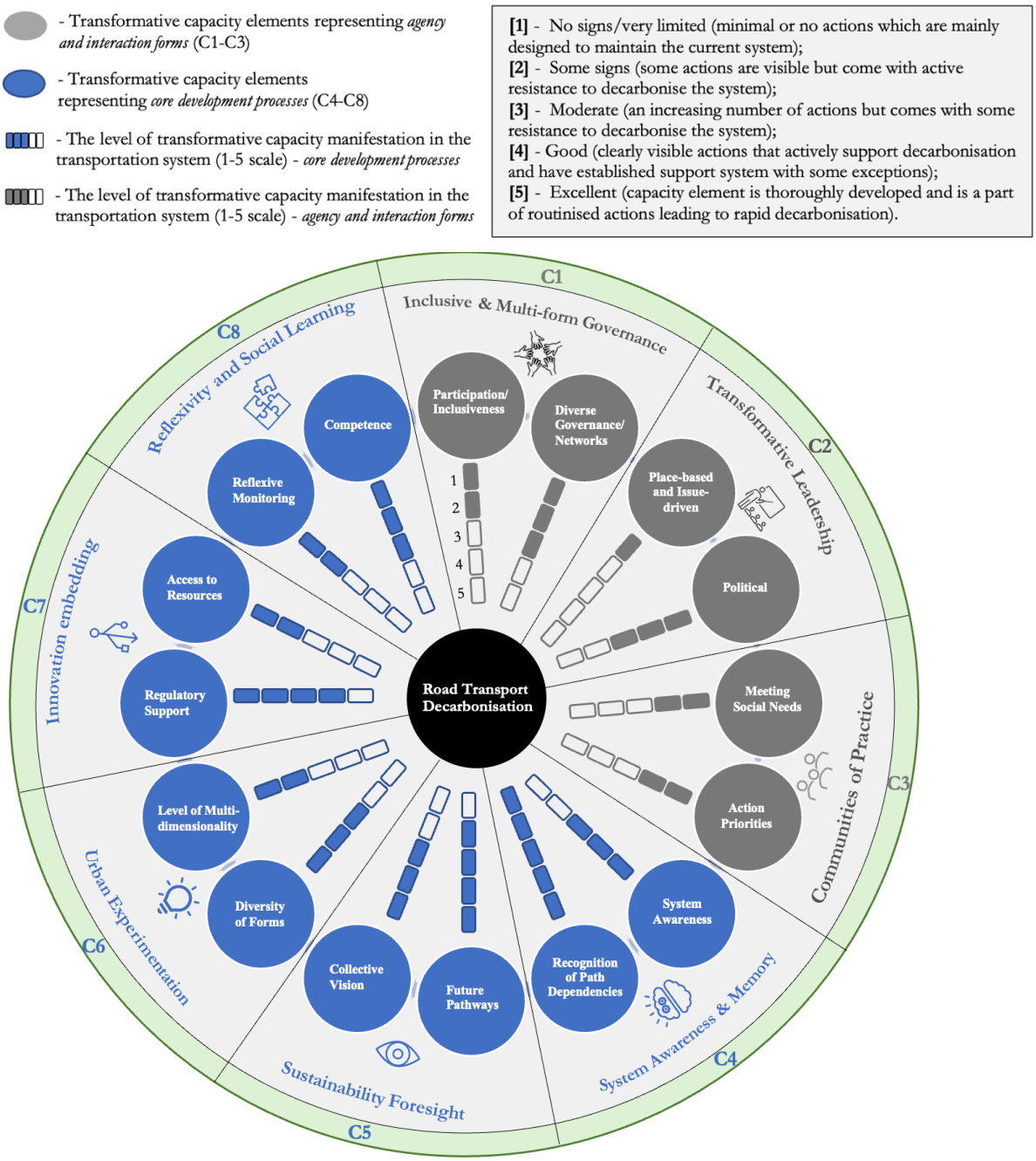

Figure 0-1. Key study findings. The operationalisation level (1-5) of different TCs (C1-C8) for road transport decarbonisation in Vilnius, Lithuania. The evaluation is based on the researcher's judgement according to the study results.

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Abbreviations

ECF	European Climate Foundation
EEA	European Environmental Agency
GHGs	Greenhouse gases
ICE	Internal Combustion Engine
IPCC	The Intergovernmental Panel on Climate Change
IEA	International Environmental Agency
MoE	Ministry of Environment of the Republic of Lithuania
MoTC	Ministry of Transportation and Communications of the Republic of Lithuania
NECP	National Energy and Climate Plan
OECD	Organisation for Economic Co-operation and Development
RRDP	Vilnius City Renewable Resources Development Plan
SUMP	Sustainable Urban Mobility Plan
TC	Transformative capacity
TCB	Transformative capacity building
TCE	Transformative capacity element
TDM	Transport Demand Management
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Programme

1 Introduction

Today's cities, more than ever, call for urgent transformations towards more sustainable ways of moving and living in general. In the sustainability context, such transformations could be defined as *"structural processes – multi-dimensional and radical changes – that can effectively direct development towards ambitious sustainability goals"* (McCormick et al., 2013, p. 1). Whether it is exercised through more efficient resource use (Rink et al., 2017; Stobbelaar et al., 2022), renewable energy integration (Mangnus et al., 2022) or inclusive and innovative transportation planning (Bertolini, 2020). Such transformations are often large-scale, visionary, and disruptive enough to reconstruct the existing systems and the ways society functions. Most importantly, transformations are required because they can turn old and unsustainable systems into new ones. In this way, sustaining the current societal and environmental needs (Broto et al., 2019).

The mentioned transformations are systematic in nature, and therefore crucial in addressing climate change, a critical challenge of modern sustainability debates (McCormick et al., 2013; Burch et al., 2018). With net anthropogenic greenhouse gas (GHG) emissions[1] rising steadily across most prominent industries worldwide, drastic measures will have to be set to meet ambitious climate mitigation goals in the upcoming decade. As cities accommodate the estimated 75% of global CO_2 emissions (United Nations, n.d.), the required changes could be reached by stimulating urban transformations. According to the latest IPPC report on climate change, a rapid reduction of transport-related emissions in cities is pivotal in achieving pathways limiting warming to 1.5°C or 2°C and reaching net-zero objectives by 2050 under the Paris Agreement (IPCC, 2022). Therefore, transport system transformations are necessary for cities to accommodate collective sustainability goals and reach climate-neutrality. The described transformations could potentially happen within the three key building blocks of the transport system - vehicles, mobility infrastructure, freight and passengers (Bazaras et al., 2022).

Despite this, the conventional transportation planning remains a visible barrier in climate change mitigation globally (EEA, 2021). The transportation sector is the second largest source of GHGs worldwide (Foltýnová et al., 2020). Last year, transportation accounted for approximately 23% of global CO_2 emissions, most falling under energy-related fugitive emissions[2] (IPCC, 2022). Also, transportation sector indicates higher dependency on fossil fuels than any other sector globally. Thus, a continuous reduction of associated GHG emissions is necessary to meet before mentioned net-zero commitments for 2050 (IEA, 2021). The timely emission reductions are specifically crucial in the upcoming years as multiple climate mitigation scenarios require at least a 20% global decrease in transport emissions by 2030 (IEA, 2021). As a result, transport decarbonisation is a topic that is receiving more attention in academic and policy discourses.

Similarly, the urban transportation emissions have not decreased at expected levels in Europe, despite the EU managing to reduce its overall GHG emissions by 32% from 1990 to 2022 across all leading sectors (Haas & Sander, 2020). To exemplify, the historical EU transportation emissions have increased by 7% since 1990 (Eurostat, 2022). The challenges of transport decarbonisation within the EU are further illustrated by the recent COVID-19 pandemic. A rebound increase of transport-related emissions by 8% was recorded in 2021 alone, during the post-pandemic recovery in Europe (IEA, 2021). This indicates a clear risk to global carbon

[1] Net-anthropogenic greenhouse gas emissions indicate a limited carbon dioxide (CO_2) budget along with other GHGs, as the emitted CO_2 emissions must not exceed the removed emissions to stabilise the carbon budget (Fankhauser, 2022).

[2] Fugitive emissions are mainly related to energy production processes when gases are released during the extraction, use, storage, and transmission processes of various fuels used for transportation (EEE, n.d.).

budget savings in a long-term perspective if the respective emissions remain unsupervised and treated under the existing policy packages (UNECE, 2021).

Numerous scholars accentuate the increased significance of local-level transformations in cities required to cater to such global transportation changes (Wang-Helmreich et al., 2022; Burch et al., 2018; Patterson et al., 2016). However, what makes transport decarbonisation explicitly challenging is the importance that transport activities have for economic development, especially in growing cities, and the role it plays as a primary social need for residents (IPCC, 2022). With 74% of the European population living in urban areas, the mobility demand in European cities continues to rise. Since 2000, the passenger travels have increased by 20%, car transport by 18% and freight transport by 22% within the EU cities (EEA, 2023). Shifting to more sustainable transport systems is also necessary because of the other environmental, health and social concerns (Foltýnová et al., 2020). These concerns are mainly associated with accelerating air pollution and traffic congestion in urban areas alongside traffic accidents and reduced public space liveability (World Economic Forum, 2022; Ribeiro et al., 2007). Even further, around 70% of the direct transport emissions come from road transportation in cities, marking an increased role of personal vehicles in leading the decarbonisation initiative (EEA, 2021). Until today, most European cities have been locked in by the abundance of private fossil-fueled vehicles, undermining the regional efforts to reach climate targets (Wolfram & Frantzeskaki, 2016; Mangnus et al., 2022). On the other hand, cities are positioned as social, technological, and political hubs that hold power and entail the resources to drive long-term transport decarbonisation (UNEP, 2022). Momentous progress has been made in the last decade to decarbonise the sector through advancing low-carbon technologies and reinforcing alternative modes of transportation. Nevertheless, it is evident that the current measures are not sufficient enough and call for drastic societal changes.

A roadmap to decarbonising transportation is particularly challenging in Lithuanian cities. The transport sector is the primary source of GHG emissions contributing to 28% of the overall national emissions and around 54% of total energy-related CO_2 emissions (OECD, 2021). This makes the transportation sector by far the largest GHGs emitter on a national scale (European Parliament, 2021). The inter-sectoral tendencies also indicate the increased significance of national transportation emissions. When compared to other sectors, they have steadily risen from 12% to 28% since 1990 (Figure 1-1). In regard to road transportation, the latest national GHG emission inventory report shows that such road-related transport emissions have continuously increased since 1994 and are currently higher than in 1990 (Figure 1-2). Unfortunately, no significant emission reductions have been recorded in the estimated period, despite stringent policy measures introduced nationally throughout the last decades (Environmental Ministry of the Republic of Lithuania, 2023).

The situation is explicitly concerning in Vilnius, the capital city of Lithuania. After reaching independence from the Soviet Union in 1990, the local expansion of transportation systems in Vilnius was guided by booming auto-mobilisation and post-soviet growth-oriented infrastructure planning (Griškevičiūtė-Gečienė & Griškevičienė, 2016). The city also holds one of the highest percentages of car ownership among European cities, with a third of the private vehicle fleet falling within the Euro 3 category[3]. This shows that most of the city vehicles are relatively old and heavy-polluting (Susisiekimo Paslaugos, 2017). Therefore, the historical city development coupled with rapid urban expansion has increased dependence on fossil fuels as the primary source for fueling individual and industrial vehicles. The latest regional and national

[3] Euro 3 is one of the six vehicle classification categories (Euro 1 - Euro 6), which determine emission standards for individual and light commercial vehicles based on their age and pollution levels. The higher the classification category, the more stringent the emission requirements.

findings also signal a heavy fossil fuel dependency in the transportation sector in Lithuania (Environmental Ministry of the Republic of Lithuania, 2023). Vilnius city is no exception in this regard (Vilniaus Planas, 2018). To exemplify, almost a half of all daily commuting trips in Vilnius are made by private residential vehicles (Vilniaus Planas, 2018). Besides, road transportation accounts for 93.9% of the total fuel use within the sector with most vehicles being fueled by petrol and diesel (Vilniaus Planas, 2018). This further results in adverse health and well-being impacts, with transportation being the leading source of air pollution and accounting for almost half of PM2.5 and NOx emissions locally (OECD, 2021; Vilniaus Universitetas, 2020). At the same time, almost a third of the city population lives in excessive noise zones linked to the increasing private vehicle use (Ministry of Environment of the Republic of Lithuania, 2018).

As a response, Vilnius city municipality has set ambitious sustainable mobility targets to be met as part of the national and collective EU efforts (see Chapter 4). Such efforts are mostly targeted to alleviate the negative climate impacts associated with the private vehicle uptake. Targets include a twofold reduction of fossil-fueled transportation usage until 2030 (EU White Paper, 2011), no CO_2 emissions from urban logistics in Vilnius city centre by 2030 (Vilniaus Planas, 2018) and climate neutrality, including net-zero transportation by 2050, as part of the European Green Deal (EU Green Deal, 2020). Despite more rapid policy responses, the adverse impacts of conventional transportation planning continue to burden a myriad of local stakeholders. These include but are not limited to local policy-makers, businesses and city residents. The mentioned stakeholders are directly required to meet the outlined climate mitigation targets or experience the negative environmental, social and health externalities linked to carbon-intensive transportation.

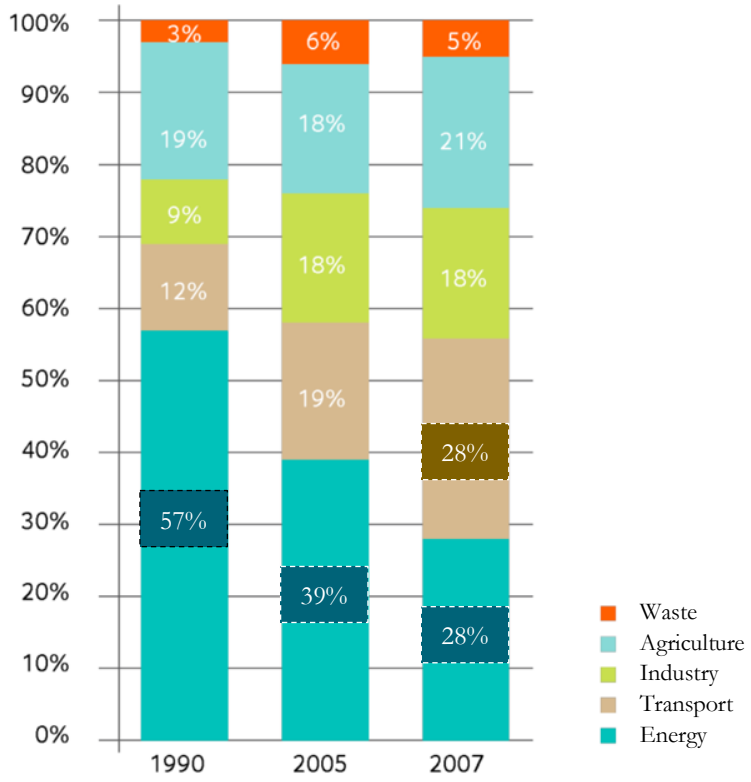


Figure 1-1. Emitted GHG emission distribution in Lithuania by sector (since 1990), in %. The leading sector(-s) for each time period are highlighted (Adopted from National Energy and Climate Plan, 2020, p. 17).

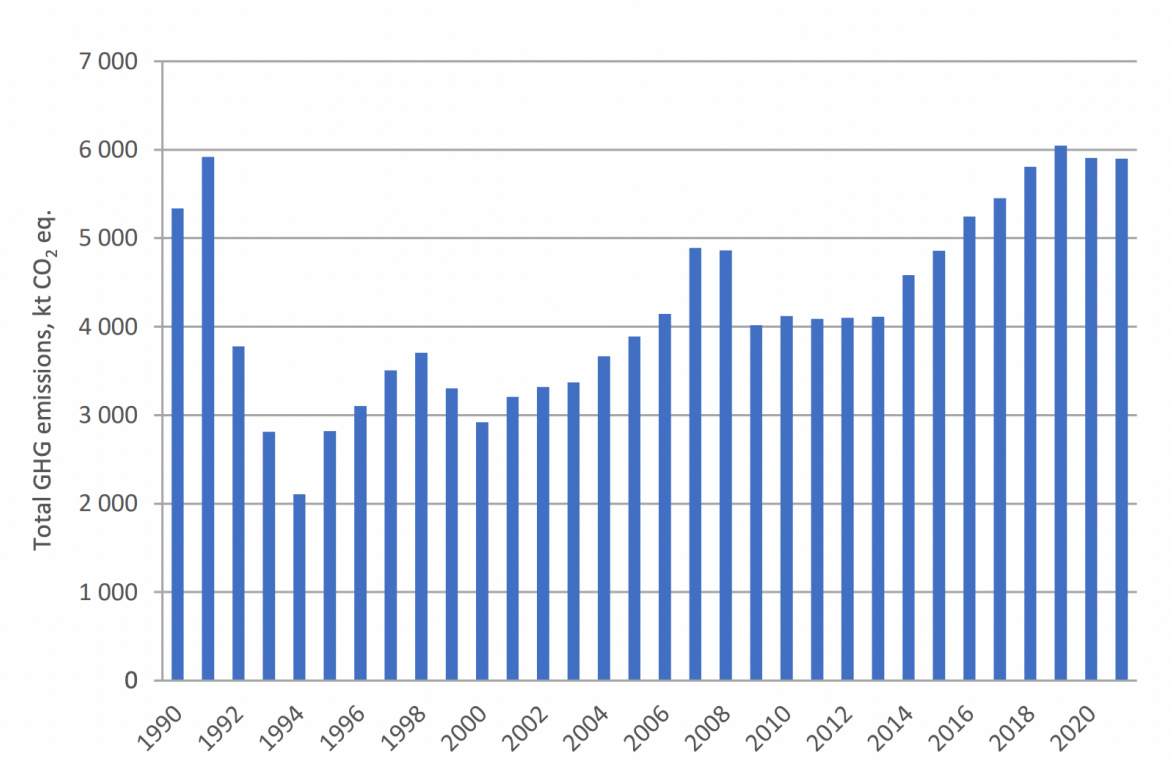


Figure 1-2. Development of Lithuania's GHG emissions from road transport since 1990. Source: National GHG Inventory Report (Environmental Ministry of the Republic of Lithuania, 2023, p. 105).

1.1 Problem Definition

The accelerating socio-ecological pressures along stringent decarbonisation targets illustrate a pressing need to rethink how the current transport system is organised in Vilnius. This further calls for more holistic and systematic actions by public and private actors to materialise the outlined transport decarbonisation objectives into practical results. Essentially, the visible fossil fuel dependency marks a growing need to investigate new and novel mechanisms to dismantle the conventional transportation system and transform it into more sustainable one.

Thus, this study proposes transformative capacity-building lenses as one of the potential approaches to investigate the decarbonisation phenomena. It is crucial to acknowledge that there are multiple ways the local municipality could decarbonise the transport sector. Some of the measures include large-scale changes in technological, infrastructural, behavioural and policy patterns (see section 2.1.1). However, this study explicitly employs the conceptualisations of transformative capacity building (see section 2.6). An abbreviation of TCB is introduced to refer to transformative capacity building throughout the document. City-level TCB could be understood as the process of enhancing collective stakeholders' abilities to come up with and implement sustainability measures while addressing socio-environmental challenges. This study addresses how cultivating such transformative capacities could be highlighted as one of the many crucial trajectories for restructuring the sector towards climate neutrality. Instead of focusing on separate notions of transportation planning (e.g., infrastructure, policy, innovation), the study revolves around recognising and utilising system-level capacities. These capacities are overarching and not only reflect changes in a single transport planning notion, but also show how different notions interlink and affect each other more broadly. An abbreviation of TC is used later on to refer to transformative capacities.

Different types of capacities are needed in cities to orchestrate and sustain transport decarbonisation. According to Wolfram et al. (2019, p. 31), such TCs could be defined as *"the collective ability of the stakeholders involved in urban development to conceive of, prepare for, initiate and perform path-deviant change"*. Therefore, the TCs become the building blocks of such directed transformative change. As mentioned, such change is often radical and focuses on creating more progressive and resilient systems while simultaneously re-inventing unsustainable systems (Wolfram, 2016). In this context, a path-deviant change is transitioning towards a more sustainable transport system through system decarbonisation, while TCs are the critical elements of this change. TCs could be related to different urban processes that foster sustainability, including the ones of collaboration, stakeholder and community engagement, and innovation development, just to name a few (Broto et al., 2019). While numerous definitions and applications of TCs exist, this study is based on the conceptualisations provided by Wolfram (2016), who determines three dimensions of TCs: 1) agency and forms of interaction, 2) core development processes and 3) relational dimension (see section 2.6).

Despite the emergence of similar TCB studies across various fields (see section 2.5), there is a limited utilisation of related frameworks in practice, especially in the transport sector (Wolfram, 2016; Loorbach et al., 2017). In addition, the literature review shows that no similar research on TCB for sustainable transportation systems was conducted in Vilnius or other Baltic cities before. Therefore, the provided study is novel in this regard and creates a local narrative for identifying essential enablers and barriers of transport decarbonisation from the transformative perspective.

The study seeks to contribute to similar research initiatives in cities within the Baltic region. As a result, addressing the increased need for low-carbon, clean and green mobility solutions within the region to advance systematic sustainable transportation transitions (Interreg Baltic Sea Region, 2021). By focusing on Vilnius city as a case study, this thesis seeks to contribute to a richer empirical understanding of the current mobility system's existing capacities, according to Wolfram (2016), and how the sector could be transformed by reinforcing TCB. Similar studies could enhance current academic inputs on what TCB means for developing a sustainable, inclusive and resilient transportation system and what local policy-makers and urban practitioners could learn from city-oriented studies, such as the presented case study in Vilnius. The proposed study could further open the opportunity to examine changes within the transport sector locally and their significance in *"elicting or hurdling every component of transformative capacity in cities so as to inform multi-actor interventions and policies for better governing urban low carbon innovations"* (Broto et al., 2019, p. 17).

1.2 Aim and Research Question

By conducting a case study, the concepts of transformative change have been empirically grounded and investigated in Vilnius city context for long-term sustainable transportation planning. Therefore, the study expects to better understand if TCB elements are visible within the local transportation system and what social, environmental, technical, and collaboration-based pillars they encompass. By doing so, the critical stakeholders and their role in building TCs are also spotlighted while identifying the gaps where TCs could be reinforced in current governance models. Thus, this study recognises system areas where TCs show the most and least potential for guiding a visionary and holistic narrative towards road transport decarbonisation. In this way, supporting the emerging research and providing a practical application of the theoretical concepts scarcely explored in the transportation sector. More specifically, one study aim is formulated for the research purposes:

- **The study aims to identify the existence or lack of potential transformative capacities which support or hinder road-transport sector decarbonisation in Vilnius, Lithuania and explore their characteristics and potential;**

Based on the research aim, one research question (RQ) with three sub-questions has been formulated to be answered in this thesis:

RQ: How are transformative capacities being built to advance local road transport decarbonisation in Vilnius, Lithuania?
RQa: How do transformative capacity elements manifest?
RQb: How are transformative capacity elements exercised by different actors/or by the municipality of Vilnius?
RQc: How could transformative capacity elements be reinforced locally?

Figure 1-3. Research Questions with sub-questions

1.3 Scope and Delimitations

The research explicitly focuses on Vilnius city as a case study. In terms of practical scoping, Vilnius city is positioned as both a geographical and institutional boundary in this study and covers the urban Vilnius city area (see Chapter 4). The city is investigated as an arena of transformative change mobilisation and as the network of relevant stakeholders that the city necessitates. It is appreciated that the national and international level decision-making considerably influences transport policies and decarbonisation pathways locally. Nevertheless, these influences are only addressed partly by analysing the dataset that is focused on the local context. It could be noted that the research primarily targets capacity building, including local actors and their interconnections alongside local-level system processes, with only an indirect consideration of external drivers and inter-system interactions. For instance, the study examines intra-system processes, meaning that other systems, despite having a considerable impact and synergies in terms of transportation-related changes (e.g., energy system), are only partly covered in the study where the relevance was identified. Also, it is considered that transport decarbonisation can be a significant driver for realising other sustainable development targets, such as improving overall mobility accessibility, air quality, noise pollution levels, social cohesion and road safety. Or on the contrary, can result in negative rebound effects on these aspects (Lah, 2017). However, these connections are not directly explored in the study.

Furthermore, the study has a pre-determined focus on urban road transportation, mainly due to its significance regarding carbon intensity and overall share of GHGs within the sector. Hence, air and water transportation, including aviation and container shipment, are out of the research scope. In this study context, urban road-based transportation is mainly concerned with individual private vehicles (e.g., light individual vehicles including cars, vans, motorcycles), public vehicles (e.g., public transportation, ride and car-sharing services, taxis), urban freight transport (e.g., short-haul road transport, light and heavy goods vehicles) and active modes of transportation (e.g., walking, cycling, electric scooters). The long haul and cross-border transportation alongside other, not specified types of transportation are also excluded from the study.

The final noteworthy consideration relates to the transferability of study results. The study derives context-dependant results that should not be generalised across other Lithuanian cities or cities with similar social, geopolitical, or environmental characteristics (e.g., cities in the Baltic region or Eastern European cities). However, the study findings could inform other inquiries and be a starting point for similar research propositions. Some other observations related to scoping limitations are discussed later on (see section 6.3).

1.4 Ethical Considerations

The primary ethical deliberations while conducting the study included pertaining to academic integrity guidelines when reviewing the academic literature and policy documents and ensuring the anonymity of the research participants interviewed. To maintain the researcher's honesty and integrity, a final thesis write-up acknowledges different authors' ideas, including text, graphs, and other visual and written material, as part of their own work with an appropriate referencing system applied throughout the paper. Equivalently, with due respect to the policy-makers and other experts' anonymity, the proposed study did not disclose the specialists' names or other personal information that could be deemed sensitive.

To capture the insights from the field professionals, written consent was received for voluntary participation in the study. The consent was also received for recording the interviews during data collection process. The insights collected from the thesis project were only used for educational purposes. All research participants were informed about general results derived from the study via email. In case of a request to share specific study results for practical purposes, such as informing policy-makers and local practitioners, it should only be done after double-checking it with study participants. Finally, all the research data was stored accordingly on the private university's account and kept with rigorous attention to its safety and anonymity. All interview recordings and transcripts were deleted 3 months after the final thesis submission.

Furthermore, it is important to acknowledge that during the research process, few institutions and additional practitioners were contacted to discuss the selected thesis topic and theoretical model. This was done in order to contextualise the proposed study and find out if the proposed study is of high relevance for local practitioners and academics. Additional meetings were also useful in collecting any relevant documentation that could inform thesis writing. Taking this into consideration, the author made sure that any relevant transportation data provided by the practitioners was used in an impartial manner. This includes having no means to favour any company's/institution's activities and any specific individual. Nor attempting to shed the ongoing developments in the city in a more positive light. Research project was not funded by any external organisation.

1.5 Audience

The proposed study assesses the local capabilities to decarbonise the transportation sector and evaluates to what extent the existing measures show signs of adaptive, reflexive, and systematic governance (Witzell et al., 2022). As a result, the primary targeted audience of this thesis is local policy-makers directly working with transport decarbonisation and advancing other sustainable mobility measures. The study findings are also more broadly relevant to other urban practitioners, municipality representatives, businesses and specialists directly or indirectly working with transportation planning, climate change mitigation, sustainable mobility and urban planning in general.

Policy-makers, especially those foreseeing, planning, and evaluating transport-related decarbonisation measures, will have to devise tangible solutions to initiate the necessary transition. Thus, the identification of relevant stakeholders and signs of system-level capacities is essential to accommodate decision-making towards transport decarbonisation. The adopted framework within the study explores transformative capacity building from multiple pillars, including social, technological, ecological, economic, and political deliberations. Consequently, the study findings can be applied in interdisciplinary contexts across various fields. This could be particularly useful for policy-makers, urban planners and specialists working across different sectors where clear synergies with the transport sector are visible. For instance, the study could be of importance to specialists working in the energy sector due to increasing renewable energy

demand to accommodate transport decarbonisation (e.g., biofuel use, electrification infrastructure). In addition, practitioners who work with urban experimentation, urban planning, and stakeholder engagement to drive low-carbon initiatives could also benefit from the study. Similarly, some insights could be relevant to other municipalities implementing Sustainable Urban Mobility Plans (SUMPs) or where ambitious sustainable mobility targets are foreseen with no clear capacity mobilisation.

Another audience is the scientific community, particularly scholars approaching sustainable transportation topics at local/regional/national/EU levels alongside researchers focusing on other Baltic and Eastern European cities with similar social, political/institutional, cultural and historical development characteristics. Although the generalisation of study findings should be avoided across different contexts, the proposed case study could provide some valuable insights regarding the identification and operationalisation of TCs in cities. Also, this thesis provides an extensive in-depth analysis of local transport decarbonisation characteristics, which could form a solid basis for informing future academic work.

Finally, the local businesses will have to adapt and shift their practices according to more stringent local climate obligations. This study could benefit such transportation and logistics companies in providing critical insights into current transport decarbonisation trends, challenges, opportunities and capacities required at the system level.

1.6 Disposition

Chapter 1 guides an introduction to the selected topic, elaborates on its significance, and identifies research aim and question. This chapter also describes the research scope, delimitations and ethical considerations while outlining the intended audience and disposition of the study. *Chapter 2* covers an overview of relevant academic literature regarding the selected topic while identifying some evident research gaps and reviewing different TCB typologies. Similarly, the complexities underpinning transport decarbonisation at EU level are presented. Most importantly, the chapter introduces a theoretical framework employed throughout the study. *Chapter 3* describes the selected research design, including the chosen methodological approach and research methods that guided data collection, data analysis and data interpretation processes. *Chapter 4* introduces the selected Vilnius case study, reviews why it was chosen and provides necessary background information as a prerequisite for the following thesis chapters. *Chapter 5* presents the main study findings on separate TCs and also links these findings to provide a summary of answers to the RQ. *Chapter 6* then situates the findings within a broader academic literature while discussing further implications of the identified TCs for local transport decarbonisation. *Chapter 7* concludes the study findings and draws some final insights while advising similar research prospects in the future. Also, this chapter elaborates on some recommendations for local municipality and practitioners to guide further implementation of TCs locally.

2 Transformative Change in Transportation Sector: Theory, Typology and Applications

Before elaborating on the selected research design (see Chapter 3), it is crucial to reflect on the existing bodies of knowledge that address urban transport decarbonisation and TCB both in practice and theory. Thus, this chapter provides a compiled overview of the existing academic literature on the selected topic. First, the general sustainable transportation tendencies within the EU are described. After that, the leading conceptualisations of transformative urban change are discussed by drawing examples from transition management and systems thinking literature. Then, the main typologies of TCB are critically reflected upon while outlining some relevant case studies. Finally, the chapter ends with an introduction of the selected theoretical framework employed in the study.

2.1 Transport Decarbonisation Narratives in the EU

"A Roadmap for Moving to a Competitive Low Carbon Economy in 2050", introduced by the EU in 2011, highlights transport decarbonisation as an inevitable pathway for long-term urban transformation. As further outlined, the EU aims to cut GHGs emissions by 80-95% by 2050, with transportation being a cornerstone of such ambition not only due to transport emissions alone but its significant contributions to energy-related emissions (European Commission, 2011). However, transport decarbonisation remains a highly complex challenge that requires systematic and integrated decision-making in different facets of urban planning (Gota et al., 2019; Broto et al., 2019; Panoutsou et al., 2021). In addition to the challenges outlined in the previous section (e.g., growing mobility demand), this section elaborates on leading policy measures for transport decarbonisation within the EU, other critical co-benefits, barriers, and potential trade-offs.

2.1.1 Leading Measures in Cities

Most scholars recognise that the transition from conventional to more sustainable modes of transportation within the EU is highly context-dependent (Haas & Sander, 2020; Panoutsou et al., 2021). Nevertheless, some re-occurring trajectories for road-transport decarbonisation in cities are well established and include the following (Damert & Rudolph, 2018, p. 8):

1. Encouraging technological improvements of the vehicles (e.g., reduced CO_2 emissions in new cars)
2. Improving the quality of the fuels used for these vehicles (e.g., fuel efficiency)
3. Further development of the vehicles' infrastructure (e.g., public transportation infrastructure)

Although these trajectories encapsulate most of the measures, other scholars elaborate on these categories by distinguishing some more concrete actions. First, the uptake of alternative and more sustainable energy sources for fueling vehicles can eventually lead to the phasing-out of fossil-fueled vehicles. These sources include electricity (Dia, 2019), biofuels (Panotsou et al., 2021) and hydrogen (Vilke et al., 2020), with the latter being mainly discussed in urban logistics context, e.g., for last-mile deliveries (Silva et al., 2023). The EU further supports this with a commitment to fully phase-out diesel and petrol cars and vans by 2035 (European Parliament, 2022). Despite fuel sources having a considerable impact, reducing the overall use of internal combustion engine (ICE) vehicles or decreasing the need to travel in the first place are the leading solutions (ECF, 2022). Some other principal measures are concerned with regulatory tools introduced by the local municipalities which restrict the movement of most polluting vehicles, such as low-emission zones (LEZ) and extra low-emission zones (ULEZ), with the latter deemed more successful for direct CO_2 reductions than their counterpart (Peters et al.,

2021). Besides, more attention is dedicated to informative measures which reduce emissions by changing residents' commuting behaviour, for instance, raising public awareness towards alternative modes of transportation (e.g., walking, cycling). Such measures complement other transportation demand management[4] (TDM) tools, such as pricing mechanisms and car parking management (Ferguson, 1990; Rye & Ison, 2016). Technological advancements are also significant as they encourage the development of Intelligent Transport Systems (ITS), including solutions in smart mobility, energy grid management and digitalisation of mobility infrastructure and data (Zawieska & Pieriegud, 2018). Finally, the emergence of broader exogenous factors can also contribute towards road transport decarbonisation. The uptake of e-commerce and teleworking[5] (Shi, 2023) and autonomous vehicles (ITF, 2021) are some of the many such examples. As mentioned before, every city adapts unique policy interventions, and these interventions can vary greatly. However, the required transition is often addressed by taking an integrated approach and combining different economic, regulatory, technological and behavioural measures (Haas & Sander, 2020). Such a combination of measures allows to weigh possible options and adjust them depending on local capacities, city characteristics and political climate (Danielis et al., 2022a).

One of the ways to conceptualise low-carbon mobility measures is the policy approach known as "Avoid-Shift-Improve" (A-S-I). Originating in the early 1990s in Germany, the A-S-I framework provides an integrated lens for structuring policy measures and strategies to reduce environmental impacts (Zhang & Hanaoka, 2022). The approach primarily focuses on demand management and has replaced the earlier "Predict-Provide-Manage" model, which was deemed less holistic (TUMI, 2019). The A-S-I model, its pillars, expected results and some examples are illustrated in Figure 2-1. "Avoid" means reducing the overall need to commute, or reducing commuting by most polluting vehicles, through such measures as land planning or compact city planning. "Shift" marks a transition from carbon-intensive vehicles to less carbon-intensive vehicles, while "Improve" focuses on enhancing the quality of the existing vehicles through fuel efficiency and technological improvements (Zhang & Hanaoka, 2022).

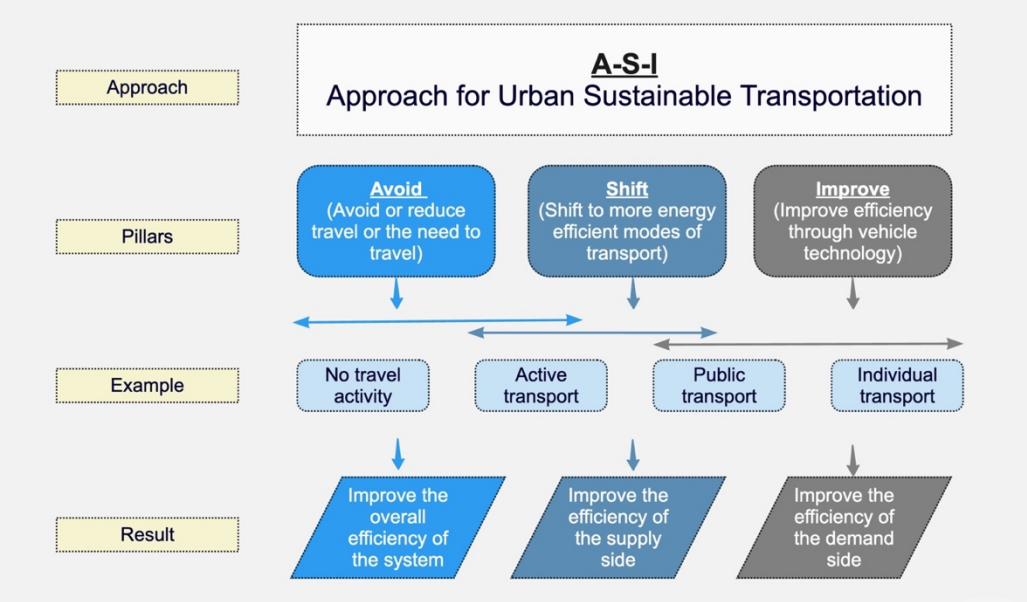


Figure 2-1. The A-S-I framework. Based on Farzaneh (2019, p. 16) and TUMI (2019, p. 2).

[4] Transportation demand management (TDM) is the set of related policies and strategies that aim to modify travel behaviour, usually towards more sustainable forms (Ferguson, 1990).

[5] Teleworking refers to working from home one or more days weekly. Teleworking would result in a decreased number of commuting trips. However, rebound effects are identified, such as increased energy use at home (Shi, 2023).

Table 2-1 further elaborates on the A-S-I approach by describing how local, regional and national policy measures can contribute towards low-carbon transportation in cities by adopting "Avoid" and "Shift" practices. It is observed that most of the measures (e.g., economic and regulatory instruments) address transport decarbonisation by encouraging a shift to less polluting vehicles. Similarly, carbon neutrality measures are introduced beyond local boundaries and could be successfully implemented at regional and national levels.

Table 2-1. The interconnectivity between sustainable mobility policy measures at different governance levels and their realisation through the A-S-I framework. Recreated from EEA (2022), based on Vanherle et al. (2021), International Transport Forum (2021) and Bartle et al. (2016).

Approach	Avoid	Shift	Examples	Typical level of Government		
				Local	Regional	National
Economic instruments to provide the right price signal/ reflecting all external costs			Congestion-charging schemes, distance-based charging			
			Fuel taxation and removal of tax exemptions			
			Car taxation			
			Parking prices			
			Tax treatment of company cars			
			Public transport pricing			
Transport infrastructure and supply of sustainable transport services			Public transit services: improving the coverage, frequency, comfort, payment systems			
			Reallocating road space			
			Traffic management and control			
			Infrastructure for multimodal freight transport			
			Providing sharing platforms for bikes, e-bikes, cargo-bikes etc.			
			Improving quality and coverage of infrastructure for walking, cycling (safe bake lanes, pavements)			
Spatial planning			Planning to increase local densities, to foster mixed use of land, to improve connectivity and accessibility			
Regulatory measures			Environmental zones, car bans, pedestrian zones, other access regulations			
			Parking regulations			
Other policy measures			Multimodal transport information, management and payment			
			Marketing and rewarding			
			Awareness campaigns			
			Legislation on teleworking			
			Site-based travel plans			

2.1.2 Co-benefits

The decarbonisation of transport systems in cities could also come with visible benefits and opportunities that stem beyond climate resilience. These benefits include new innovation diffusion, enhanced risk management, reinforced mobility system's flexibility and better choice-inclusiveness for city residents (Wolfram & Frantzeskaki, 2016; Gota et al., 2019; Mangnus et

al., 2022). In addition, the co-benefits of improved air quality, increased accessibility to transport services and energy efficiency and reduced noise pollution are often outlined as reasons that push decarbonisation agenda forward on a local level (Lah, 2015). Also, low-carbon transport could be linked to the long-term security of energy systems as most conventional transportation relies on petroleum products. As a result, the diversification of energy sources for transportation improves system's stability and resilience to external shocks (Lah, 2015; Glynn et al., 2017).

Other non-climate benefits include reduced expenditures in public health due to residents moving more actively and being less exposed to before mentioned air pollution and indirect job creation through expanding sustainable mobility sector (Jennings et al., 2020). Scholars also note that sustainable mobility can lead to just transition[6] by providing other social benefits. For example, community cohesion can be stimulated by dedicating less space to car infrastructure and using the additional space allocation for active commuting or other social activities (Abram et al., 2022). Similarly, sustainable mobility could be linked to decreased structural inequality and poverty levels via improved transport and fuel affordability and choice-inclusivity in cities (Creutzig et al., 2012; Jennings et al., 2020).

2.1.3 Barriers and Trade-offs

Along with the advantages of transport decarbonisation, critical barriers and trade-offs prevent current mobility systems from being transformed. First and foremost, the literature accentuates the financial and technological insufficiencies as the major challenge for large-scale transport decarbonisation in cities. The economic constraints are exhibited by the high costs associated with the deployment of sustainable transport technologies. These financial limitations are visible when considering the public infrastructure development for EV charging and the accessibility and affordability of EVs for public and residential uses (Siskos et al., 2018; Dia, 2019). Besides, fuel efficiency improvements (OECD, 2021) and hydrogen production, storage and distribution (Vilke et al., 2020) are expensive, and no affordable technologies exist for large-scale implementation. Similarly, when considering urban logistics, ICCT (2022) elaborates on the lacking EV infrastructure for fuelling trucks, high costs and a general shortage of low-carbon vehicles for transporting goods. Lah (2015) adds that most sustainable transport technologies require high initial costs, which are not always feasible for businesses and municipalities. Hoen et al. (2017) further call for large-scale investments and innovation diffusion in the transportation sector to overcome these barriers.

Furthermore, current policy packages must be revised to drive large-scale behavioural changes in cities (OECD, 2021). This could be further aligned with missing political will and public support towards new policy measures. A lack of public engagement is linked to existing 'transport taboos', which according to Gössling and Cohen (2014, p. 1-2), emerged due to *"interlinked barriers to the design, acceptance and implementation of such transport policies that remain unaddressed as they constitute a political risk, and their discussion would violate existing order"*. This is further supported by Hoen et al. (2017), who also note that political willingness is not always aligned, especially when coordinating policy interventions at different scales and throughout different sectors.

Finally, introducing sustainable mobility measures should be well considered to avoid potential trade-offs. Most of these trade-offs link back to upfront financial investments required for technological development, as the same funding streams could be invested elsewhere or they

[6] Just transition (JT) elaborates on the need to share the benefits and costs of transport decarbonisation in a equitable and fairly manner for all, while addressing issues of inter and intra-generational justice that emerge in the current system due to pre-existing socio-economic arrangments (Abram et al., p 2).

are simply insufficient (Lah, 2015; Turner et al., 2022; Zhang et al., 2023). The emerging rebound effects are also noticed. For instance, energy efficiency improvements for transportation can lead to decreased energy use costs; however, if the demand for energy is not decreased at the same or higher level, the overall consumption can increase (Lah, 2015). Moreover, Peñasco et al. (2021) argue that the introduction of some policy instruments in cities (e.g., LEZ, carbon taxes) can have unfavourable outcomes in a short-term perspective, particularly in terms of distributional and competitiveness effects. This could specifically affect smaller and medium-sized enterprises and low-income households. The adverse outcomes could also emerge if, due to these measures, the CO_2 emissions are not directly addressed but moved elsewhere, indicating a so-called off-shoring of emissions (Peñasco et al., 2021). Dugan et al. (2022) complement such views by arguing that phasing-out fossil-fueled cars are primarily beneficial to high-income households in city centres and medium-income households in suburban areas. Lah (2015) adds that establishing additional fuel and car taxes, or other conflicting policies, can disproportionately increase the burden on residents if appropriate alternatives are not provided. Finally, some other scholars note negative externalities associated with the loss of labour in transportation industries that rely on fossil fuels, which can negatively affect economic development at a local scale (Vandeplas et al., 2022). Nevertheless, scholars agree that most of these trade-offs and rebound effects can be tackled with balanced policy packages (Lah, 2015; and targeted capacity building at the system-level (Axsen et al., 2020).

2.2 Theoretical Conceptualisations of Transformative Change

This section reviews the background literature on urban transformative change and provides some of the main theoretical typologies that are commonly used to conceptualise TCs in sustainability contexts. For instance, in transition management (see section 2.3) and systems thinking (see section 2.4) theories. Some relevant case studies (see section 2.5) are also revisited to highlight their contribution to TCB literature.

Although the characteristics of transformative urban change are explored in various academic disciplines, the concept remains multi-faceted with no unanimous definition across them. The emergence of 'transformation' as a concept in urban context goes back to 1950s, with Polanyi (1994) applying transformation term to explain radical political-economic change that characterised the introduction of market state[7] (Patterson et al., 2017). In contemporary context, as mentioned in Chapter 1, multiple scholars acknowledge an increased need for transformative changes in cities as a response to pressing challenges of urbanisation (Burch et al., 2018), climate change (McCormick et al., 2013) and unsustainable consumption patterns (Kuzemko & Britton, 2020; Stobbelaar et al., 2022). Therefore, most transformations arise as a response to societal pressures (Wolfram, 2016).

Hölscher & Frantzeskaki (2021) further describe urban transformation as a multiplex process of radical and system-level disturbances across social, cultural, economic, ecological, technological and institutional pillars of the city. Thus, such processes seek to dismantle and re-imagine the traditional urban structures in order to overcome socio-environmental pressures that the cities face and increase resilience of urban systems (Wolfram, 2019; Hölscher & Frantzeskaki, 2021, Witzell et al., 2022). Research on urban transformations then, explores why transformations happen, why they happen in specific places and how they happen (Alberti et al., 2018). Although the research on transformations regarding climate change mitigation are accelerating, it ony happened in the last few decades (Broto et al., 2019). Therefore, such research is somewhat faded into the background, especially for applied research in

[7] Polanyi (1994) describes 'market state' as the state which creates favourable conditions for economic growth by encouraging free market economy, which is supported by the state's policies.

transportation planning, urban geography and other disciplines (Bertolini, 2020; Tuominen et al., 2022). Nevertheless, some of the most prevailing conceptualisations of transformative urban change in environmental sciences are generally rooted in TCB (Hölscher et al., 2019; Witzell et al., 2022) and transition management (Loorbach, 2010). These concepts and their applications are further explored in the following sections.

2.2.1 Transformative Capacities (TCs)

The theoretical origins of the TC concept lead back to the resilience theory, which was introduced by Holling in 1973, seeking to investigate the role of change and what type of change could be considered resilient and adaptive (Olsson et al., 2014; Wolfram et al., 2019). More recently, the TC concepts have emerged within contemporary climate governance literature as a targeted focus area (Patterson et al., 2017). Some valuable contributions were made towards contextualising resilient change management in cities necessary for driving successful climate change mitigation (Kuzemko & Britton, 2020). Hölscher et al. (2019) recognise the significance of TCs by noting that cities which lack such capacities in their governance models might face severe structural barriers to effective climate action. Also, the ongoing changes in governance structures to support climate mitigation open up multiple research opportunities to explore the role of prominent stakeholders and how effective climate governance in the context of urban transformations could be supported (Hölscher et al., 2019). However, Burch et al. (2018) noted that such system-level transport transformations in cities are frequently fluid, messy, and non-linear, characterised by a myriad of paths and require engagement from multiple networks of actors.

2.3 Transition Management (Socio-technical Transitions)

Transition management research defines *transformative change* as processes that lead to radical transitions in socio-technical systems (Kivimma et al., 2019). Complementing the views of Hölscher & Frantzeskaki (2021), Kivimma et al. (2021) argue that such transitions also occur across multiple societal domains, including organisational, socio-cultural and material. Ghosh et al. (2022) further elaborate that transitions are evolutionary and do not occur fast but result from incremental and gradual changes throughout the mentioned societal domains.

Correspondingly, Geels (2018) elaborates on the importance of socio-technical transitions and how such transitions are developed by emerging landscape pressures (e.g., global policies for climate change) and changes in the existing regimes (e.g., conventional transportation planning). He explains that transition occurs when a window of opportunity emerges, and niche technology is mainstreamed (e.g., EV technologies). Such transitions could also be approached as system-level transformations that may differ depending on timing, technological development, local institutions and multi-level relations and interactions between stakeholders (Markard et al., 2012; Geels, 2018; Frantzeskaki & Wittmayer, 2018).

The socio-technical transitions research also suggests relevant concepts for engaging with evaluation approaches for transformative change. One of the most profound TC conceptualisations was developed by Loorbach (2010), who approaches transformative capacity building through a transition management framework. The author highlights four 'spheres' necessary for adaptive and functional transformations in cities, including strategic, tactical, reflexive, and operational capacities. Thus, arguing that short-term initiatives should be guided by a long-term vision while accentuating the importance of self-steering, timely innovation management and systematic observation of urban networks as processes that enhance TCB (Loorbach, 2010). Such concepts as visioning, learning and experimentation have also been frequently mentioned in transitions literature as a guide towards city transformations (Loorbach et al., 2017).

Finally, the transition research has evolved drastically in recent decades with new approaches emerging to evaluate socio-technical transitions, such as strategic niche management (SNM) and technological innovation systems (TIS) (Markard et al., 2012) and urban climate transition literature (Glaas et al., 2019).

2.4 Systems Thinking

Another approach to understanding transformations is systems thinking. Although its origins lead back to business management and organisational sciences (Gunderson & Holling, 2002), the systems thinking theory is extensively applied throughout sustainability-related disciplines. Systems thinking elaborates that systems are made of interrelated parts that form a uniform identity towards reaching a common goal, whereas the relationships between those parts maintain the system itself (Price et al., 2003). According to Voulvoulis et al. (2022), systems thinking is critical in researching multi-faceted sustainability challenges such as decarbonisation. As the authors explain, the current interlinkages between urban systems are frequently guided by significant social, economic and technical incentives that result in unsustainable lock-ins (Voulvoulis et al., 2022). This could be linked to conventional modes of transportation that are explored in the study. Therefore, the systems thinking theory could be used to conceptualise the proposed study by investigating how transportation system behaves and how different systems' components interact to reach expected transformative outcomes, e.g., long-term decarbonisation.

It is acknowledged that besides the introduced theories, other approaches could be applied to conceptualise and evaluate sustainable mobility transformations. For instance, social practice theory (Barros, 2016), evaluation theory (Mickwitz et al., 2016) and tactical urbanism (Silva, 2016), with the latter more frequently used in urban planning literature for transforming public places in cities. Although the presented theories are different in their structural approaches, all of them could be effectively utilised to further the understanding of transport decarbonisation. Whether by focusing on the system itself and its parts (e.g., systems thinking, social practice theory) or by highlighting the importance of switching from conventional transportation to new forms of mobility, with a focus on the process itself (e.g., transition management).

2.5 Case Studies on TCB

The research on TCs and their operationalisation could be grouped into two categories. First, applying TC frameworks for evaluation purposes to foster urban learning (Wolfram, 2016; Broto et al., 2019). Second, to investigate urban governance practices for adaptive climate change mitigation (Torrens, 2019; Hölscher et al., 2019; Witzell et al., 2022). Some of these case studies are detailed below.

Regarding transportation-related studies, Witzell et al. (2022) conducted an in-depth study of Sweden's national policy initiative for transport decarbonisation by identifying relevant agents for long-term TCB. More specifically, the concept of TC was explored by assessing overall policy capacities in stewarding, unlocking, transforming and orchestrating large-scale sustainable changes, according to Loorbach (2010). Orchestrating capacity was, therefore, identified as the weakest transport policy link, revealing areas for improvement in coordinating multi-actor networks and stimulating cross-sectoral synergies.

However, other studies employ TCB in different sectors or investigate them more broadly. For instance, Hölscher et al. (2019) focus on a case study in Rotterdam, the Netherlands, to investigate TCB across the five most carbon-intensive sectors for overall climate governance. The study summarises that some areas, such as innovation development and networks for adaptive governance, are still at niche levels and require ongoing capacity building in the future.

Similar to Witzell et al. (2022), Neij et al. (2021) adopt the framework provided by Loorbach (2010) for the case study in Sweden to explore energy efficiency in buildings. The authors integrate transformative lenses to evaluate policy effectiveness, outlining critical practices for the timely improvement of policy evaluation practices. Instead of focusing on the relevance and efficiency of the policy, the focus is drawn towards identifying opportunities for systematic change by encouraging visioning, urban experimentation, and continuous learning. Moreover, Broto et al. (2019) provide an in-depth global analysis of 400 sustainability initiatives, exploring to what extent TCB characterises these initiatives. Borgström (2019) sheds more insights on TCs' role in steering urban transformations at a national level in Sweden. Finally, the study by Obergassel et al. (2019) discusses the significance of TCB for socially inclusive urban settlement development in South Africa.

2.6 A TCB Framework for the Proposed Study

The framework by Wolfram (2016) was selected to assess the TCB in the local context and to position the study within relevant theoretical conceptualisations of transformative urban change. The author proposes a model with ten interdependent key components (C1–C10) that support urban TCB (Figure 2-2). The TCB elements in the framework were derived by systemising a large volume of literature across different disciplines. As the existing transformative capacity concepts vary greatly and frequently lack practical applicability in an urban policy context, Wolfram (2016, p. 121) has introduced this framework to target such shortcomings and provides a list of integrated elements that reflect *"the particularities of urban contexts and/or practical operationalisation of transformative capacities"*. Thus, the framework could be interpreted as a theoretical-analytical tool to explore different stakeholder and institutional consolations that can be applied to strategic governance towards low-carbon planning in cities (Wolfram, 2016).

The author further aggregates TC elements into three categories. C1–C3 elements refer to *agency and interaction forms*, illustrating the emergence of different stakeholder networks and their interactions required to drive transformative change. C4–C8 elements identify *core development processes,* which describe actions that these stakeholder consolations should perform towards transformative change. Finally, C9–C10 elements represent *relational dimensions*, which outline how actors and processes are facilitated at different scales and agency levels. According to Wolfram (2016), all these elements are interdependent, and development or underdevelopment in one element can affect others, reinforcing or undermining the capacity towards transformation.

The reason behind selecting this particular framework is mainly practical. While most of the existing TCB frameworks are theoretically stimulating, they lack a set of clear criteria to assess capacity building in practice. Therefore, the outlined framework was selected due to its extensiveness in describing not only the elements that constitute TCB but also a compilation of clearly defined and tangible criteria behind every element. Based on the literature review, Wolfram's framework provides one of the most comprehensive accounts of TCB operationalisation in sustainability contexts. As this research was the first attempt to evaluate TCB in Vilnius city, the framework has proven to bring the most value to the study.

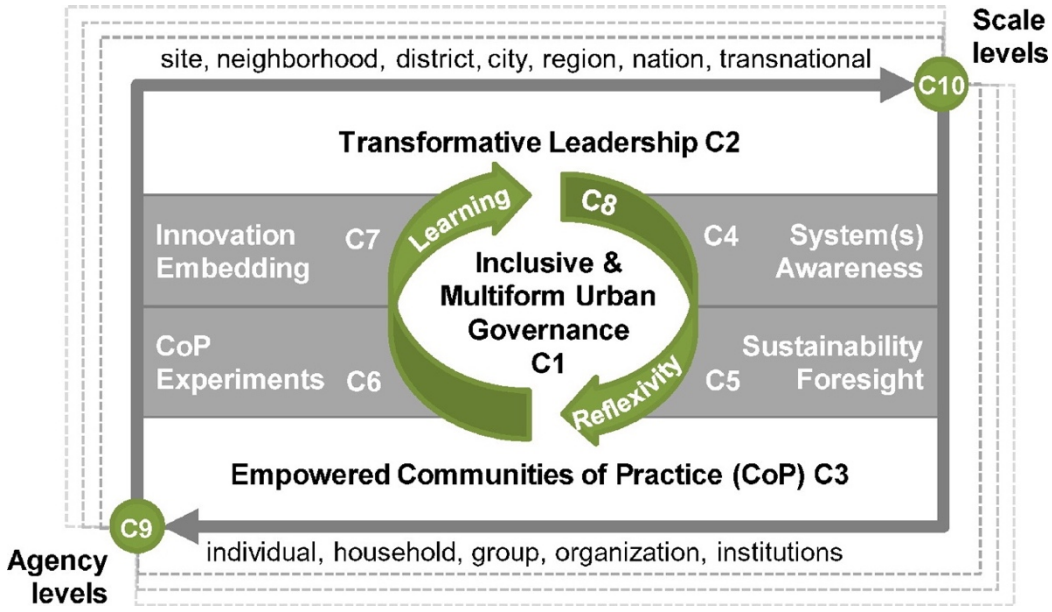


Figure 2-2: A TCB framework applied in the study (Wolfram, 2016, p. 126).

For this study purpose, C1-C8 elements were examined in the local transportation system. Although C9-C10 elements are significant in unifying all the remaining elements, they have not been directly addressed in the study for a few reasons. Foremost, due to time and methodological constraints, investigating these elements would have required a more in-depth understanding and analysis of the remaining elements. Another reason is the practicality of the research. The TCB was not explored in local systems before. Thus, it seemed most reasonable to provide an account of primary elements covering prominent stakeholders and development processes. The selected C1-C8 elements are further described in Table 2-2, pinpointing their brief definitions and significance for transformative change.

Table 2-2: The selected TCB elements and their definitions (Authors own, adopted from Wolfram, 2016).

Code	Transformative capacity	Definition & Significance
C1.	Inclusive & Multiform Governance	Signifies the existence of diverse, flexible and robust governance structures needed for transport decarbonisation. Works as leverage for building political willingness, trust, legitimacy and knowledge for transformation (Booher, 2003; Ubels et al., 2010; Chu, 2018).
C2.	Transformative Leadership	Describes the leadership forms and attributes that encourage transport decarbonisation. Polycentric, socially embedded, issue-driven and place-based leadership is vital for individual and political roles to support transformation (Denis et al, 2012; Sotarauta et al., 2012).
C3.	Autonomous Communities of Practice	Illustrates the significance of local social needs/human agency in terms of sustainability and overall development. The aligned recognition and prioritisation of these needs are necessary for inclusive transport decarbonisation (Moulaert et al., 2013).
C4.	Systems awareness & Memory	Determines stakeholder awareness towards required transformation while recognising system dynamics, path dependencies and obduracies undermining transport decarbonisation. Links culture with structures, practices and systemic memory (Garud & Nayyar, 1994; Gottschick, 2013).

C5.	Sustainability Foresight	Elaborates on commonly shared sustainability visioning in governance structures (scenarios/visions/long-term narratives) that allows the co-creation of knowledge and determination of actionable strategies and projects for transport decarbonisation (Wittmayer et al., 2014; Patterson et al., 2017).
C6.	Urban Experimentation	Outlines the level of practical urban experimentation that enhances further transport decarbonisation. Such experimentation is crucial for knowledge creation and social/policy learning (Dolata, 2009; Wittmayer et al., 2014).
C7.	Effective Sustainability Innovation Embedding	Investigates how transformative resources are facilitated by gradually removing barriers to innovative practices and embedding them into routines, organisations, action plans and especially legal frameworks for transport decarbonisation (Ferguson et al., 2013; Ghosh et al., 2020).
C8.	Reflexivity & Social Learning	Evaluates the assessment methods used for self- and system-reflection (monitoring, evaluation). This implies reflexivity formats for formal and informal assessment of transport decarbonisation measures to enable positive feedback loops (Lam et al., 2021; Losleben, 2023).

2.7 Conclusions from Literature Review

The reviewed academic literature from different disciplines and schools of thought reveals that transformative change as a topic of interest becomes more frequently mentioned in numerous academic discourses and plays an increasingly important role in ensuring urban sustainability. This is particularly evident in three scenarios. First, when discussing practical measures and challenges for climate change mitigation (e.g., innovation diffusion, institutional barriers). Second, when engaging with the theoretical conceptualisations of TC and TCB (e.g., transition management, systems thinking). Third, when discussing the ways to stimulate the co-creation of knowledge between the stakeholders and fostering inclusive co-learning for urban sustainability. The described scenarios even further reinforce the presented study's rationale as the high significance of the topic was identified throughout. Despite this, the literature accentuates that sustainability issues still need to be discussed in cities on a higher strategic level, indicating a gap between theoretical and practical interest in driving sustainable transformations.

Regarding transport decarbonisation, the literature portrays a pressing need to rethink the current mobility practices in cities and transform them in the upcoming decades. This is further illustrated by highlighting how conventional transportation planning has inscribed particular path dependencies and routines into urban life, which are neither sustainable nor socially beneficial. Thus, a clear call is made to utilise various forms of material and non-material resources in cities to fade out the conventional transportation paradigms. Despite the accelerating attention towards sustainable mobility, scholars note that there is no silver bullet solution to address the associated challenges, and the pressures should be addressed by a balanced mix of policy packages.

Finally, the academic literature shows that there is a significant academic shortage of TC and TCB frameworks' applications in the transportation sector. Although some extensive studies exist across multiple sectors and varying geographical scales, case studies focusing on a city-level investigation of transport decarbonisation narratives are scarce. The practical applicability of related frameworks is mainly limited to urban focus, while most case studies are conducted in Western Europe and Scandinavian cities.

3 Research Design, Materials and Methods

This chapter elaborates on the methodological logic employed throughout the thesis project to bring more clarity to the selected study design and underlying research processes while serving as a guide for similar inquiries. The chapter starts by introducing research design characteristics and explaining how it fits the selected theoretical framework. Later, an overview of the chosen research methods for the study is presented while elaborating on data collection and data analysis processes tailored to address the research aim and RQ. The chapter ends with some considerations of the researcher's role and reflexivity in the research process.

3.1 Research Design: Qualitative Inquiry

As the main aim of the thesis is to identify the potential signs of TCs within the local transport system, the qualitative study design was selected for the study. Thus, the study showcases qualitative research characteristics with the systematic collection, organisation, and interpretation of qualitative data. The study design incorporates interviews and document analysis to explore the TCB in a local context. More specifically, the semi-structured interviews with professionals in the mobility and sustainability-related spheres (see section 3.2.2) and content analysis of the local and national sustainable mobility and climate policies (see section 3.2.3) built a core for data collection. The study employs exploratory sequential approach (Creswell & Creswell, 2018), with interviews performed first and being a leading data collection method, which is then followed by document analysis to cross-check and provide additional insights. The study was performed in 4 stages: 1) establishing the research design; 2) collecting data; 3) analysing data and 4) interpreting data to answer RQ. Figure 3-1 depicts the research flow and research stages, including considerations on the selected research approach, use of different methods and how they feed into deriving study results. The data collection and data analysis procedures are further discussed in the following sections of this chapter.

The qualitative research approach was deemed most suitable for the selected study due to its intrinsic benefit in collecting in-depth insights into participants' experiences and perspectives (Creswell & Creswell, 2018). The proposed research follows an inductive data collection logic with collected observations allowing to identify structural patterns within the system that could be linked to test relevant theories and contribute to the existing models (Creswell & Creswell, 2018). Some of the most prominent qualitative research characteristics include investigation of meanings, values and narratives ascribed by individuals or groups of individuals towards a particular social phenomenon. In qualitative research, the data is typically collected in a natural setting through collection of textual and oral information with a focus on uncovering complex meanings and structural patterns within data (Peters, 2017). In this way, qualitative research contributes towards deriving a holistic account of the selected phenomenon while acknowledging its complexity, the key actors involved, and the reasoning behind it (Creswell & Creswell, 2018). The researcher plays a pivotal role in such a research process and can influence the research results through personal bias and positionality[8] (Peters, 2017). Thus, the reflexivity techniques are applied to address the associated limitations, which are further discussed in section 3.4.

Furthermore, this study entails emergent and exploratory design characteristics. Emergent research design indicates a flexible and not fully structured approach to research, leaving space for methodological alterations during data collection (Creswell & Creswell, 2018). Similarly, an

[8] Positionality refers to any characteristics that shape one's position as a researcher, such as race, nationality, age, gender, social and economic status, personal and professional experiences (Rose, 1997, p. 309).

exploratory approach was used when conducting a pre-study for the project, aiming to provide more context when exploring an under-researched area of interest (Hunter et al., 2019). In this case, TCB for system-level transition in Vilnius city context. Both approaches are often found in qualitative research inquiries (Creswell & Creswell, 2018). The worldview reflected in the presented study falls within ideas of constructivism, which states that knowledge is always subjective and *"realities are constructions of the mind and that there exist as many such constructions as there are individuals"* (Mohajan et al., 2022, p. 8). Hajer & Wagenaar (2005) state that the constructivist perspective places significance on change and institutions as important pillars in urban planning and policies. In addition, the study shows signs of a pragmatic worldview. Although the study does not employ a mixed-methods design, it is concerned with identifying the most suitable methods and deriving practical applications to address a particular problem (Creswell & Creswell, 2018). In this case, it seeks to recognise the level of existence and optimisation of key transformative capacities for transport decarbonization locally. At the same time, identifying systematic barriers and enablers while providing application-oriented policy recommendations. At last, most previous studies on sustainable mobility planning and transport decarbonisation in the Baltic cities use quantitative methods and often single method of inquiry (Iwinska et al., 2018), missing out on capturing nuanced qualitative intricacies (Wesener et al., 2021). Survey inquiries are the most prominent in the mentioned research designs (Iwińska et al., 2018). To address this limitation, this study adopts two qualitative methods as part of data triangulation process[9], deriving a rich set of qualitative insights into local decarbonisation complexities.

3.1.1 Case Study Approach

The introduced study is conducted using Vilnius city as a single case study. The application of case study design is increasingly applied in qualitative inquiries to derive context-specific and rich insights in a specific geographic locale within limited spatial and temporal considerations (Creswell & Creswell, 2018). A case study could be defined as *"a research approach to investigate contemporary real-life phenomenon through detailed contextual analysis of a limited number of events or conditions and their relationships" (*Onatu, 2012, p. 1). Due to the complexity of processes and plurality of actors involved in driving transformative urban change at a city scale (Witzell et al., 2022), the case study of land-based transportation in Vilnius has been selected to narrow down the scope of the project. Similarly, such a choice was helpful in providing new and more comprehensive observations, which are particularly suitable for less researched topics (Flyvbjerg, 2006). As a result, the case study approach seemed to be most practical to investigate the extent to which the TCs are articulated within the current governance models for transportation planning. Thus, providing more tangible and concise insights. Using the case study design was also more compatible with adapting the TC framework introduced by Wolfram (2016), which was described in the section 2.7.

Despite the wide-ranging applications of a case study as a methodological approach in social sciences (Yin, 2014), it has been criticised for several reasons. First, some critics note a lack of reliability and generalisation of study findings, arguing that small cases are mostly suited for exploratory and experimentation purposes (Zainal, 2007). Others have criticised case studies due to high researcher's exposure to influence the results of such studies, while the findings face shortages in objectivity and rigour (Onatu, 2012). Nevertheless, if executed in a structured, transparent and robust way, case studies can prove extremely useful in untangling complex challenges as they are conducted within the context of their application (Flyvbjerg, 2006). In addition, the study provided by Hölscher et al. (2019) shows how the case study approach can

[9] Data triangulation refers to using multiple methods of inquiry, different types of methods or multiple data sources to address the reserch questions. Therefore, applied as a methodological technique to improve data validity in qualitative research (Carter et al., 2014).

be used to derive rigorous findings in similar inquiries. Considering that no similar studies have been conducted in Vilnius city, the aim of the case study is rather exploratory. This means that the research focus is primarily on identifying prevailing capacities and recognising how the selected capacities are exerted in local sustainable transportation governance.

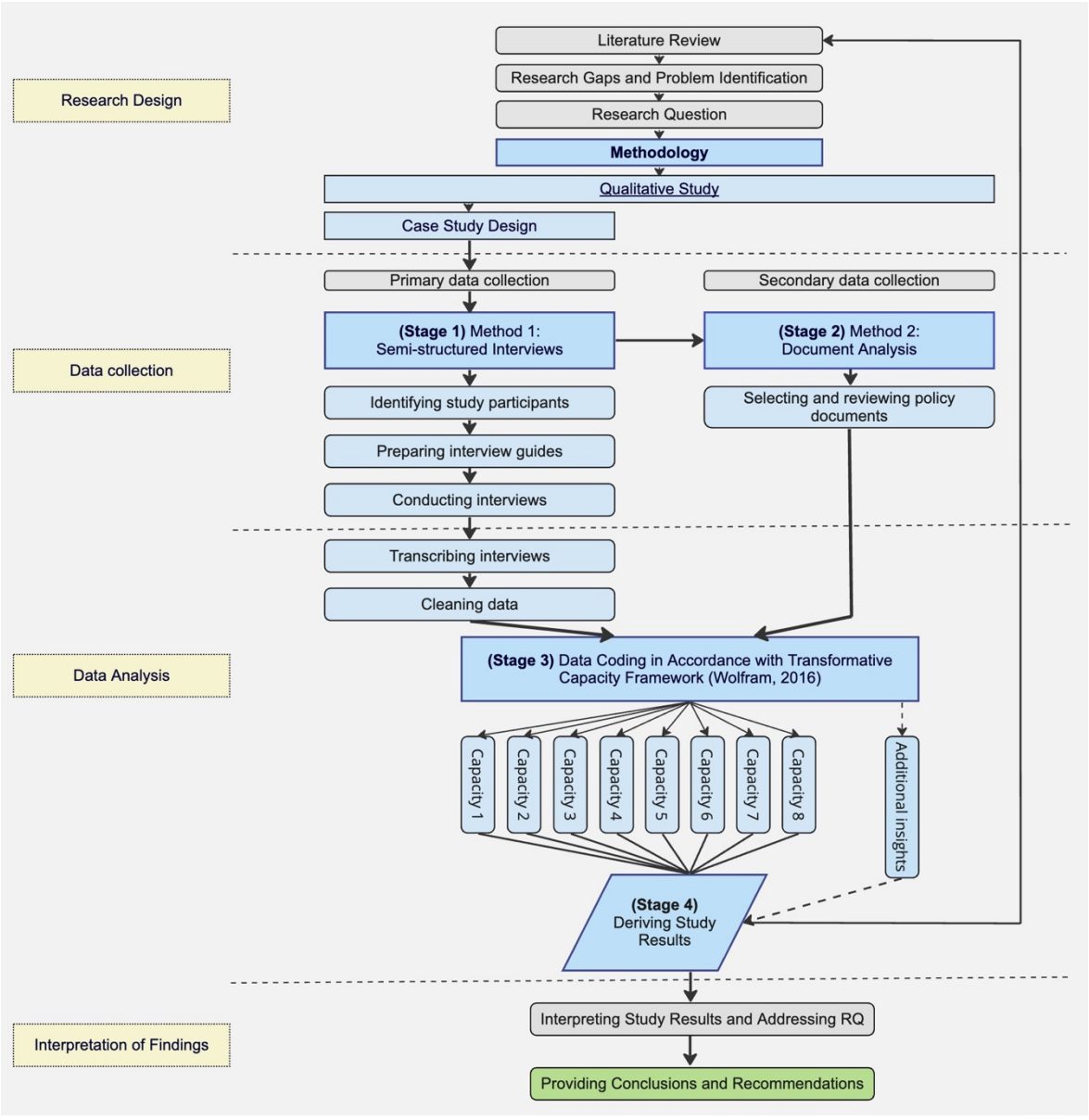


Figure 3-1. Research design, research logic and use of different methods to derive study results.

3.2 Data collection

Twofold data collection process was performed, including primary data from semi-structured interviews and insights captured from secondary document analysis. As mentioned before, data triangulation was considered with such diversification of research methods bringing a more balanced and nuanced understanding of the phenomenon under investigation (Bryman, 2006; Yeger & Steiger, 2013). Data triangulation was specifically selected to improve reliability of the study findings, simultaneously addressing some of the limitations associated with case study inquires outlined in previous section (Onatu, 2012; Creswell & Creswell, 2018). Workshops, in a form of focus group discussions with relevant stakeholders, were also considered as a potential method for data collection, however, was eventually not chosen due to limited study timeframe and stakeholder availability. The data collection process followed a structured logic when

identifying relevant stakeholders and when performing semi-interviews in accordance with the predetermined framework (see sections 3.2.1 and 3.2.2)

3.2.1 Identification and Recruitment of Study Participants

When discussing key actors in transport decarbonisation, multiple authors acknowledge an array of relevant stakeholders which should be addressed. The stakeholders and the extent to which they are involved in similar inquiries vary from place to place as they often express divergent interests due to existing political and institutional systems in a specific locale (Glaas et al., 2019; Schreuder & Horlings, 2022). Therefore, the identification of stakeholders for the study was guided by completing a thorough desktop research on urban transformation governance literature and by reviewing sustainable mobility initiatives in Lithuania. This was supplemented by a review of case studies that employ similar theoretical frameworks. As a result, the local government, policy experts, businesses, urban planners, users, civil society, knowledge institutions, such as universities and other various intermediaries (e.g., consulting firms and NGOs) were identified as the leading stakeholders in driving transformative mobility changes at urban scale (Loorbach, 2010; Broto et al., 2019; Ghosh et al., 2020). Such identification was supported by informal conversations with local field practitioners and a pre-study, which was completed in preparation for writing this thesis. The stakeholders which were involved in the case study and their categorisation are further detailed in Figure 3.2. However, it is important to note that users and civil society were not directly addressed in this study and were only considered indirectly. Such a decision was motivated by reflecting upon the research aim and research question as the study seeks to assess the TCs at a system-level rather than individual-level. And according to Wolfram (2019), TC is not possessed by individuals but is a result of interactions between different stakeholders in a specific institutional setting with its intrinsic socio-technical conditions.

Finally, a snowballing technique was adopted as a purposeful stakeholder sampling method (Creswell & Creswell, 2018; Geddes et al., 2017). When recruiting study participants, the pre-existing contacts were utilised which were obtained by prior work experience in the mobility field in Vilnius. Similarly, the informal discussions with local practitioners during the pre-study period were particularly beneficial for expanding the stakeholder network and targeting professionals in the sustainable mobility field. A few additional meetings were also organised with academics from local universities in Vilnius to identify which stakeholders hold the most influence and could be consulted to discuss system-level changes in the transportation sector. As a result, the pre-existing and newly obtained network of contacts helped to reach out to and recruit most of the study participants.

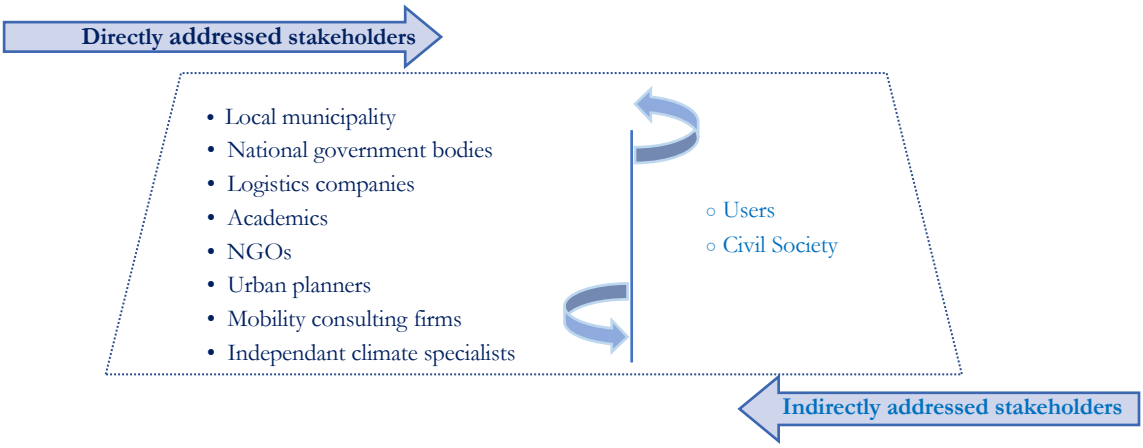


Figure 3-2. Directly and indirectly addressed stakeholder groups.

3.2.2 Semi-structured interviews

Semi-structured interviews were considered as the primary data collection method for capturing the stakeholders' perspectives on transformative capacities and their role in supporting road transport decarbonisation. Interviews are one of the most frequently utilised research methods across social sciences as they allow to gather rich qualitative observations and have flexible nature (e.g., can be easily incorporated with other research methods) (Clifford and Valentine, 2003; Bryman, 2015). For the same reason, the interviews were chosen as the proposed study could not be completed in a comprehensive manner by merely conducting a survey, completing desktop research, or observing study territory/participants. A semi-structured interview type was selected as the most suitable for the study, maintaining a natural flow of conversation, yet making sure that the researcher can keep the required line of questioning (Creswell & Creswell, 2018). This was also beneficial in ensuring that all necessary information is captured for data analysis (e.g., different types of transformative capacities are considered and addressed by the specific interviewees).

Despite the multiple advantages of an interview as a research method, some limitations had to be considered. Firstly, the insights collected from the interviews only provide an indirect and filtered information expressed by study participants (Creswell & Creswell, 2018). Secondly, interview findings could be influenced by both researcher's bias and the participant's ability to articulate their views and express their opinion freely (Creswell & Creswell, 2018). Thirdly, interviews can be a particularly time-demanding research method due to scheduling and organising meetings, transcribing and analysing heavy volumes of qualitative data (Bryman, 2015). To address such limitations, document analysis was used as a supplementary research method for reducing interview-associated bias while semi-structured interviews were conducted in a timely and organised manner to avoid excessive workload.

26 semi-structured interviews (n=26) were conducted between 7th March and 5th April 2023, with all interviews taking place online and using Zoom and Microsoft Teams communication platforms. All interviews except one were conducted in Lithuanian language with the remaining interview being conducted in English. Interview duration varied from 0.5 hour to 1.5 hours. Most of the interviewees hold positions directly associated with strategic transportation planning or decarbonisation topics at local and national levels. The remaining interviewees work with sustainable mobility and other sustainability topics indirectly (e.g., through community engagement, consulting, and educational activities). The interviewed professionals represented 6 stakeholder categories. including academics from local universities (n=6), local government specialists (n=5), transport and climate change experts from national government bodies (n=4), transportation companies (n=4), intermediaries such as mobility consulting and urban planning firms (n=4) and NGO and community representatives (n=3). A full list of interviewed stakeholders, their occupation and the TCEs discussed throughout interviews are further detailed in Table 4.2 (see page 31).

To ensure a purposeful data collection process, the interviewees were asked beforehand to identify which transformative capacity element(-s) match their expertise the most. This was considered because of two reasons. First, to match stakeholder expertise and collect as specific insights as possible due to the complexity and width of transport decarbonisation topic. Also, the primary data collection design features 6 stakeholder categories and 8 elements that have to be thoroughly covered. Thus, such decision allowed to collect more comprehensive insights on few selected TCs per interview instead of briefly covering all TCs. Secondly, most transportation and sustainability professionals in Lithuania work with a variety of topics simultaneously. Thus, such interviewee-determined pre-selection of capacity elements allowed a more organised and framework-tailored data collection process, avoiding abstract and non-representational

interviews that jump from one element to the other, with no specific insights collected. Despite a structured approach to data collection based on the selected framework, semi-structured interviews were flexible enough, allowing interviewees to express other context-dependent and capacity-related views which might have not been necessarily covered by the framework itself. Evidently, the selected interview design came with some additional limitations which are further explored in Chapter 6 (see section 6.3). Based on selected TCs, the personalised interview guides were tailored for each stakeholder to collect detailed insights. The example of an interview guide is provided in Appendix A. At the same time, interviewees were asked to sign an online consent form (see Appendix B) before the interviews, ensuring that approval is received for interview recording and voluntary participation in the study. Interviews were conducted until a saturation point was reached. Meaning that all pre-determined stakeholder categories were represented, and all 8 transformative capacity elementsv sufficiently covered or at least indirectly covered by the stakeholders, as determined in the theoretical framework.

3.2.3 Document Analysis

A document analysis was performed as a complementary and follow-up method to derive more comprehensive findings and address some of the methodological limitations of the interviews. As a research method, document analysis could be defined as a *"systematic procedure to reviewing and evaluating documents - both printed and electronic … in order to elicit meaning, gain understanding and develop empirical knowledge"* (Bowen, 2009, p. 1). Frequently, document review is used in triangulation with other qualitative methods, such as interviews and focus groups, to improve the credibility of study findings (Creswell & Creswell, 2018). Document analysis can be a highly valuable qualitative method that enables the researcher to access and interpret the secondary data that represents the exact words of the participants and reflects the complexities to which participants have drawn the most attention (Crewell & Creswell, 2018). Besides, it is a convenient method for complementary data collection as the researcher can access the data at a suitable time while the data collection process is typically less time-consuming than interviews. Nevertheless, one should be aware of some limitations that document review as a research method imposes. For instance, a selectivity bias exists when assessing which documents to review. Some papers might also lack in detail as often the primary aim of the policy documents is not research-oriented (Bowen, 2009).

The document analysis was instrumental in identifying how the specific types of TCs are positioned and addressed by policy-makers in the city and nation-level strategic policy documents. Most importantly, document analysis proved helpful in recognising if there are any inconsistencies between the theoretical visioning of transport decarbonisation and real-life actions highlighted by the interviewees. This has pushed to investigate any visible discrepancies between datasets further. Therefore, recognising to what extent TCs are operationalised in strategic-level policy-making versus concrete, practical actions.

Document data was analysed in addition to interview data to counterbalance both methods' limitations and to collect empirical insights, which might have been overlooked if only a single method of inquiry had been employed (Peters, 2017). A list of policy documents reviewed for the study is presented in Table 4.1. A majority of the selected policy pieces are directly concerned with local transport decarbonisation. Specific parts of other national-level documents were also analysed to examine national-level influences on local TCB, as TCs are often reinforced externally (Witzell et al., 2022). The documents for the analysis were selected by performing a three-stage selection process. First, desktop research on policy documentation was completed alongside consultations with some local practitioners in the primary stage of the research. This has allowed to identify the leading system-level strategic policy documents that directly address local transport decarbonisation or influence climate governance on a broader national level.

Second, an additional list of policy documents was compiled during interviews, based on the interviewees' recommendations and continuous references to specific transport documentation. Last, both preliminary document lists were crossed-checked to highlight the documentation that was recognised as leading based on desktop research and expert opinions. Such a selection process encouraged a more-structured approach when identifying policy documents and has addressed some of the limitations linked to the researcher's selection bias. Some further limitations of document analysis are reflected upon in Chapter 6 (see section 6.3).

Table 3-1: A list of local and national policy documents reviewed for secondary data analysis, authors own.

No.	Document/Policy Name	Document/ Policy Scale	Brief Description	Text under investigation	Publishing date
1.	Vilnius Sustainable Urban Mobility Plan (SUMP)	Local	SUMP is a city-level sustainable mobility strategy introduced by the local municipality. The plan is the leading sustainable mobility operationalisation document for the 2018-2030 period, including decarbonisation goals	Shortened version of the final document	2018
2.	Vilnius City Development Plan (BP)	Local	BP is a city-level governance plan, overseeing long-term development in infrastructure, transportation, energy, housing, and social community building (2021-2030)	Transportation and energy related parts	2021
3.	Vilnius City Renewable Resources Development Plan	Local	City's action plan for the development of the renewable energy (2023-2030) under National Energy Independence Strategy	Parts on renewable energy use in transportation	2023
4.	National Mobility Development Plan	National	The national plan is aimed at harmoniously developing the Lithuanian transportation system and effectively managing state resources at a national scale (2014-2026)	Transportation-related parts	2014
5.	National Energy and Climate Plan (2021-2030) (NECP)	National	Leading national document to meet GHGs targets (2021-2030), mandated by the EU.	Transportation-related parts	2020

3.3 Data Analysis

3.3.1 TCB Framework Operationalisation

A list of criteria and sub-criteria was established to evaluate different categories of TCs introduced in the theoretical framework (see Appendix D) and address them by conducting interviews and/or performing document analysis. However, some criteria and sub-criteria outlined by Wolfram (2016) were adjusted based on insights from Broto et al. (2019) and Witzell et al. (2022), as some terms in the original framework were too ambiguous to fit into the

transport-specific study. The determined criteria and sub-criteria were used as a guide during data collection and analysis processes to identify how TCs are exerted locally. The sub-criteria was used to indicate whether the existence of specific TCs was deemed satisfactory. On the other hand, a lack of fulfilling a specific sub-criterion indicates a shortcoming in a particular TC. However, it is essential to note that the operationalisation of the criteria list was used as an indicative guide rather than a strict set manual. Thus, it allowed study participants to identify elements/processes/linkages that were perceived as most important in TCB. This has allowed to assess the extent of TCB in the transport system in Vilnius while deriving other context-specific insights that could be necessary in building local TCs.

3.3.1 Codebook Thematic Analysis

The qualitative data collected from semi-structured interviews and policy documents was analysed by following the TCs criteria and sub-criteria established in the selected theoretical framework. Such an approach could be interpreted as a codebook thematic analysis when a researcher applies a pre-determined coding structure. Although, in most instances, a codebook is developed by a researcher during the coding process (Thompson, 2022), such coding structures could also be based on previous research and frameworks (Braun et al., 2019). As reaching a saturation point in qualitative inquiries can be challenging, using a codebook approach can also be useful in improving the validity of such studies (Ando et al., 2014). Codebook thematic analysis is often seen as a more pragmatic attempt to analyse data than thematic analysis. Also, new codes and themes can be defined inductively throughout the analytical process and the engagement with the data (Braun et al., 2019).

In this case, data analysis was performed using the criteria list described in the framework by Wolfram (2016). An overall of 33 sub-criteria were examined in 8 TC groups. Later, the coding blocks for every sub-criteria analysis were established accordingly, both inductively and deductively (see Appendix E). Coding was done in 4 stages, based on recommendations provided by Creswell & Creswell (2018): (1) organising and preparing data for the analysis, (2) going through all data, (3) generating data into coding blocks, and (4) reviewing data.

3.3.1 Data Processing

Primary interview data were processed manually by preparing the interview transcripts and then performing coding by following the mentioned coding stages. Microsoft Word and Microsoft Excel programmes were used to prepare, structure and code data. Although coding by hand can be time-consuming and laborious (Creswell & Creswell, 2018), it was deemed more suitable, especially for collecting relevant quotes and identifying nuances within the data that could have been overlooked. Conversely, the policy document data were analysed by using Nvivo 12 software. As policy documents were extensive, the qualitative software was applied due to convenience and time limitations while maintaining the accuracy of study results (Zamawe, 2015).

3.4 Researcher's role and reflexivity

Reflexivity in qualitative research refers to *"the method the researcher enacts for avoiding the false neutrality and universality of academic knowledge"* (Rose, 1997, p. 306). In other words, reflexivity is awareness of one's bias and allows one to critically reflect on personal positionality as a researcher and how past experiences shape study findings (Creswell & Creswell, 2018). Such bias could emerge when selecting methods, determining epistemological and ontological positioning of the study or interpreting data results.

A few reflexivity techniques were employed throughout the research process, as proposed by Haynes (2012), to acknowledge the associated bias:

1. The motivation to engage with and previous links to the selected topic were revised. It was recognised that academic interest in sustainable mobility topics aligns with the personal and professional interests of the researcher as well as previous educational background. Also, previous work experience in sustainable transportation field in Vilnius, Lithuania could have encouraged a personal interest in selecting the topic for thesis project.
2. Before starting the research process, a list of underlying personal assumptions related to the thesis topic was made to identify any presuppositions brought into the study.
3. During the data transcription process, the interview recordings were rewatched while reflecting on how the questions were formulated and how this could have influenced further dialogue and potential answers.

Table 3-2: A list of interviewed stakeholders, their categorisation and TCEs discussed during the interviews (C1-C8)

Transformative Capacity Element (in code)				**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**Other**
Stakeholder group	*Respondent number (code for in-text referencing)*	*Position/Expertise*	*Institution*	*Element(-s) covered in interviews (● - selected as a primary topic, ○ - addressed indirectly)*								
Academia	(1)	Head of Transport and Logistics Competence Centre	Vilnius TECH University		○		○	●	●	●		●
	(2)	Climate Change Researcher	Vilnius University	●	○	●	●	○		●		
	(3)	Transport and Urban Planning Researcher	Vilnius TECH University	○	●		●	●	○			
	(4)	Transport Policy Researcher	Vilnius TECH University			●			●	○		
	(5)	Environmental Management Researcher	Vilnius University	●				○			○	●
	(6)	Head of Human Geography and Demography Institute	Vilnius University		○	●	○		●			●
Local Government	(7)	Chief City Architect	Vilnius City Municipality	○	○	●		●			●	
	(8)	Head of Territory Planning	Vilniaus Planas			○				○		●
	(9)	Senior Public Transport Engineer	Susisiekimo Paslaugos			○		○	○	○		●
	(10)	Community Engagement Specialist	Vilniaus Planas	●	○	●			○		●	
	(11)	Head of Energy Department	Vilnius City Municipality			●		○		●	○	●
National Government	(12)	Senior Advisor of Future Mobility Policy Group	Ministry of Transport and Communications	●	●			●	●	●	○	
	(13)	Head of Climate Policy Group	Ministry of Environment	●	●			●			●	
	(14)	Former Advisor to the Minister	Ministry of Environment	○		●	○	○			●	
	(15)	Head of Infrastructure Policy Group	Ministry of Transport and Communications			●	●		○	●		
Transportation Companies	(16)	Head of Sustainability	Lietuvos Paštas		○	○				○		●
	(17)	Regional Manager	UAB Scania		○			○		○		●
	(18)	Transport and Service Manager	DPD			○		○		○		●
	(19)	Head of Logistics	Omniva		○	○				○		●
Intermediares	(20)	Transport Project Manager	NORMALis.TECH	●	●			○	○	●		
	(21)	Urban Planner and Co-Founder	PUPA	○		●	●		●		○	
	(22)	Sustainable mobility expert / CEO	Gaučė ir Ko	○	○	○	●	●		○		
	(23)	Mobility and Innovation Partner	MC Mobility Consultants				●	●	●	●		
NGOs and Community	(24)	Climate Change Communicator	Freelance	●	●			●			○	
	(25)	Representative	Extinction Rebellion	●	○			○				●
	(26)	Climate Change Specialist	Erudito Licėjus	○	○	●		●			●	

4 Case Study of Vilnius City

4.1 City Characteristics

Vilnius is the capital and the largest city in Lithuania, situated in the south-eastern part of the country. Around 669 000 inhabitants live in Vilnius city including the agglomeration area, making it the biggest city in the Baltic region (OSP, 2022). Vilnius is one of the few cities in the country with increasing population and is an important economic, financial and logistical junction in North-eastern Europe. Around 1,32 million commuting trips are made in Vilnius daily (Vilniaus Planas, 2018). City is divided into three functional zones: central, middle and periphery area. Thus, the city area, which is also a study area, is presented in Figure 4-1.

After gaining independence from the Soviet Union back in 1990, the city has undergone a rapid urban development marked by distinctive socio-spatial changes. For instance, intensifying urbanisation and suburbanisation processes and privatisation of public spaces (Barnfiel and Plyushteva, 2015). As a result of accelerating urban sprawl[10] throughout the last decades, the city's population density has shrunk significantly. This has led to increased average commuting distances between the city center and other parts in order to reach home, work or travel for educational and recreational purposes (Griskeviciute-Geciene and Griskeviciute, 2016). Thus, travelling by car has become a most common type of commuting and remained as such until this day. Around 67% of the city's inhabitants live outside the city centre and use individual cars to reach central city area on a daily basis while around 16% of all daily journeys in the city are completed through the routes connecting residential and central city areas (Bazaras et al., 2022). Due to mentioned characteristics reinforced by urban and economic development, the city has followed the conventional transportation narrative with further expansion of car-oriented infrastructure to accommodate residents' needs. Over 365 000 individual private vehicles were registered in Vilnius in 2021, with an increase of 8% since 2019 (OSP, 2022).

4.2. Case Study Selection

Vilnius was selected as a case study for several reasons. Firstly, as mentioned in Introduction, the city is characteristed by increasing socio-environmental pressures due to conventional transportation planning, which should be investigated in more depth. These include transportation being a leading source of air pollution and GHG emissions locally. Also, the system is characterised by high dependency of fossil fuels for transportation and high ownership of private vehicles while almost a half of daily commuting trips are completed by a car (Vilniaus Planas, 2018). Secondly, both scholars and policy-makers highlight the urgency of decarbonising the transportation sector locally (Susisiekimo Paslaugos, 2018), which is also supported by emerging local mobility strategies. The introduction of local SUMP to address these challenges presents an interesting research opportunity to explore local transformation narratives necessary to accommodate road transport decarbonisation. Lastly, the study fills in some of the academic literature gaps as no extensive studies, especially qualitative, are present with a focus on transport decarbonisation.

[10] Urban sprawl is generally typified as low-density, haphazard development spiraling outward from urban centers (Burchell et al. 1998)

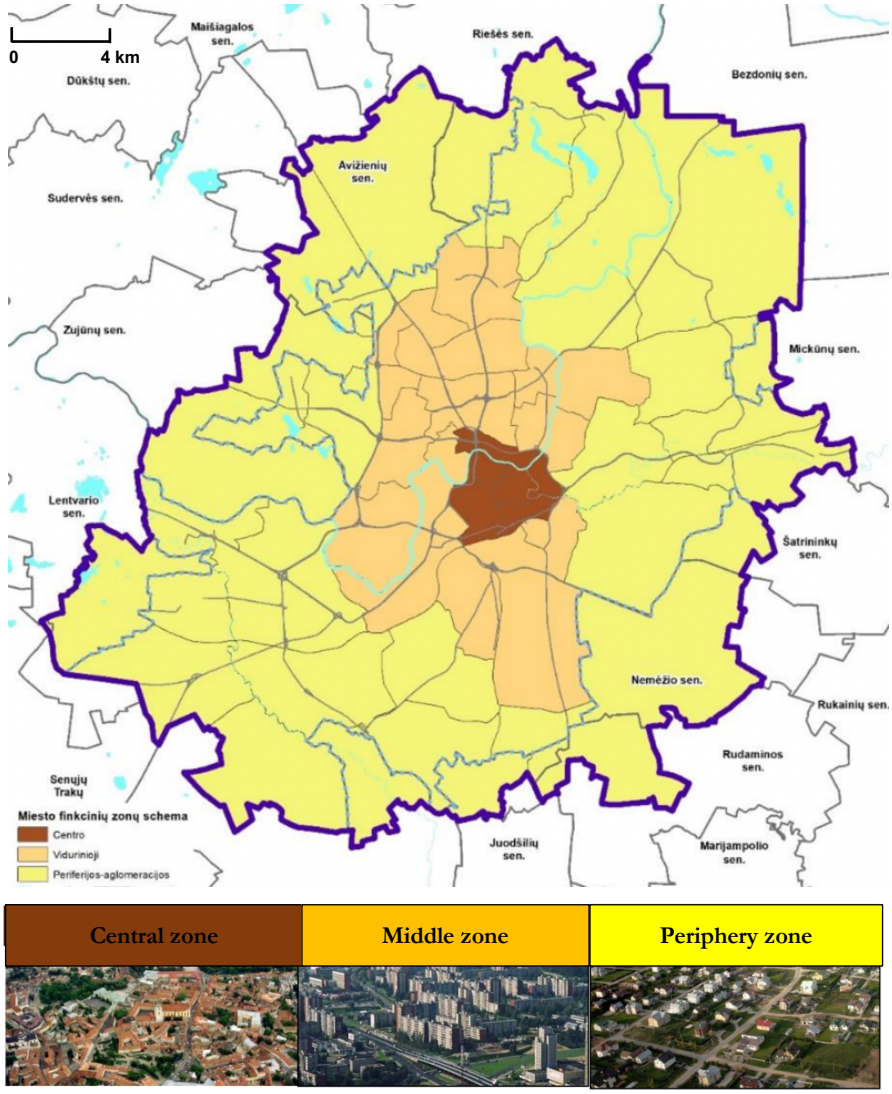


Figure 4-1. The geographical boundary of Vilnius city and the structure of its functional zones (Vilnius SUMP, Vilniaus Planas, 2018, p. 18).

4.3. Sustainable Mobility Goals

The local municipality has foreseen significant reductions in transport CO_2 emissions to achieve the outlined targets, with Vilnius Sustainable Urban Mobility Plan (SUMP) introduced in 2018, leading to this ambition (Vilniaus Planas, 2018). The main focus of SUMP is to ensure safe, innovative, affordable and socially accessible transportation for all city residents alongside the aforementioned environmental commitments. The SUMP established nine thematic areas prioritised for the city's sustainable transport development until 2030 (Figure 4-2). As described in SUMP, the main strategic development direction for decreasing transport CO_2 emissions is the uptake of alternative and more sustainable modes of transportation such as public transportation, active modes of transportation (e.g., cycling and walking), EVs and shared mobility services (e.g., car-pooling, bike-sharing scheme, hybrid mobility services). Thus, reducing the modal share of individual cars significantly, from 45% in 2016 to 22% in 2030 and reaching the desired modal split change in the upcoming decade (Table 4-1). Some

other complementary measures include switching to less carbon-intensive alternative fuel (e.g., hydrogen fuel cells for heavy goods vehicles, biomethane) and other regulatory and infrastructural interventions (e.g., foreseen introduction of the first Low-Emission Zone in 2024, cycling-friendly street design and pilot studies for designated pedestrian zones). A list of local policy goals until 2030 related to road transport decarbonisation is provided below (Vilniaus Planas, 2018, p. 363):

1. Reduce CO_2 emissions from road transport by 20%, compared to 2014 data;
2. No CO_2 emissions from public transportation in the urban centres;
3. Reducing transit traffic in the Old Town to 0%;
4. At least 20% of the individual private vehicle fleet is powered by alternative fuel sources (electric vehicles, hydrogen, biofuel);
5. At least 80% of urban logistics are powered by alternative fuel sources (electric vehicles, hydrogen, biofuel, other hybrid vehicles).

Table 4-1. Distribution of trips made by Vilnius city residents (2016-2020) and expected distribution in 2030 (compiled by the author based on Vilnius SUMP, 2018, p. 351).

Travelling Type	Modal Split (%)		
	2016	**2020**	**2030 (expected)**
Private car	45.1	43	22 (3% - electric cars)
Walking	29.4	30	35
Public Transportation	24.3	25	30
Cycling	0.7	1	10
Public car (Car-sharing)	0.5	1	3

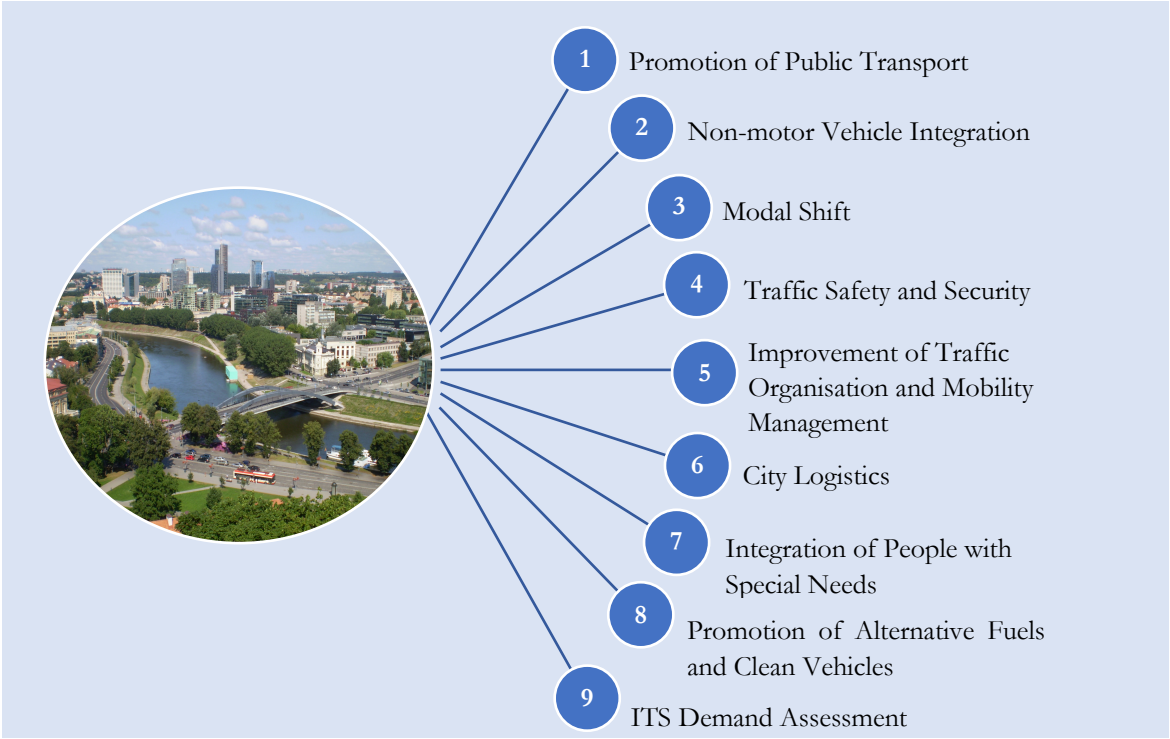


Figure 4-2. A list of thematic sustainable mobility areas prioritised in Vilnius strategic transport development until 2030 (Authors own, adopted from Vilnius SUMP, Vilniaus Planas, 2018).

5 Study Results and Analysis

This chapter presents thesis findings and analysis, performed in consonance with the conceptual framework introduced in Chapter 2. Therefore, this section thoroughly discusses the prevalence of the eight selected TCEs in the local transportation system for road transport decarbonisation and answers the study RQ. Simultaneously, an evaluation of how these TCEs are operationalised within the city's context is provided. The order in which the results are introduced is non-linear nor standard and is adjusted to ensure the most logical flow of derived study findings.

First, the chapter extensively reviews results on eight TCEs (C1-C8) regarding criteria and sub-criteria identified in the theoretical framework. In other words, the framework was utilised as lenses to gather and portray all study findings in a structured manner which are then used to address RQ. The results of every TCEs are introduced one after another and follow the logic presented in Figure 5-1. The first paragraphs of the sections summarise crucial insights on every TCE. The findings and analysis for every element are arranged in a structured manner identifying commonly shared views among all stakeholders and then describing the prevailing opinions in different stakeholder categories.

After that, the structured results on TCEs (C1-C8) are interpreted to address study RQ. A summary of answers to RQ is provided in section 5.9, based on C1-C8 findings. A broader deliberation of results in relation to RQ is presented in the Discussion (see Chapter 6).

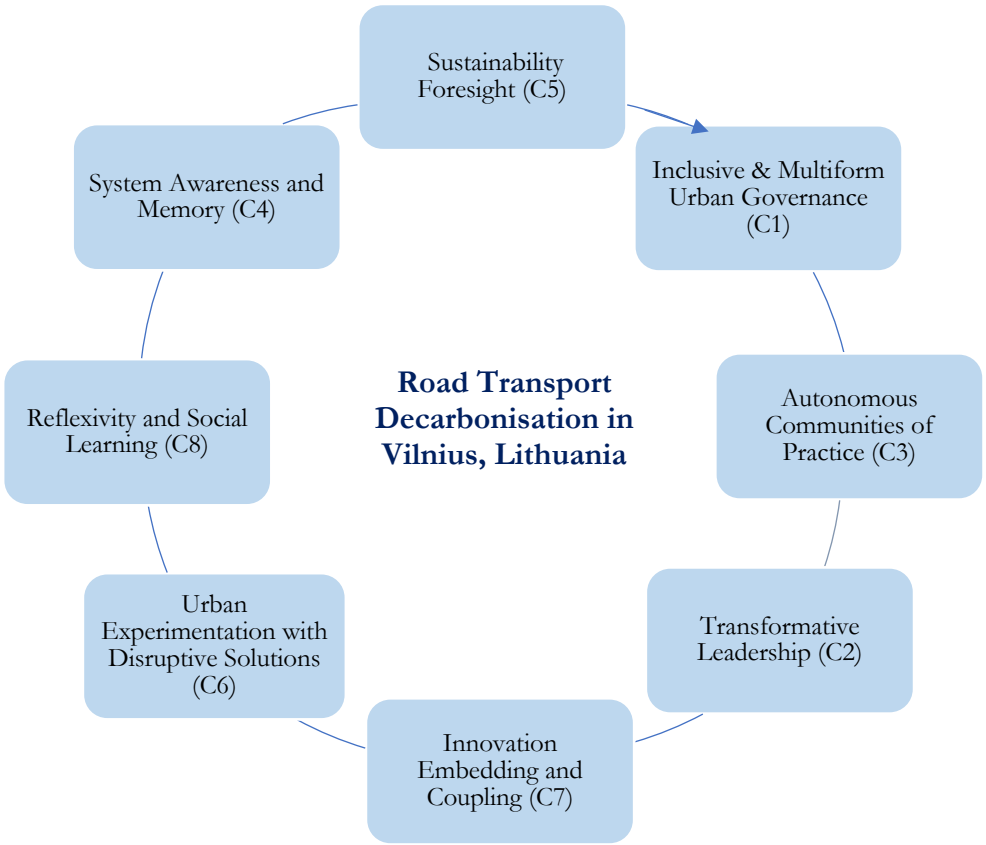


Figure 5-1. Eight TCEs analysed, and the order in which the results are presented. Author's own.

5.1. Sustainability Foresight (C5)

When describing the current and future transport decarbonisation pathways, interviewees agree that the situation in the city is improving, with the climate change agenda gradually becoming a strategic level priority. This is primarily motivated by pressure from EU institutions via legislation and opportunities associated with funding sustainable mobility projects. Social, health, and environmental implications are also essential in establishing local decarbonisation narratives. However, system-level decarbonisation is perceived as highly challenging among stakeholders due to infrastructural and institutional barriers, such as policy fragmentation. Nevertheless, most specialists stay optimistic and believe that full transport decarbonisation is feasible in the long run with the continuous implementation of the Vilnius SUMP.

5.1.1 Collective Vision for Radical Sustainability Changes

Numerous interviewees recognise the great significance of transport decarbonisation in achieving climate neutrality by 2050 and highlight that transportation is a leading source of GHG emissions and overall pollution levels in the city and at a national level. When reflecting on the role of transport decarbonisation, all interviewees unanimously agreed that reducing GHG emissions is essential to ensuring the long-term sustainability of Vilnius city (R1-26). An apparent interdependence was identified between decarbonising the sector and ensuring the long-term social well-being of city residents alongside more favourable environmental conditions. Multiple practitioners have noted that transport decarbonisation is integral to overarching sustainable mobility development in the city and should be prioritised accordingly. This is further supported by views of one of the intermediaries:

> ["It seems to me that transport decarbonisation is a part of the overall sustainable transportation puzzle that the government aims to solve (…) it comes side-by-side with other important parameters such as traffic safety, air and noise pollution, public health, infrastructure quality, social well-being and gender equality necessary for the future sustainability of the city" (R23, 21 March 2023).]

While highlighting the increasing importance of road transport decarbonisation, interviewees elaborated on multiple drivers for such transformation (Figure 5-2). Pressures related to EU influences, such as push in legislation, financing opportunities and joint projects, were identified as the leading driver for local road transport decarbonisation. A significant 92% of the interviewees accentuated the EU's role as pivotal in encouraging a shift to less carbon-intensive transportation. All interviewees identified EU influence as the primary driver in all stakeholder categories except for NGOs and Communities[11]. The pressure is particularly felt by local and national government bodies seeking to follow the EU guidelines and comply with the emerging legislative changes to reach common climate change targets. For example, a recently introduced EU ban on diesel and gasoline cars prohibits the sales of fossil-fueled vehicles by 2035 in member countries, including Lithuania (R1,13,14). Another example is the obligation to contribute towards reaching complete carbon-neutrality within the continent by 2050 as part of the EU Green Deal (R7-15). Similarly, the SUMPs discussed in Chapter 4 were also established as part of the EU sustainable mobility agenda. As the representative from the Ministry of Environment notes: *"new EU obligations are felt at multiple levels - if previously we could have a growing trend of greenhouse gases, now we have to reduce our national emissions by 21% by 2030, compared to 2005"* (R13). Similarly, transportation companies and intermediaries note that

[11] NGOs and Community stakeholder group prioritised social, health and environmental concerns linked to the impacts of climate change as the leading driver for road transport decarbonisation.

emerging legislative demands (e.g., climate reporting initiatives) motivate private companies to work on carbon accounting and internal sustainability policies (R16-23). However, when discussing the influence of the EU on local sustainability initiatives, most interviewees believe that financial incentive is the most noticeable as most decarbonisation activities locally are completed by utilising EU-funded programmes and projects. This point of view is further elaborated by one of the ministry representatives:

> ["With most of the additional financing opportunities in the transportation sector being dedicated to sustainable mobility development within the EU, local policy-makers and industry representatives see no other choice but rely on such funding streams to not only advance the overall quality of the transport system but make sure that such advancements are sustainable and future-oriented" (Respondent 15, 4 April 2023).]

Another primary driver is the interconnection between transport decarbonisation and improving social and health conditions within the city, which was mentioned by 65% of the interviewees. Local government bodies, intermediaries and community representatives have repeatedly expressed concerns towards issues of traffic congestion and air pollution in the city, which are continuously connected to private vehicle uptake. Academic representatives identified the same concern stating that other transportation emissions such as nitrogen oxides (NOx) and particulate matter (PM) are particularly harmful to residents' health. Because of this, a common belief was held among the mentioned stakeholder groups that measures employed for transport decarbonisation[12], will eventually contribute towards tackling these social and environmental challenges in the city. As a result, improved public health conditions and city residents' well-being are commonly perceived as societal benefits gained from initiating change in the transport sector as part of climate change mitigation (R22-26).

A third identified driver relates to complexities underpinning transport decarbonisation. A majority of interviewees perceived decarbonisation as a relatively sharp departure from the current mobility practices. Therefore, decarbonisation will inevitably re-structure the city's planning activities and influence how the city functions as a whole. 58% of interviewees argued that the transportation sector, compared to other sectors, is particularly challenging to decarbonise. This is because mobility, first and foremost, is a social need, and any slightest changes to its availability could have severe and sometimes even negative impacts on residents. Similarly, decarbonising road transportation was perceived as a complex task due to the multiplicity of measures that should come side-by-side to achieve system-level changes. Because transport decarbonisation is a complex phenomenon, interviewees call for immediate action to meet local and EU targets in the upcoming decade(-s). This is further exemplified by the quote from a researcher at university:

> ["In many other sectors, technologies are being rapidly applied in operational processes. For instance, filtration systems are being installed in boilers and power plants. In this case, it is easier to reduce carbon emissions by improving efficiency in some facilities instead of, let us say, taking 1000 polluting cars out of our streets. Transport decarbonisation is more tangled than that. It requires changes in infrastructure, legislation, and political willingness, and, at the same time, it calls for rapid changes in how citizens behave. Therefore, decarbonisation will

[12] E.g. traffic restrictions, uptake of alternative fuels, public transportation development and actives modes of transportation

not happen overnight, it will take time, and because of that, we need to act on it now"] (Respondent 4, 22 March 2023).]

Other reasons to switch to less carbon-intensive road transportation include negative environmental impacts associated with the current mobility practices (50% of interviewees). Air pollution and climate change risks were identified as the most significant. 35% of interviewees pinpointed more environmentally focused international legislation practices as a potential driver (e.g., Sustainable Development Goals - SDGs). Meanwhile, societal pressures, such as experienced pressure to decarbonise from city residents and consumers, were recognised by 31% of interviewees. Finally, some transportation companies notice a surging push to decarbonise due to perceived necessity among business partners and other internal shareholders (15% of interviewees). A more detailed overview of motivation to reduce GHGs in different stakeholder categories is portrayed in Annex C.

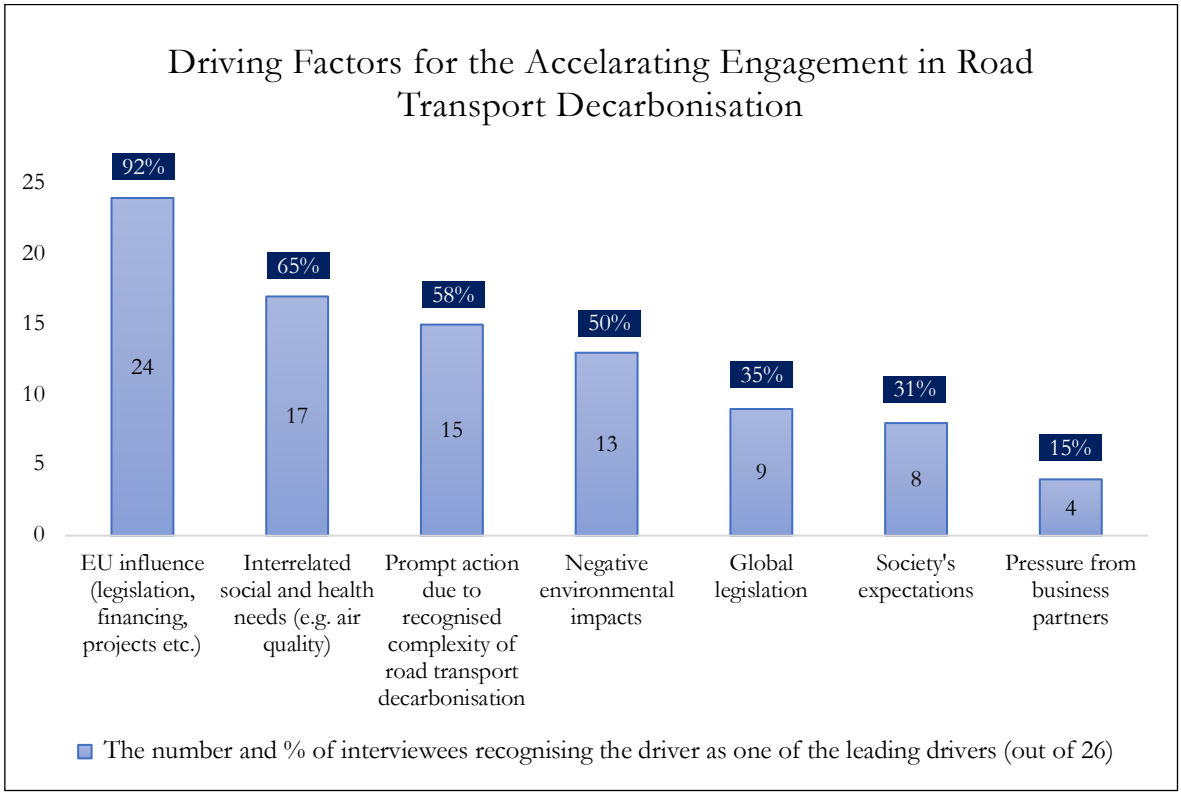


Figure 5-2. Driving factors for accelerating engagement in road transport decarbonisation as identified by specialists in different areas (expressed in number and overall % of specialists identifying the driver as significant).

5.1.2 Change Narrative and Alternative Pathways

In addition to recognising the role of transport decarbonisation in broader urban planning discourses, it is necessary to identify if any new narratives are emerging at a system level. Therefore, the stakeholders were asked to reflect on the extent to which transport decarbonisation is being prioritised in strategic day-to-day activities and governance models (Table 5-1). The results show that most interviewees hold a mixed opinion about such prioritisation. Despite an increased interest in transport decarbonisation, most interviewees noted that such attention is still fragmented or emerging too slowly (50% of interviewees). Overall, around 21% of interviewees perceived transport decarbonisation to be strategically prioritised. Another 18% argued that the topic receives greatly more attention but is still not

at a priority level. The remaining 12% notice only very limited or no increase in attention or significance of the topic on a strategic level. Although the strategic prioritisation of transport decarbonisation is not fully realised locally, most stakeholders emphasise the ascending tendencies with the sustainable mobility narrative gradually entering the political domain. The quote from an intermediary further supports this:

> ["Of course, there is still a long way to go: one minister cannot achieve Green Deal alone, and one manager - decarbonise the entire company's supply chain. However, if we look at the political level, a breakthrough in awareness raising - happened. What used to be few initiatives at the level of some enthusiasts is now becoming a part of national policy *(climate agenda)*. Some of it because of changes in perception, maybe some because of existing trends, maybe to fit in or simply organically - but it has happened"] (Respondent 22, 20 March 2023).]

Table 5-1. Extent to which road transport decarbonisation is perceived to be strategically prioritised in a day-to-day activities and governance models[13]

	Responses (total in occurence)	% (from responses)	Stakeholder category(-ies) with most respondents supporting the view
Negative tone	4	**11,8%**	NGO's and Community
No attention	2	5,9%	
Some attention but very limited	2	5,9%	
Mixed tone	17	**50%**	Intermediaries
Visibly increasing attention, but it's fragmented	9	26,5%	
Visibly increasing attention, but it's coming too slow	8	23,5%	
Positive tone	13	**38,2%**	National Government & Transportation companies
Greatly increasing attention, but not a priority	6	17,6%	
Greatly increasing attention, is strategically prioritised	7	20,6	
Total	34	100%	-

Inter- and Intra-system Trends

Spotlighting trends and other central societal tendencies within the transportation sector has also been beneficial in locally evaluating the existence of carbon neutrality narratives. When discussing external influences, most interviewees from academia and governing bodies have identified the COVID-19 pandemic as a significant recent disruptance in how people travel and how their need to travel has changed. Such changes were often characterised by a decreased tendency to commute to work during the pandemic and a shift to online communication platforms for business meetings. This has resulted in both positive and negative outcomes. Some interviewees argue that during this period, the use of polluting private vehicles has been reduced while residents were encouraged to rethink their daily commuting practices, with some potentially reducing their needs for daily commuting post-pandemic. However, no exact numbers were provided to support such claims. On the contrary,

[13] Responses have been collected based on the occurence of mentions. The total accounted responses exceed the number of interwiewees due to multiple mentions within the tonal category.

other specialists believe that the pandemic has lessened the popularity of public transportation due to sanitary preconceptions attached to it. Thus, such a shift could have undesirable implications for the future uptake of public transportation. Besides, many experts praised Vilnius city's choice to join the EU Climate Mission initiative last year (April 2022), which was marked as another important decision for local climate governance. As part of the EU Mission, Vilnius became 1 of 100 European cities which will implement a new innovation programme aimed at significantly reducing GHGs and potentially becoming climate-neutral by 2030. The mission was organised under the Horizon Europe research programme with a foreseen €350 million investment in innovation projects across mission cities. Lastly, some interviewees noticed a trend in the inter-sectoral integration of renewable energy infrastructure, such as wind and solar energy, for public buildings and individual households (R11,12,14). Lastly, community representatives were satisfied with accelerating public greening initiatives such as planting trees in public spaces (e.g., the Green Wave initiative organised by the local municipality) (R10,23,24).

When the focus was shifted to trends within the transportation system, the introduction of loop traffic in the Old Town city area and accelerating interventions for the humanisation of city streets were pinpointed by most interviewees. Both initiatives were strategically established as part of Vilnius SUMP back in 2018. As a result, the loop traffic system started operating in the central city area in the summer of 2020, with one-way traffic directionality, four main loops and was accompanied by respective traffic signs. An initial idea behind such intervention was to reduce unnecessary transit through the city centre while decreasing pollution and GHG emission levels accordingly. In comparison, street humanisation was selected as a space transformation strategy by narrowing the carriageway part of the street and dedicating more space for public use. In addition to the mentioned trends, numerous interviewees recognise improving accessibility and quality of infrastructure for sustainable modes of mobility. To exemplify, community representatives notice clear improvements in cycling infrastructure and expansion of the overall infrastructure network and its connectivity, leading to higher popularity of cycling in the city. Municipality representatives argue that steep improvements in public transportation quality were completed, with new routes emerging to enhance the connection between the city centre and surrounding areas. Similarly, some interviewees identified an emergence of the so-called *"electric scooter wave",* with a trend of rapidly increasing scooter use within the city, especially among younger audiences. From a strategic stance, specialists recognise more systemic city-level interventions to improve air pollution and contribute towards decarbonisation, such as the expected introduction of the Low Emission Zone (LEZs) in Vilnius by 2024 (P14-17). Finally, few respondents highlight changes around the mentality of climate governance with more climate change coverage in media (R23,24), more political debates around decarbonisation topics during local elections (R5,14) and an increase in overall political will to initiate sustainability-oriented changes (P9,11). Although the positive tendencies towards the visibility of climate change are noticed, most interviewees agree that such engagement is still highly inconsistent.

Pathways to Accommodating SUMP 2030 Ambitions

During During the discussion on potential scenarios for road transport decarbonisation in Vilnius, a majority of interviewees identified SUMP as the most significant local strategic document to guide this vision. As introduced in detail in Chapter 4 and reflected by stakeholders, SUMP proposes strategic city-scale measures for sustainable mobility development. Some of these measures directly or indirectly address the potential road transport decarbonisation pathways. According to the interviewed specialists, the desired SUMP result

is a drastic modal split change by 2030, which would eventually lead to indirect road transport decarbonisation due to the reduced use of private fossil-fueled vehicles.

Similarly, the encouraged uptake of alternative fuels will not only contribute towards tackling air pollution issues but could also result in significant cuts in CO2. Besides, experts accentuate other city-level strategies which could support long-term decarbonisation due to its focus on sustainable mobility (e.g., the General Vilnius Plan and the City of Vilnius Street Design Manual). However, some specialists still need to be convinced about the use of such plans as only a small portion of the budget is usually dedicated to immediate decarbonisation measures (R2).

Furthermore, when asked to evaluate the city's capacity to meet sustainable mobility goals until 2030, as stated in SUMP, specialists' opinions diverged (Figure 5-3). Over 90% of interviewees, who mentioned SUMP during the interview, praised the overall importance of implementing such a strategic plan in Vilnius within the upcoming decade. Nevertheless, most of these interviewees are concerned over the practical realisation of outlined goals. All to one stakeholder perceived SUMP goals to be challenging. 19% of interviewees believed that the goals are over-ambitious and not rational in light of the current governance system and structural/institutional barriers to decarbonisation. Specialists who supported this position highlighted governance fragmentation across local-regional-national scales and lack of detailed action plans as the most significant hurdles. Overall, 77% of interviewees deemed such strategic ambition feasible to achieve, with 35% keeping an optimistic tone, 31% having mixed feelings, and 11% believing that such implementation is possible but would come with some exceptions[14]. The interviewees who expressed mixed views were primarily unsure about the stability of the political will to initiate and continue implementing changes throughout the years. Similarly, rapid infrastructural, technological, and behavioural changes will be necessary to accompany such a transition. Municipality representatives, when asked about the ongoing progress of SUMP implementation, mention that progress is there but is relatively slow-going:

> ["We only have preliminary data on the city's modal split from a survey conducted last fall, and the official results have not been published yet. It seems very slow to me so far *(progress)*. The initial results show a slight increase in trips undertaken by cyclists, using public transportation and walking. However, we do not have exact numbers yet, but from the feeling, I can say - that change is happening slowly. However, I would say there cannot be a quick change when we talk about modal split"] (Respondent 7, 5 April 2023).]

[14] Few respondents mentioned that overall, SUMP realisation is possible. However, some aspects will not be fully fulfilled, such as increasing the modal split of cycling up to 7,5% until 2030.

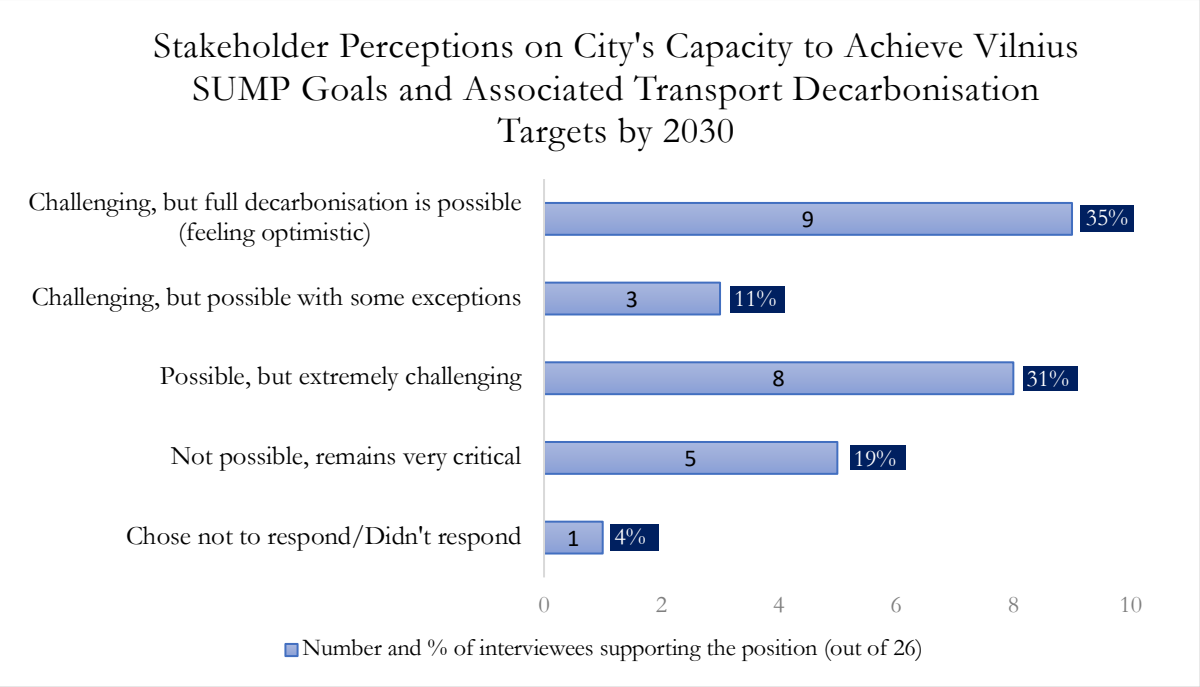


Figure 5-3. Stakeholder perceptions on city's capacity to achieve Vilnius SUMP goals and associated transport decarbonisation targets (expressed in number and overall % of specialists supporting specific position).

5.2 Inclusive & Multiform Governance (C1)

Specialists explain that transport decarbonisation is mainly addressed by following a top-down governance approach with regulatory instruments being introduced at EU and national level and then being gradually implemented in Vilnius. While local municipality is outlined as the critical stakeholder in facilitating sector-level decarbonisation, the signs of emerging bottom-up approach are also identified. Increasing community inclusion in strategic planning and establishement of trans-national networks for transport decarbonisation are the main examples bottom-up engagement. On the contrary, the current governance model lacks stronger inclusion of businesses and academic representatives in strategic decision-making.

5.2.1 Participation and Inclusiveness in Decision-making

Besides the EU influence being a main driver, as outlined in section 5.1, every consulted practitioner has highlighted local municipality and its subordinate institutions as the most important stakeholder in leading transport decarbonisation in the city. Interviewees have continuously highlighted the pivotal role of Vilnius City Municipality and its municipal enterprises "Susisiekimo Paslaugos" and "Vilniaus Planas", responsible for strategic and practical mobility planning and provision of services. According to academics, municipality holds the most power in utilising local resources and implementing decarbonisation-oriented policy packages (R1-6). Transportation companies recognise the input of local government bodies in providing necessary public infrastructure, enabling policy conditions and knowledge provision for effective electrification of their vehicle fleets (e.g., reinforcing energy grid capacity and public charging infrastructure) (R16,17,18). Intermediares note that local municipality has the most responsibility in ensuring that city residents are provided with different alternatives for sustainable mobility and reinforcing the availability, convenience and affordability of these alternatives (R20-24).

Similarly, city residents and local communities are identified as another highly influential stakeholder groups. Local and national government bodies pinpointed that long-term road transport decarbonisation is only possible with the society's support and after initiating rapid behavioural changes towards more sustainable individual mobility practices (R7-10; 12-14).

Other significant actors to drive the necessary transformation, according to interviewees, were national institutions alongside transportation and urban logistics companies. Such institutions are national ministries (Ministry of Environment, Ministry of Transport and Communications, Ministry of Energy, Ministry of Economy and Innovation) (R1-11) and Environmental Protection Agency (R20). They were deemed to be central actors in shaping national-level policies oriented towards sustainable mobility practices which simultaneously accelerate changes in Vilnius city and the surrounding regions (R20-23). Higher level governance bodies also provide voluntary recommendations (e.g., for technological mobility development) and mandatory obligations (e.g., implementation of SUMPs in municipalities) (R13). The role of transportation companies was also recognised as they are not only required to meet their climate targets (R16-19) but are pressured to contribute to sector-level decarbonisation by the society and business partners (R17-19).

Less accentuated, but deemed relevant stakeholders are non-governmental organisations (NGO's) and associations, consulting firms and universities together with other educational institutions. NGOs are expressing more concern to keep the companies and municipality accountable for their climate agenda (R25). Indermediaries - in facilitiating collaboration between municipality and non-state actors and establishing change-oriented platforms (R23). On the other hand, universities notice an uprise in research interests focused on mobility decarbonisation and broader sustainable transportation management (R5).

While identification of leading stakeholders was clear and straitgthforward, the interviewees expressed more mixed views when evaluating the inclusiveness of different actors in strategic mobility planning. The last few years have been marked by visible positive tendencies regarding community engagement (R7,10,20-22). Specialists recognise that community engagement receives more attention and could enhance policy planning and practical decision-making for climate governance. Representatives from ministries note that strategic stakeholder consulting in the transportation sector was limited to national, high-importance projects and was very context dependant before, but now is becoming a part of routinised procedures in national governance (R13,15). In Vilnius case, local government bodies recognise the growing importance and benefits that such participatory and inclusive governance entails:

> ["When you start collaborating with residents, they begin to feel as if that decision is theirs, and this greatly encourages and empowers the society (…) and from here, when talking about any kind of involvement in general, the sense of ownership increases, as well as responsibility to act" (Respondent 10, 20 March 2023).]

A relatively large part of interviewees who elaborated on this topic, provide some relevant examples how the accelerating community collaboration creates a better environment for transportation planning. For example, some intermediaries and municipality representatives point out that consultation of the residents became obligatory when implementing city-level projects (e.g., when preparing territory planning strategies or developing logistical corridors) (R8,13,20). Most importantly, now stakeholders have to be involved in the early consulting stages of the mobility projects instead of the aftermath of it as was practiced before (R10). This also means that if residents do not support the development of specific projects, the

implementation can be complicated, postponed or revised according to community needs (R10, 20). In the early stages of advancing Vilnius SUMP, the representatives of different city communities, associations and districts were also extensively involved in primary preparation stages to co-develop the plan altogether. Vilnius SUMP was also regarded by EU institutions as exemplary SUMP in terms of stakeholder engagement, setting an example for other European cities (R22). Additionally, community participation is utilised when advancing decisions on a more practical level. This is especially visible when developing new infrastructure for active modes of mobility (e.g., cycling lanes, pedestrian paths) and when optimising public transport routes to connect metropolitan-suburban areas (R7,9).

Despite improved conditions for particapotary community engagement, the specialists argue that such integration has only occurred recently, is still in a bounded, relatively primary stages and is far from being employed systematically. This is due to a lack of regular and constructive communication between municipality and city residents, clear structure of strategic participation models and participatory culture in public domain (R2,10,22-23). Some experts also add that self-governance is not always plausible as residents tend to favour decisions that are beneficial personally, but not necessarily for the city while individual views can be unpredictable and guided by rather emotional and not rational intention (R13-15). The following quote exemplifies some of the discussed positions:

> ["Community involvement is really emerging (especially in Vilnius Municipality), and I really notice that, at least in the last few years, since 2019. It moved forward substantially and was approved in such a way that any large public space alteration, including changes in transport system, requires a meeting with residents (…) However, I must admit that such engagement is complicated and still mostly takes place at practical level, covering individual cases rather than being a well-tailored strategic tool for sustainable transportation planning" (Respondent 10, 20 March 2023).]

To further conflict the ongoing developments in participatory models, numerous interviewees deliberate on missing inputs from academic-scientific institutions and lacking eagerness from businesses to contribute to sustainable strategic governane. For example, the academics' participation is reflected in some instances, mostly when deciding upon long-term mobility strategies, such as the mentioned SUMP example. Nevertheless, their overall contribution is deemed to be very minimal. The academic cooperation does exist but is mainly perceived as ad-hoc instead of must-to (R2,5,22). University representatives claim that such exclusion is not only misadressed in decision-making but greatly underestimated by the general society alltogether (R1,6). Oftentimes, academics express their views and competence informally. For instance, through teaching, broader research output and participation in conferences and other sustainability-oriented events (R2,6). The statement below further elaborates on this:

> ["Academic views are still greatly marginalised locally by the governing bodies and only applied when it suits the intended purpose (…) Don't get me wrong, without a doubt, we try to get involved, we participate in various public events and educate people on climate change, however society and policymakers sometimes just don't listen, we do not hold a powerful voice yet" (Respondent 2, 7 March 2023).]

In contrary, national representatives consider academic input to be of high importance, however, very context specific and sometimes lacking practical applicability. Thus, it becomes difficult to systematically integrate academic views and come up with a compromise. Another

issue regarding academic engagement is the complexity of the transport decarbonisation itself. Policy-makers are sometimes struggling to identify what academic engagement is needed or, depending on the project, receive support from foreign universities with specialised expertise (R12). Others are concerned that academic quality on a national level does not correspond with capacities required for system-level decarbonisation while engineering and other pivotal professions do not receive much attention among younger generation (R3-6).

Considering business inclusion, intermediaries and academics spotlight a delayed response from larger transportation companies and general businesses. According to them, such enterprises hold necessary tools to make impactful contributions to road transport decarbonisation. However, their willingness to be involved in strategic planning is somewhat scarce despite some noteworthy examples (e.g., electric scooter enterprises) (R3,6). Transportation companies themselves argue that their inclusion depends on the company's internal processes, general sustainability direction and priorities, meaning that such inclusion must be to some extent beneficial for the company (R19). Alternatively, academics recognise the great potential that public-private cooperation would bring for local decarbonisation (e.g., through ride-sharing services). On the other hand, intermediaries reflect on lack of trust between different stakeholders, particularly when initiating collaborations with businesses. These concerns are reflected in the quote below:

> ["Some transport companies have a lot of data about where people go. They can help with effective solutions, other companies could also help with ticket systems and so on (…) But the collaboration model is somewhat complicated because it is thought that the business must do it on a voluntary basis and sometimes even pay the municipality. The collaboration ties exist, but they are not yet very mature. There is also mutual mistrust: for example, businesses do not fully trust the municipality either because they think that the business is doing it for its own benefit (…) We have not yet learnt how to start a constructive dialogue, but this is a global problem, it is lacking everywhere" (Respondent 20, 15 March 2023)].

5.2.2 Diverse Governance Modes & Networks

Diverse Governance Modes

The results show that bottom-up approach in the transportation sector is emerging but does not directly target transport decarbonisation. According to specialists, a dialogue around significance of diverse governing forms for climate change mitigation is already happening locally, with more recognition to and appreciation of community activities. Most interviewees also argue that road transport decarbonisation requires support from multiplicity of actors across numerous governing levels and scales. In addition, communication and cooperation between different stakeholders was mentioned as an example of good practice not only for transport decarbonisation but all mobility practices more generally.

Most of practical interest in establishing multi-form governance structures is coming from governing institutions themselves. This was also discussed in previous section by providing strategic community engagement examples that have started to occur recently. Alternatively, some interviewees recognise a strengthening interest from the society to influence decision-making. However, such interest is occasional and is mainly exercised by participating in local elections (R3,5,10,23). For example, more pressure is felt from the residents to tackle air pollution and associated health issues (R5,22). Community representatives also express an emerging municipality support for civic engagement through provision of permits to initiate various forms of local activism (R25). However, such engagement from the public is mostly

focused on improving labour rights or once again, when expressing personal disatisfaction towards local air quality and heavy-polluting industries outside transportation sector.

Networks

Firstly, specialists notice an emerging local network of district-based communities which are keen on cooperating with local municipality on mobility matters. As Vilnius city is characterised by relalatively high socio-economic fragmentation between the districts (R6), neighborhoods are more actively expressing their concerns and push local municipality to address their district needs. An example of this could be Užupis, a so-called micronation in Vilnius, a residential area which is separated from the rest of the city by Vilnele River. According to some municipality and community representatives, a collaborative and participatory network was established with Užupis community to test traffic pilot studies and street humanisation ideas. This was done by conducting an extensive survey and collecting local community insights on current accessibility and infrastructure-related challenges faced within the area.

Secondly, some interviewees argue that pedestrians and cyclists are receiving a more active voice in local mobility debates. There are established associations (e.g., Pedestrian Association - LPA and Cyclists' Community - LCC) which actively vocalise local residents' concerns over infrastructural needs. This is further facilitated by active social media groups where pedestrians and cyclists share their daily commuting experiences. As noted by local municipality representatives, they notice a rapid uptake of such engagement while the concerns expressed on such online platforms are being evaluated and addressed accordingly by mobility specialists at the municipality or its subordinate institutions.

Finally, some specialists elaborate on trans-national networks between local municipality and other EU institutions and cities. This is again mainly exercised through participation in EU programmes and funding initiatives and could be linked to increasing significance of EU as a driver for sustainability transitions locally (discussed in Section 5.1.1).

5.3 Autonomous Communities of Practice (C3)

The necessary agency, in terms of actors and their interconnections, to initiate transport system transformation is observed locally. This is reflected by municipality's recognition of residents' social needs and targeted actions to address them. However, there is a visible absence of local community's support for transport decarbonisation. This further results in municipality-society contradictions and local resistance when implementing sustainable mobility measures in the city.

5.3.1 Meeting Social Needs

During the discussion on road transport decarbonisation as an emerging societal priority among different stakeholder groups, specialists had divergent views. Local and national government bodies clearly recognise system decarbonisation as not only environmental, but social premise for long-term city sustainability. This was also reflected when elaborating on city's sustainability actions with reduction of GHGs being simultaneously linked to other benefits for well-being, public health and liveability of the city (section 5.1). Businesses also consider the importance of providing accessible and timely mobility services for all city residents and seeks to address social needs despite holding a fairly pragmatic view when asked about environmental sustainability. According to transportation companies, not all transportation enterprises are convinced that sustainability is a suitable strategic path for them

while others tend to express their interest in sustainability but do not act on it actively or their actions are unstructured and random (R16).

However, all interviewees collectively agree that the main obstactle to achieve decarbonisation is lacking community's support which is expressed by public resistance to sustainable mobility initiatives. This is primarily conveyed by public dissatisfaction towards traffic regulations (e.g., loop traffic), street humanisation and any restrictive or cost-related measures that directly target car use. Specialists have distinghuised several reasons for this.

First, stakeholders note that public has an explicitly strong attachement to private car use as a primary mode of transportation and any measures that restrict commuting by an individual car or makes it less convenient is received with great opposition. For istance, the proposal of introducing an annual car pollution tax was met with great controversy among the public (R6). On the other hand, conveniece, comfort and accessibility were described as the main factors behind such high reliance on private cars, imposing resistance to considering alternative means of commuting (R2,6,14,21).

Secondly, a majority of interviewees argue that transport decarbonisation is not socially prioritised need because other issues are viewed superior to climate change. For instance, financial stability and overall quality of life were a few of the mentioned ones. Other interviewees add that climate change is typically a well-educated and financially well-off resident's concern (R3,5,21,23,26) while others also mention that it is oftentimes a young person's concern (R3,23,26). Some intermediaries further reflect on sustainability-related needs by using a Maslow's model for the societal hierarchy of needs (R14,23). A quote below summarises the presented view:

> ["Looking at the pyramid of needs (Maslow's model), first, we have food and water and sense of security and stability as primary societal needs. Only when these needs are satisfied, we start having an outer look at other issues: we don't want to have polluted air in the city and we start caring about the environment and climate change (…) Although Vilnius is developing economically and more people have social and financial stability, around a third of people still live below or near poverty line. As a result, there are other more important struggles that people have to deal with on a daily basis" (Respondent 23, 21 March 2023)].

Thus, complexities underpinning transport decarbonisation often fade into the background. It is further noted that although sustainable mobility initiatives are planned holistically, they do not necessarily reflect the social realities of city residents. As further explained by a sustainable mobility specialist:

> ["Sometimes sustainability looks perfect on paper, but when you actually talk to city residents, you see the other side of it. Let's say for a single mom who has three children, probably it's not that convenient to take kids to school or a toddler to the kindergarden by using public transportation (…) An attempt is made to solve social problems through transportation planning when sometimes transportation is only a symptom of them" (Respondent 20, 15 March 2023)].

Finally, it is believed that a majority of residents are conflicted with new sustainable mobility decisions due to a lack of sufficient climate education or because the negative environmental impacts are not directly experienced now (or not experienced to a high degree). Even if climate change is perceived as a societal risk among some, *"they still hold the view that it can be addressed*

later or by someone else" (R6) or perceive it as a *"distant problem somewhere else" (R5).* Although most interviewees argue that public perceptions are gradually shifting, such a shift is still not as fast as desired or required for systematic change.

5.3.2 Action Priorities

As mentioned in the previous sections, decarbonisation is more consistently positioned as a prioritised strategic topic in local transportation governance. Nevertheless, when reflecting on soft and hard measures for transformation, almost every specialist note that strict regulative instruments are inevatible to ensure a timely transport decarbonisation in Vilnius. Such command-and-control approach is required due to the mentioned lack of public eagerness towards sustainability which makes municipality and national representatives push most of the necessary change from the top downwards. An example of local actions could be less favourable accessibility of parking lots due to increased vehicle parking taxes. Simultanously, education and informative instruments were mentioned by most interviewees as secondary measures that should come together with stricter policies.

What makes situation more complicated locally, is the compromise that has to be found between ensuring long-term decarbonisation by introduction of more restraining regulatory measures and making sure that community's social needs are heard and addressed. The representatives from local and national government explain that implementation of more financially commanding measures, especially charges such as fees and tolls, could be particularly senstitive decisions to make as they provide the overall benefit to the community but not necessarily favour every individual (R7,13,14).

Some interviewees also note that sustainable mobility interventions, if introduced rapidly, can have a detrimental impact on local communities (R3,21,22,23). Therefore, stakeholders argue that access to mobility is a public interest, and any related changes have to be implemented gradually. This has to be completed with sensitivity to different social groups and potentially more vulnerable groups (e.g., seniors, children).

5.4 Transformative Leadership (C2)

The study results show that local and national leadership for transport decarbonisation is slowly emerging, mainly due to EU and national-level pushes. Local municipality is unanimously named a leader for transport decarbonisation in Vilnius. Nevertheless, the existing forms of local leadership are very scattered and are rather articulated by occasional initiatives by few specialists instead of being characterised by clearly directed actions and values. Specialists dinstinguish two barriers for local leadership: lacking alignment of uniform and uninterrupted vision and weak community interest in following and supporting leaders.

5.4.1 Place-based and Issue-driven Leadership

When elaborating on place-based leadership for sustainability transitions, the first thing that specialists noticed was the geographically uneven dispersion of leadership forms at a national level. This is particularly relevant when comparing different municipalities. Specialists identify a great gap between bigger and smaller cities, with later having significantly less orchestrated and directed ambition to decarbonise. Vilnius was noted as a clear leader in such a ambition in a national context with one of the respondents mentioning that *"probably there is no Lithuanian who has not heard about street humanisation in Vilnius by now" (R21).* Meanwhile, Tauragė was identified as an example of smaller municipalities with great leadership in sustainable mobility. Nevertheless, specialists agree that more authority should be shifted to municipalities

themselves (R3,7,12,13,14). Thus, embracing municipalities as the leaders which can and know how to embed decarbonisation narratives into their own governance models.

However, when focusing on Vilnius more specifically, city municipality was unanimously identified as a leader in transport decarbonisation locally. Such leadership was mostly associated with before mentioned introduction of SUMP and other major strategic developments (section 5.1). Nevertheless, quite a few experts believed that leadership in local climate change governance is mostly issue-driven. This means that leadership arises mostly in situations when clear negative impacts are already experienced or when there is a visible outer push (e.g., EU legislative push for decarbonisation). Internally arising leadership examples were less noticed despite ocassional initatives from the municipality, community, and businesses, with some of them outlined in the previous sections. As few intermediaries observe, some forms of sustainability leadership definitely exist and are noticed, but the question is whether they are really exercised extensively, or it is because of the *'sustainability bubble'* that thespecialists live in (R20-22).

5.4.2 Political Leadership and Articulation of Visions

In light of politically focused leadership, interviewees expressed mixed opinions. Many are praising local municipality for recent changes in the quality and accessibility of sustainable mobility infrastructure as well as direct and frequent communication around overall transportation changes, especially in the last few years. Some others argue that no significant forms of leadership were felt locally or only visible in other sectors (e.g., energy sector). Most interviewees agree that political leadership is articulated to some extent, but is still lacking, especially in showcasing a uniform and uninterrupted vision. And in places where such leadership exists, often it is exercised by a minority of the same specialists who, by changing their sustainability focus and work environment, bring leadership to new domains and other local and national institutions (R3,13,14,22).

The main reason behind the absence of desired leadership, according to the specialists, is twofold. First, a fragmentation of political willingness due to constantly shifting political climate. Although the municipality's competence and ambition was deemed satisfactory to drive road transport decarbonisation, the frequent changes in political forces in-between election periods was highlighted as the single biggest issue for continuity of local political willingness required for large-scale changes:

> ["As municipality elections take place every four years, you never know what a new mayor and their team will decide to do. This is a major stimulant for frequent errors in the strategic continuity of sustainable mobility initiatives. Even if you have a very well-articulated direction for development in the following years, this can turn around entirely after the elections." (Respondent 5, 8 March 2023)].

Another significant driver that hinders political leadership towards transport decarbonisation is community resistance. As reported in the previous section (see 5.3), the societal support for sustainable mobility initatives is relatively scarce while sustainability culture is at its primary stages. Specialists believe that such reluctance to support sustainable mobility initatives creates unfavourable conditions for strong leadership in transport decarbonisation and postpones implementation of the required course of action (R3,7,11). The reasons behind such resistance are further articulated in section 5.8.

When describing how public views influence leadership forms, most representatives turn back to topics related to social needs which were discussed in the previous section. To complement these findings, interviewees from local and national governing bodies emphasise that expressing approval for measures which are perceived as controversial among residents (e.g., street humanisation or carbon taxing) can significantly influence political popularity and community's trust in municipality:

> ["Will your rating go down because of this? As a politician, someone who is elected to local municipality or national government, you always ask that yourself. Sometimes you can risk your career or credibility by making unpopular decisions." (Respondent X, 5 April 2023)].

Another respondent supports such views by adding that ensuring balance between political ambition and resident's needs is somewhat complicated:

> ["There is enough political competence and ambition for change, the question is how to politically manevour changes between green agenda and residents' needs so that both sides are satisfied." (Respondent 4, 21 March 2023)].

Furthermore, no uniform consensus on responsibility sharing was observed by respondents, especially among national level institutions. Although ministry representatives themselves argue that a continuous dialogue is maintained between the ministries for joint coordination of policy packages (R13,15), some interviewees note that there is still no clear vision alignment between these bodies, which could further slow down the expected progress (R2,5). While some practitioners call for more clear leadership from the specific ministries, the ministries call for more leadership from local practitioners. Therefore, it illustrates further disagreements between national and local level governing bodies around who should be leading the corresponding policy development for transport decarbonisation.

5.5 Innovation Embedding & Coupling (C7)

The signs of innovation embedding and coupling for transport decarbonisation in Vilnius are observed across all prominent stakeholder networks - from local municipality to transportation companies and national institutions. Continuous mobility innovation development was described by most interviewees as a topic of great significance. The primary technological trends observed for reducing climate impact are use of hydrogen as an alternative fuel, uptake of electric vehicles, digitalisation and transport optimisation systems. While the recent technological developments are supported by strong regulatory push from national and EU institutions, the diffusion of these innovations locally is constrained by resource inefficiencies. These financial constraints emerge due to large costs of hydrogen development infrastructure and high market cost for individual electric vehicles. At the same time, concerns arise over large-scale electrification due to energy grid capacity requirements and renewable energy availability while use of hydrogen is still in primary stages with questions raised over its practical feasibility and large-scale applicability in cities.

5.5.1 Emerging Transport Innovations

City municipality foresees a large-scale development of hydrogen as an alternative fuel for energy sector decarbonisation in the upcoming decade, which includes hydrogen use for transportation. Some of the potential pathways are integration of hydrogen to create more environmentally friendly gas mix for industrial processes and hydrogen utilisation to decrease GHGs in urban logistics (e.g., in vans and trucks). More specifically, there is a rapid investment

interest expressed by municipality to build hydrogen facilities using EU funds in the upcoming years. Therefore, local produce could replace diesel and gasoline with renewable fuel, especially for heavy-load vehicles (R11,17-20) and public buses (R1,4,9,11). The transportation companies also place exploratory focus on hydrogen innovations with an aim to decarbonise their vehicle fleets. This is exemplified by increasing R&D budget dedicated to hydrogen technologies and new partnerships with potential suppliers (R17-19). Similarly, biofuel (e.g., biodiesel) were considered as another alternative fuel source that is being actively investigated by the municipality and transportation companies.

Electrification of public transportation, individual and industrial vehicles was perceived as another technological interest. Currently, only around 5% of Vilnius public transportation park is electrified. And such electrification tendencies were noticed only in the last couple of years. However, the municipality aims to significantly increase this percentage by 2030, aiming that 55% of public transportation park would be fueled by renewable energy sources, with electric vehicles being at the core of such developments (R9). A similar trend was observed in terms of e-scooters, with most specialists noticing a major increase in a number of city residents using them for everyday commuting, which was named 'local mobility phenomenon". In addition, academics and intermediaries notice a positive tendency in emergence of new Lithuanian companies which manufacture electric buses and could accelerate such provision with ALTAS company being one of the provided examples (R1,14,21). Finally, electrification is becoming an inseparable part of local logistics landscape, with the biggest logistics companies in the city (e.g., Lietuvos Paštas, DPD, Omniva) identifying the rapid uptake of electric vehicles in the upcoming years as part of their sustainability commitments.

A myriad of other innovations were mentioned by stakeholders, but not covered as extensively as hydrogen and electrification. These include GPS and route optimisation (dynamic routing) systems for public transportation and logistics companies, which could significantly improve transport milage efficiency (R9, 17,18). Also, real-time traffic operation and monitoring systems, which could help to avoid half-loaded trucks (save loading space), optimise loading and unloading times and reduce the number of unnecessary traffic errors (R9,19,23). Digitalisation was discussed as particularly important sustainability measure for local heavy-duty vehicle industry, with document digitalisation allowing for up to 20% CO_2 savings throughout supply chain (R20). Finally, autonomous vehicles, individualised trip planners and modernised ticket systems for public transportation were also pinpointed by interviewees. All of the mentioned measures directly or indirectly reduce GHG emissions from transportation (e.g., via decreased overall fuel use and modal shift).

5.5.2 Regulatory Support

In terms of agency required to push local innovations forward, interviews and document analysis indicate that EU plays a particularly vital role in innovation embedding and coupling locally. The reason for this is three-fold. First, EU provides policy recommendations for innovation diffusion which are reflected in strategic mobility planning documents at national level. Secondly, as mentioned in section 5.1.1, EU has a major influence on local system in terms of financial incentives that are acquired by participating in the EU programmes, as well as utilising other regional funding streams. Thirdly, most technological trends for transport decarbonisation also come from the EU and are mainly channeled via common partnerships, which again link to both pressure from regional policies and financing prospects (R1,11,12,15). As the representative from Vilnius Transport and Logistics Competence Centre states:

> ["Technological decarbonisation solutions mostly reach us from the European Commision, since we depend on external funding, mainly international projects. The innovations which are pushed by EU policy (…) they reach us too, and often they are placed as a priority and we work on that" (Respondent 1, 22 March 2023)].

However, some experts believe that EU, even being a leading change agent, is itself behind when providing solutions for heavy vehicles and logistics decarbonisation in member nations (R4,5). As further explained, the critical EU policies on hydrogen and mobility electrification are still being prepared, with no detailed action plans or case studies provided.

Furthermore, the mentioned innovations are simultanously encouraged by national legislation (R12,15). Recently introduced Energy and Climate Development Plan (NECP) and Lithuania's Mobility Development Plan until 2050 support the acceleration of sustainable innovations, with their guidelines being mirrored in Vilnius city policies. For instance, Vilnius City Renewable Resources Development Plan (RRDP) suggests that alternative fuel use in transportation, alongside solar energy uptake, SUMP and building modernisation, is one the main measures to increase the total renewable energy balance to 43,44% in the city by 2030.

5.5.3 Access to Resources

Nevertheless, stakeholders recognise some structural barriers that prevent the discussed innovations from being mainstreamed locally. The shortcomings in financial and infrastructural resources are the main issue to advance such innovations forward.

For hydrogen use, interviewees indicate that there is a lack of commercial availability for tangible applications. However, this is visible not only in Vilnius but on a global scale with hydrogen undergoing testing phases internationally (R1,4,5,11). And even if such commercial availability appears, hydrogen utilisation only makes sense for urban logistics and public transportation, as hydrogen use for light vehicles cannot compete with electricity due to energy inefficiencies Besides, there is a limited supply of hydrogen-tailored vehicles. The municipality representative elaborates that *"even if we would buy a hydrogen bus today, there are only few manufacturers in Germany and Europe in general that could provide such buses and the queue time would be around two years" (R11).* This could be further linked to costs associated with hydrogen use due to lack of manufacturers and general market availability. Other specialists are also contradicted over how sustainable hydrogen really is because of the additional industrial processes required for production and transportation. Lastly, hydrogen is highly explosive which raises additional safety concerns.

Similar concerns were expressed when discussing electrification prospects. The high cost of electric vehicles and required supporting infrastructure was indicated as the main drawback. This specifically affects residents as vehicles are simply too expensive for a regular citizen while there is no financialy viable alternative to replace fossil-fueled cars (R1,2,11,16). In terms of obtaining electric vehicles for public transportation, electric buses are also significantly more expensive (R11). In addition to this, charging points for electric vehicles require additional energy grid support and the current infrastructure is not adapted to the increase energy consumption (R1,23). In parallel with discussions around hydrogen, interviewees were concerned how sustainable electric mobility is as such developments have to come with significant share of renewable energy in the total mix, which is far from being fulfilled as of now (R1,11,16,23). Moreover, recent geopolitical tensions have resulted in higher energy prices

and fluctuations (R1,3,16) which could also hinder technological embedding of electric vehicles.

Even though respective challenges were highlighted during the interviews, specialists remain positive about the future as recent tendencies show progress for innovation development. For example, the costs of individual electric vehicles are gradually decreasing while major renewable energy projects are underway which could signalize increasing renewable energy capacities to welcome such innovations.

5.6 Urban Experimentation with Disruptive Solutions (C6)

Various forms of urban sustainability-oriented experimentation are recognised in Vilnius, with noticeable acceleration of urban living labs and street-level pilots. Local and national government bodies and other stakeholder groups acknowledge the social and environmental benefits of such initiatives for transport decarbonisation. However, the majority of such experimentation is aimed at improving the social liveability of Vilnius public spaces and testing out new mobility technologies. Hence, transport decarbonisation is an indirectly considered end goal rather than the holistically integrated purpose of such initiatives. In addition, a level of local experimentation is highly dependent on and visibly restricted by financial capabilities, contrasting community support, absence of trust between different stakeholder groups and availability of high-quality data.

5.6.1 Diversity of Forms

Most interviewees note that it is difficult to determine the exact level of mobility-oriented experimentation undertaken at the city (R4,9,11,12,17,22). However, there is a consensus among local and national governing bodies that experimentation in transportation sector should be encouraged as it stimulates creativity, cultivates practical know-how and allows to trial new technologies before large-scale implementation (R7,9,12,22). Intermediaries express similar views by elaborating on experimentation as a necessary means to push novel sustainability initiatives forward, especially as most of such initiatives could not be realised by any other means. Thus, they project creative ideas and allow local municipality and other actors to learn from them (R21-23). A positive attitude towards urban experimentation as a potential tool to facilitate sustainable mobility solutions is supported by the representative at the Ministry of Transport and Communications:

> ["I really support urban experimentation (…) it is useful for the city and the government, especially in demonstrating what we can achieve and what we, as a society, can be in the future (…) That's why our team tries to exercise new pilots as much as possible: it is necessary to experiment. Otherwise, we will remain in the same position." (Respondent 12, 28 March 2023)].

When describing experimentation examples in Vilnius, governing bodies and intermediaries note that most emphasis is placed on public space humanisation pilots. For instance, imposing new traffic regulation measures (e.g., speed limits) to test bicycle- and pedestrian-friendly street design models or turning parking lots into green spaces. One of the academics elaborates on such street restriction pilots, mentioning *Minties, Tuskulėnų* and *Žirmūnų* streets as noteworthy examples in Vilnius (R3). To exemplify further, the introduction of loop traffic in the city's Old Town has started as an experiment to improve the liveability of the central city area by imposing additional entrance regulations. Therefore, it has eventually become one of the most successful examples of urban level-experimentation leading to a normalised practice today (R22).

Technology-related pilot studies were mentioned as another experimentation category which receives more attention. Businesses and community representatives notice an expansion of electrification infrastructure, with new charging points emerging for electric vehicles (R17, 25). On a similar note, the use of natural gas for fueling public buses was perceived as a relatively recently emerged form of experimentation which by now has become a common practice for replacing more polluting buses (R9). Some other stakeholders recognise the accumulating interest in testing out new autonomous buses (R22) and exploring the potential of hydrogen-fueled buses (R4,11), which were mentioned in the previous section (see section 5.6).

5.6.2 Level of Multi-dimensionality

It becomes apparent that most forms of visible urban experimentation are aimed at broader sustainable mobility development. For instance, focusing on social cohesion, health, and air quality improvements by reducing the number of private vehicles operating in specific city areas. While it is recognised as part of integral mobility planning, the document analysis and further interviews with specialists show that there is a lack of experimentation examples which are communicated as a direct measure to reduce transport emissions. As of now, only a few before-mentioned technologies are actively orchestrated to tackle CO_2 emissions. However, most of them are still relatively niche innovations discussed at the policy level with scarce practical applications. Besides, the foreseen implementation of a Low-Emission Zone (LEZ) in 2024 is perceived as another important pilot which could not only reduce air pollution levels in the city centre but contribute towards overall road transport decarbonisation. Nevertheless, it falls into the same category of the measures which are yet to be tested in the future.

In terms of limitations, most specialists identify financial resources as the single biggest obstacle hindering further development of disruptive and sustainable solutions through experimentation (R3,4,9,12,21,22). Although pilots and small-scale trials often are less expensive than some other measures, they still heavily rely on available financial funding. As further articulated by the Ministry representative:

> ["But once again, the level of experimentation depends on finance. If we are able to find something through the projects, we will be happy and will definitely do it. Otherwise, we have to work with what we have at hand" (Respondent 12, 28 March 2023)].

At the same time, some experts highlight that it is hard to predict how society will react to different experimentation forms. This is particularly relevant for restricting measures and humanisation initiatives as some of them *"are welcomed with high public dissatisfaction due to worsened conditions for using a car for commuting"* (R3). This could be linked to a lack of public support for sustainable mobility development discussed before (see section 5.4). Some other mentioned barriers are mistrust between different stakeholder groups to initiate pilot studies together and data availability concerns:

> ["As I said in the beginning, I appreciate the pilots and their emergence in Vilnius. However, we need more advanced and real-time mobility data sources which could be utilised for new pilot studies as well as the culture of trust between government, businesses and community, which are not yet fully realised in the city" (Respondent 22, 20 March 2023)].

Shifting the focus to how the local experimentation forms could be improved, most respondents mention that more experimentation is required in general. Few respondents also

note that most pilots are strictly infrastructural, while more experiments aimed at testing mobility demand management would be appreciated (R5,22). Quite a few specialists also hold a mixed opinion about some street humanisation pilots as *"their implementation is not always done holistically and can be harmful if not implemented in consideration to stakeholders' needs" (R3,5,8,21).* Finally, intermediaries and business representatives note that financial support could significantly encourage more experimentation from the private sector:

> ["In order to avoid a shortage of various forms of experiments, there must be some kind of encouragement, let's say financial support. This is due to the fact that companies themselves can only do as much as their limited resources." (Respondent 21, 14 March 2023)].

5.7 Reflexivity & Social Learning (C8)

There are some existing monitoring and evaluation practices within municipality that allow self-reflection on the sustainable mobility progress. It is noted that these practices to some extent target improvements in other capacity elements for transport decarbonisation locally. These are urban experimentation (C6), inclusive governance (C1), sustainability foresight (C5) and innovation embedding (C7). However, interviewees argue that despite some positive examples, reflexivity and monitoring practices are somewhat lacking on a strategic level, primarily due to shortcomings in human and financial resources. The capacity element could also be enhanced by reinforcing methodological and practical competence in the transportation sector.

5.7.1 Reflexive monitoring

When the focus was shifted to strategic and reflexive learning, most interviewees agreed that such practices are important in achieving long-term decarbonisation. However, they are not applied to the extent they would desire. An idea of incorporating reflexive practices primarly stems from a need to meet SUMP targets by 2030, with multiple practices applied to evaluate the ongoing progress. Municipality representatives mention that separate action plans are prepared on few years basis to fulfil 2030 targets step-by-step and build progress throughout the period. Key practices to encourage strategic learning that are performed by the municipality are the following: 1) resident and business surveys on commuting practices and 2) pilot studies focused on traffic regulation changes. Both of these practices allow to reflect upon residents' and other stakeholders' views on specific changes as well as gather more data on how and where people commute.

Some interviewees also acknowledge that drastic changes are not the way to go forward towards complete decarbonisation as they can affect society on many instances. For example, an introduction of vehicle pollution tax could disproportionally affect some social groups (e.g., low-income households). As a result, further research was performed to understand how such tax would affect households with less favourable conditions before the tax introduction was discussed on a strategic implementation level. This way, the reflexive practices are applied to ensure that no further harm is done, even though the intentions are always good.

In terms of community engagement, the specialists note that civic involvement is perceived as a learning cycle with its final stage being feedback reception from residents. During municipality meetings with city residents, it is a common practice to leave some time to receive reflections, whether by discussing the quality of the session in smaller groups or asking residents to fill out questionnaires. Nonetheless, it is not always possible or feasible to collect such feedback due to lack of time or simply availability of human resources at hand. Such self-

monitoring often has to come from internal resources which are limited. Besides, such self-evaluation is mostly informal with no clear monitoring structure. Similar views are further articulated by the community engagement specialist:

> ["There is a guide prepared for municipalities with set recommendations, clearly outlining how municipalities can collect feedback from residents - what forms to provide and how to do it - and of course recommendations for organising self-evaluation (as an organiser of activities). As of now, it occurs more informarly, but I really do see the need to have more detailed guidelines for such processe when implementing changes in city mobility services" (Respondent 10, 20 March 2023)].

Finally, learning processes for decarbonisation are locally encouraged by looking at what other countries are doing and what monitoring practices are working elsewhere. As further explained:

> ["Lithuania is a relatively young and small country and sometimes there is no need to invent something groundbreaking, it is enough to take a closer look at principles in other countries and learn from them" (Respondent 23, 15 March 2023)].

5.7.2 Methodological and Practical Competence

When asked about knowledge creation for local decarbonisation, the prevailing opinion amongst interviewees was that there is not enough specialists that could systematically work with complex topics such as transport decarbonisation. Although sustainability topics receive more attention and local popularity, numerous interviewees believe that universities and other educational institutions do not prepare enough highly skilled professionals in this field of interest. This could be explained by few reasons. First, some specialists came back to the characteristics of the country itself. As already mentioned in Section 5.7.1, with Lithuania being a small country, the knowledge-based capacities are also less developed than in bigger countries that possess significantly more advanced infrastructural, financial and human capital for offering world-class education. And even if professionals are prepared for similar work, their education is heavily based on theory rather than practical skillset.

Secondly, some experts argue that educational institutions themselves do not strike enough enthusiasm in younger generation while particular professions lack overall interest from society, such as engineering-related professions. Thirdly, academics argue that sustainable mobility concepts and planning tools in Lithuania have only started to be integrated on a larger scale in the last few decades. This is simpy because such concepts were uknown or only interpreted as separate rathen than integral nodes of mobility planning, lacking in holistic perspectives. Finally, few specialists interpret a lack of expertise not as an issue but rather a result of ongoing shortcoming of engagement throughout the years.

This could be further linked to strategic implementation challenges. According to some specialists, another challenge is that working in public sector is not prestigious in Lithuania while salaries are somewhat lower than in private companies. Therefore, attracting talents to public insitutions is not as easy and often has to come from an individual drive and passion for the subject rather than from prestige-related and financial incentives. And even though the needed specialists are there, often one specialist is responsible for multiple strategic areas, placing an additional burden. It was also mentioned that high profile experts frequently work at municipality level and then move onto national institutions to continue work or ongoing

projects. Finally, some other interviewees highlight that there is a specific work culture in the country with specialists working simultaneously in different areas. Thus, lacking targeted specialists who would specialise in niche areas.

During the discussion on the ways in which such overcomings are dealth with, specialists note that some of the required knowledge is being 'imported' from abroad while institutions try to attract local talents working and studying abroad. But even when such talent is attracted from elsewhere, sometimes such professionals do not understand local complexities, or their vision does not necessarily align with the vision of local specialists. Because of this, interviewees argue that it is very important to stimulate education locally and expand existing knowledge networks. Another way in which such concerns are addressed is that institutions are looking for young and ambitious individuals who do not necessarily have all the required knowledge at hand. Instead, such individuals undergo training, and their competencies are 'built-in' within the institution. This is exemplified in the following quote:

> ["Well, if you develop that team yourself from the second year of the university, then that's fine, but the university as a whole has not yet prepared adequate, full-fledged critical people who can immediately and consistently understand their capabilities and skills to work with complex sustainability topics. The preparation in Lithuanian universities is still very theoretical, you still have students coming into work who do not know how to use basic softwares" (Respondent 22, 20 March 2023).]

5.8 System Awareness & Memory (C4)

According to previously discussed results and additional insights captured during interviews and documents analysis, it is evident that stakeholders have an explicitly good understanding of local transport system dynamics. The degree of changeability that is required for system-level decarbonisation and systematic barriers are clearly identified. Interviewees also elaborate on essential pillars for transformation in terms of regulations, infrastructure, technologies, social needs and values. At the same time, the system path dependencies are further articulated by drawing examples from historical city development.

5.8.1 System Awareness

Stakeholders are able to recognise the critical regulatory, technological, social and infrastructural needs for transport decarbonisation which were described in previous sections (5.1-5.7). In addition to that, specialists identify most prelavent barriers for the main road transport decarbonisation pathways, which are presented in Figure 5-4.

Furthermore, stakeholders elaborate on additional city development tendencies that can influence decarbonisation patterns, even if they were not directly covered under specific capacity element. This could also indicate a high overall system awareness. A majority of interviewees highlight that urban sprawl, characterised by urban expansion to suburban areas, poses some significant challenges for mobility management locally. As the city continues to grow outwards, the average commuting distances between the city center and other parts of the city increase. Thus, commuting by car becomes the most convenient, and sometimes the only possible way to reach home, work or travel for other purposes within acceptable time limit (R2,3,6,9,21,22). Such views are further supported by the quote below:

> ["Because of the urban sprawl, we have a large variation in how population is distributed across the city. As infrastructure mostly remains the same and was

> created for the distribution of people before the expansion, the current system may not respond to current needs or people's behaviour. This ends up with people being forced to drive longer distances, farther from home, and pollute more" (Respondent 6, 14 March 2023).]

Others note that city expansion increases mobility demand in general, as more people are commuting to Vilnius from surrounding cities or relocate permanently (R2,5,6). That leads to additional burden on the transport system as more vehicles and people have to be accommodated locally. Some interviewees also discuss that despite gradually growing mobility needs in Vilnius, the budget allocated for transport development remains similar (R2,5). Some irregularities were also observed when debating about synergies with other sectors. For instance, the heating oil is still used for space and water heating in some residential areas during colder seasons in Vilnius. Therefore, specialists argue that such use of highly polluting petroleum products is not only detrimental to residents' health, but could potentially counterbalance any progress made in reducing transportation emissions (R2,13,14,20). Considering tendencies at a national level, interviewees also note that the national transportation emissions have increased in the last years due to growing car ownership levels (R13,14,23).

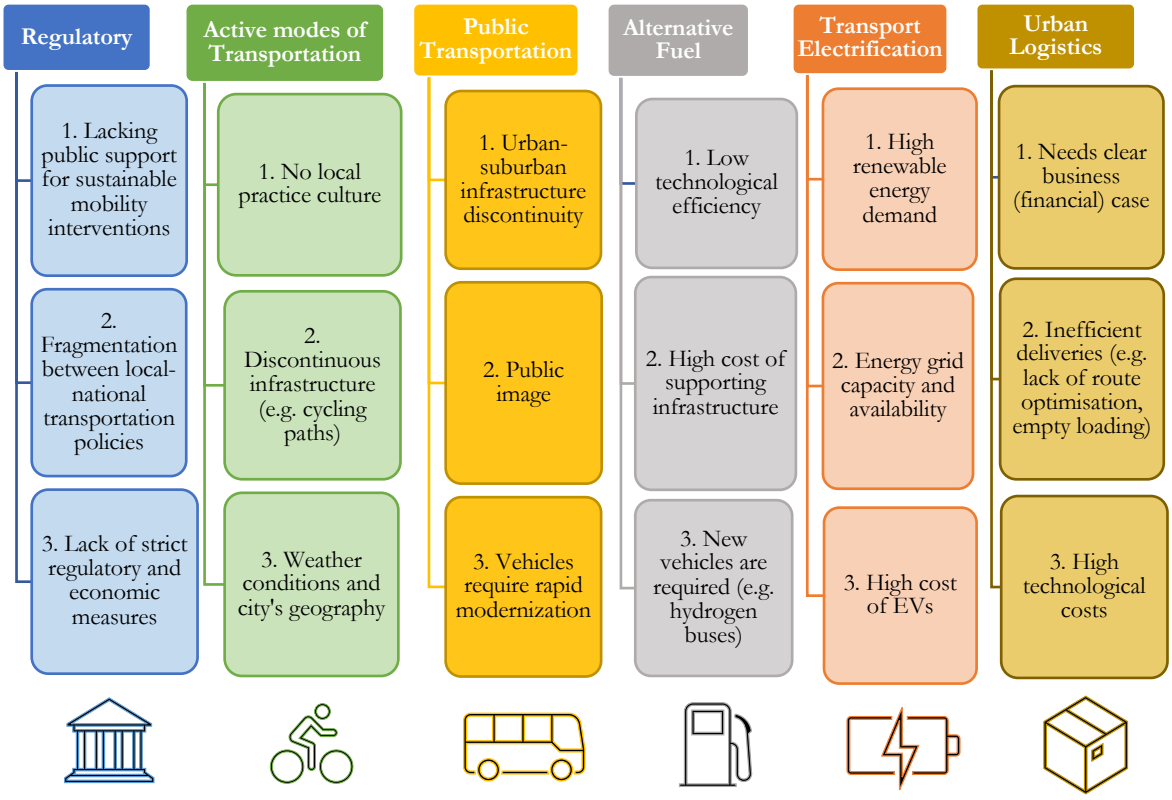


Figure 5-4. Stakeholder perceptions on key barriers for road transport decarbonisation in Vilnius based on six identified change categories. Authors own.

5.8.2 Recognition of Path Dependencies

Alongside showcasing high awareness of system characteristics and complexities underpinning it, stakeholders communicate how transport development in the past is creating resistance to change today. The interviewees refer to a so-called system memory, highlighting that particular system lock-ins have emerged due to historic legacies.

This is primarily connected to communist regime and its influence on post city developments after gaining independence from the Soviet Union in 1990. The quote below from academia representative illustrates the importance of system memory and how it created infrastructural and habitual dependancies:

> ["Systemic memory is always there, and it affects us, through our experiences and city planning (…) historical legacy has determined what infrastructure we have today and how people use it to move around the city. We are like this because of our past stories, and it brings some defiance to changing our habits. It is a part of our cultural mentality as we are very much connected to our mobility identities from the past" (Respondent 1, 7 March 2023).]

All interviewees agree that system memory is a vital component of understanding how the system functions today and could function in the future. Similarly, all stakeholders add that strong values and infrastructure surrounding car-use could be an evident roadblock to achieving decarbonisation targets because it slows down the natural transition to using other modes of commuting and prevents the emergence of new infrastructure. As articulated by academic representative: *"A new version of the city is basically beeing created and functions in the old space. Old structures from the past essentially act as an anchor that prevents change from happening"* (R6).

When elaborating on the examples of the historical dependencies, respondents note that during occupation years (1944-1990), public transportation was the main mode of commuting in Vilnius, with limited ownership of private cars. Since gaining independence in 1990, the city has witnessed a transformation of booming car-use as a sign of individuality, freedom and social status. Therefore, the city planning was organised around supporting the increased demand for car infrastructure in the last decades (R1,3,4,6,20,24). Others note that because of that, a car has become a symbol of convenience, comfort and even prestige, with numerous households having at least a few cars today (R5,14,20,24). At the same time, general car prices have also decreased, becoming more accessible for the wider spectrum of social groups (R3,5,23). On contrary, some interviewees argue that such car-dependancy has not necessarily developed only because of the historical circumstances, but was rather a result of global automobilization trends, which were also witnessed in Western Europe and North America (R1,4).

Moreover, interviewees discuss how such past dependencies could be eliminated by shifting generational mentality. As previously explained in section *identification of social needs* (see 5.3.1), car-centric attitudes stimulate opposition to sustainable mobility among the local public. Therefore, stakeholders believe that the upcoming generation is more environmentally conscious and expresses more open support for sustainable mobility:

> ["Today, young people have a completely different mindset, they welcome changes and are more willing to accept the emerging sustainable mobility trends. If children of the same age (when I was growing up) were told to ride a bicycle to school - they would laugh at it. Now, they cycle with complete respect (…) the attitutes are changing , there are also young people who have e-scooters and skateboards" (Respondent 3, 16 March 2023).]

> Finally, a majority of interviewees believe that transformative changes will occur in the city when young people will more actively express their voice in local elections. This is illustrated by the quote below:

["It is known that the largest group of voters is around sixty years old in Vilnius and in Lithuania more generally. Most of these voters gained their education during occupation years, they understand problems differently and have a distinctive point of view. On contrary, the youngest group (around 18-24) constitutes a very small percentage of voters, they take part in elections significantly less frequent. Changes will come with changes in this balance" (Respondent 3, 16 March 2023).]

5.9 Summary of Study Results

After presenting detailed results on eight transformative capacity elements, as reflected in the study framework, this section concludes the results in relation to the research question and sub-questions. Study results are then used to evaluate the extent to which the transformative capacity elements are being built to advance local road transport decarbonisation in Vilnius. Therefore, Figure 5-5 illustrates the operationalisation level of each transformative capacity element based on compiled study findings.

RQa: How do transformative capacity elements manifest?

All reviewed TCEs in the Vilnius transportation system are manifested through strategic governing and more practical initiatives. Nevertheless, the utilisation level of different TCs within the system varies greatly. For instance, such capacities as *system awareness & memory (C4)* and *sustainability foresight (C5)* are well established and positioned to support the transition from fossil-fueled transportation to more sustainable mobility forms. Stakeholders are able to reflect upon the current system's characteristics critically, identify systemic decarbonisation barriers, recognise the level of changeability required within the system and weigh different decarbonisation pathways required for large-scale change. This is further mirrored in strategic policy documents (e.g., NECP, Vilnius SUMP), which acknowledge the system's path dependencies and describe the necessary steps to materialise the collective vision for sustainable mobility. Both capacities are developed by allowing strategic knowledge transfers within governance structures while knowledge about the system characteristics is openly accessible to different stakeholders via local transport strategies. The capacity of *innovation embedding and coupling (C7)* is clearly noticeable and encouraged within the system. However, its practical realisation and contribution to transport decarbonisation is less clear than in other more developed capacities. On the other hand, the capacities of *transformative leadership (C2)* and *autonomous communities of practice (C3)* are scarcely embedded, with only limited signs of their presence to encourage the system's decarbonisation. These capacities are less manifested, arguably due to weak public engagement in decarbonisation narratives, which is an essential prerequisite for operationalising these capacities. Both capacities are only visible (if visible) in specific system areas, are highly fragmented and are met with high resistance from different stakeholder groups. Interestingly, all the remaining capacities, including *urban experimentation with disruptive solutions (C6), inclusive & multiform governance (C1) and reflexivity and social learning (C8)*, are moderately displayed in the system. Yet, they are not actively supported to push road transport decarbonisation forward and receive some considerable resistance. Specialists perceived these capacities as 'emerging' or 'slowly improving'. The document analysis also indicates some noteworthy examples of their utilisation, however, not at the system level.

RQb: How transformative capacity elements are advanced by different actors/or by the city of Vilnius?

Most TCEs, which are actively reflected within the system *(C4 - system awareness & memory, C5 - sustainability foresight)*, are directly advanced by the Vilnius city municipality and its subordinate institutions and supported by national governing bodies. These capacities are operationalised through local and national strategic planning and ingrained in high-priority policy documentation to reduce GHGs within the sector. Besides, these capacities show engagement from other influential stakeholders. For example, transportation companies and intermediaries recognise distinctive social, infrastructural, technical and infrastructural lock-ins within the system and seek to address them by contributing towards collective sustainability visioning. Although numerous stakeholders reinforce both capacities, they require more alignment of

priorities and intentional and continuous collaboration between prominent actors. In addition, *innovation embedding and coupling (C7)* capacity is being promptly improved by the local municipality, its subordinate institutions and higher-level governing bodies (e.g., ministries). For instance, this could be completed by creating more favourable conditions for technological development and innovation diffusion locally. This is also observed in local strategic documents (e.g., RRDP), which foresee an ongoing development of new sustainable transportation technologies (e.g., hydrogen and electrification). Some engagement is recognised by transportation companies which actively discuss technological advancements for climate neutrality. However, their participation is highly dependent on practical and internal benefits that could be acquired by encouraging technological development. The capacities of *inclusive & multiform governance (C1), reflexivity and social learning (C8) and urban experimentation with disruptive solutions (C6*) are similarly advanced by local and national governing bodies. However, their utilisation is less straightforward. While most stakeholders recognise these capacities, they are only occasionally reflected in local and national transportation policy, with urban experimentation receiving slightly more attention than the others. The remaining capacities, including *transformative leadership (C2) and autonomous communities of practice (C3)*, are only infrequently exercised by the governing bodies or other stakeholders. For instance, sustainable leadership is stimulated by shifting more authority to local municipalities to implement sustainability measures, while some occasional leadership is noticed among larger transportation companies. Overall, the facilitation of TCEs primarily emerges from the local municipality and national government initiatives, while bottom-up governance for accelerating TCEs is yet mostly submerged.

RQc: How transformative capacity elements could be reinforced?

The most frequently mentioned measures to reinforce the existing TCEs are concerned with 1) strengthening collaboration between different stakeholder groups, 2) raising public awareness towards sustainable mobility, and 3) making sustainable modes of transportation competitive enough to become alternatives to convenient transportation. More specifically, the capacities *of inclusive & multiform governance (C1), transformative leadership (C2),* and *autonomous communities of practice (C3)* would particularly benefit from establishing a firmer dialogue with the public. This could be achieved by sustainability-focused public education aimed at creating commonly shared values, beliefs and professional competence for transport decarbonisation and climate change mitigation more generally. Also, these elements could be reinforced by establishing a more structured approach to public engagement and communication practices at the strategic level. S*ystem awareness & memory (C4)* and *sustainability foresight (C5)* capacities could be improved by better transportation policy alignment between local-national levels and more aligned priorities and procedures for a collective vision towards transport decarbonisation. Moreover, the capacities of *urban experimentation with disruptive solutions (C6)* and *innovation embedding and coupling (C7)* could be mainly enhanced by removing financial, infrastructural, and market-related barriers or by utilising external EU resources to enhance their local applicability. Finally, reflexivity *and social learning (C8)* could be supported by establishing clear strategic guidelines for self-evaluation procedures and building a local sustainability knowledge base through stakeholder partnerships and reinforcing local and transnational networks.

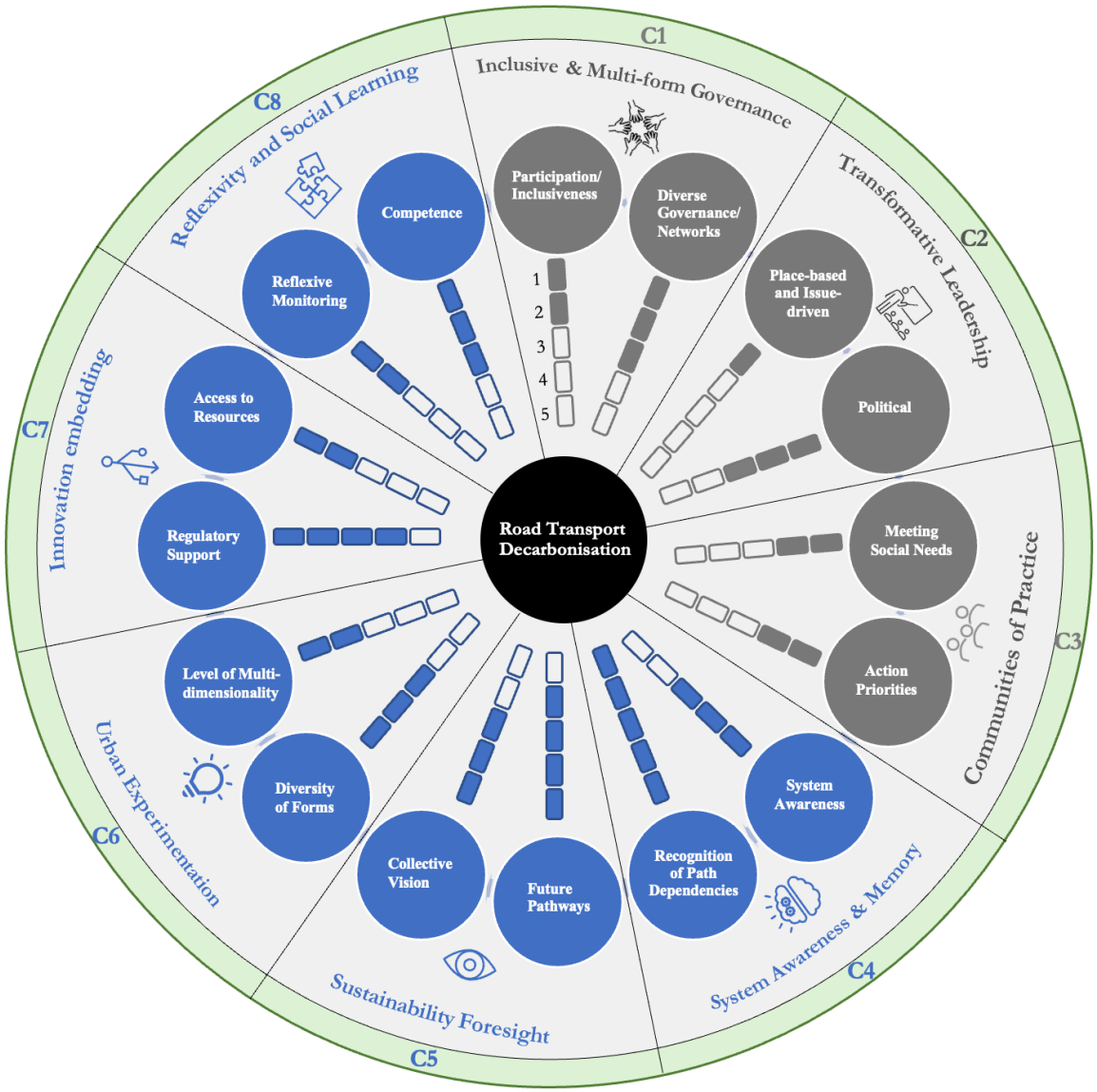
- Transformative capacity elements representing *agency and interaction forms* (C1-C3)

- Transformative capacity elements representing *core development processes* (C4-C8)

- The level of transformative capacity manifestation in the transportation system (1-5 scale) - *core development processes*

- The level of transformative capacity manifestation in the transportation system (1-5 scale) - *agency and interaction forms*

[1] - No signs/very limited (minimal or no actions which are mainly designed to maintain the current system);
[2] - Some signs (some actions are visible but come with active resistance to decarbonise the system);
[3] - Moderate (an increasing number of actions but comes with some resistance to decarbonise the system);
[4] - Good (clearly visible actions that actively support decarbonisation and have established support system with some exceptions);
[5] - Excellent (capacity element is thoroughly developed and is a part of routinised actions leading to rapid decarbonisation).



Positive highlights	***Highlights for improvement***
[1] Excellent awareness of the level of changeability required within the system, clearly identified decarbonisation barriers, and pathways to achieve it in a long-term perspective *(C4, C5)*	**[1]** Absence of public support for sustainable mobility initiatives characterised by strong resistance *(C3)*
[2] Sustainable innovation development is strongly supported by legislation *(C7)*	**[2]** Lack of more diverse and frequent leadership forms that articulate common vision and values *(C2)*
[3] The increasing role of urban experimentation *(C6)* and bottom-up governance *(C1)* as catalysts for change	**[3]** No sufficient access to resources for large-scale sustainable innovation diffusion *(C7)*

Figure 5-5. Summary of study results. The operationalisation level (1–5) of different TCs for road transport decarbonisation in Vilnius. The evaluation is based on the researcher's judgement according to the study results.

6 Discussion

This chapter seeks to thoroughly discuss and relate the study findings to the existing academic literature on TC building in the transportation sector and sustainability field more broadly. The chapter starts by critically reflecting on the general study findings and their contribution (section 6.1). Then, the critical deliberation on methodological, design-related and other research limitations is provided (section 6.2).

6.1. Significance of Study Findings

The study results show that local governing bodies tend to recognise and prioritise the mentioned TCs in their strategic activities. However, these processes are still very fragmented and rather random - they do not reflect holistic or systematic nature just yet. This could be further linked to an emerging need to encourage bottom-up governance and drive transformations from underneath (Dirix et al., 2013).

The general findings support the results from Holshter et al. (2019) study, highlighting the growing significance of transport decarbonisation in cities and indicating that the transportation sector is fundamentally more complicated when it comes to system-level decarbonisation. In addition, research complements the views expressed by Holshter et al. (2019) by emphasising the emergence of more complex climate governance structures which are cross-sectoral, multi-dimensional, multi-scalar and require multi-actor partnerships (e.g., public-private sector engagement). Similarly, the study shows that enhancement in one TC can have a positive or negative impact on other elements (Wolfram, 2019). In addition, the study findings are similar to the ones of Witzell et al. (2022), arguing that TC management needs more orchestration and identification of linkages between different TC elements and processes at the governance level.

Conversely, the study results differ from Broto et al. (2019), who identify a lack of evidence for TC visibility in sustainability initiatives across European cities. The results could be different because of the different scoping selected for the project or different sets of criteria.

Most importantly, the presented research makes a notable contribution to the existing academic literature on transformative capacity utilisation for urban climate governance (Loorbach, 2010; Broto et al., 2019; Hölscher et al., 2019; Witzell et al., 2022), particularly for studies on transformative urban change in the Baltic region. The study illustrates how TCB frameworks could be applied in practice and used to critically assess the emergence of new transformative and sustainable systems in cities.

6.2 Critical Reflections on Research Limitations

The presented study has several limitations which should be addressed accordingly. To begin with, the reliability and validity of study results are limited. *Reliability* is concerned with the replicability of study results in similar inquiries using the same research methods and techniques and determines whether research results could be generalised more broadly (Bryman, 2012). However, in qualitative research reliability could be seen as a consequence of validity (Patton, 2001). Thus, the presented limitations are mainly focused on *validity* instead. According to Leung et al. (2015: 325), validity in qualitative research is defined as the *"appropriateness of the tools, processes, and data"* used in the research and determines the trustworthiness of data and study findings. Regarding internal validity, a few biases were identified and approached accordingly.

First, the researcher's bias emerged when determining the study design, methods, and participant sampling. For example, when deciding which stakeholders (and stakeholder categories) to select and interview and which policy documents and (or) their parts to review for the study. Besides, the study design selection relied on a pre-determined TCs framework (Wolfram, 2016). Thus, the structured approach to data collection using the framework has potentially influenced the final findings, as they were primarily derived deductively. A more structured approach to research design and data collection was deemed more relevant in this context, as no similar research was undertaken locally. In addition, the study's main aim was to reflect upon the visibility of the well-established transformative capacity typologies in the academic literature. It is acknowledged that the study results could have been different if interview data was coded inductively or if other policy documents had been selected for the analysis. Also, it is essential to mention that qualitative data interpretation is highly dependent on the researcher's skillset and personal biases (Bryman, 2012). A few strategies were employed to limit the researcher's bias, including data triangulation, peer debriefing and a detailed and transparent coding approach. Robson (2002) argues that all these techniques can help reduce researcher bias and deal with validity concerns. Data triangulation (interviews and documents) was beneficial in deriving a more comprehensive and in-depth overview of the phenomenon investigated. At the same time, regular feedback sessions with other peers throughout the study process allowed better reflection on some study assumptions and limitations. Besides, detailed coding structures were established when analysing interview data and policy documents to ensure a rigorous data analysis process (See Appendix E). Finally, instead of selecting pre-determined TCEs for discussion, interviewees could also select 'other' topics related to transport decarbonisation which were later linked to specific TCEs as indirect insights (e.g., intra- and inter-trends in *sustainability foresight - C5* and other system characteristics in *system awareness - C4.1*). This ensured that any significant insights were not overlooked and appropriately addressed in the final findings.

Second, the respondent's bias should be considered too, as interviews were a primary data collection method. Bowen (2009) argues that respondents may be biased towards providing the most desirable answer or may feel uncomfortable enough to provide unpopular and (or) straightforward answers. To minimise the respondent's bias, a large sample was selected for the interviews *(R=26),* including at least a few members from every stakeholder category and different level governance bodies. Also, the stakeholder grouping into separate categories allowed to compare results between different actor networks. This has further resulted in rich and detailed insights on all transformative capacity elements under investigation while addressing some of the indicated respondent's biases.

Some other limitations were also reflected upon. For instance, despite all selected stakeholder categories being represented in the study, some had larger participant samples (e.g., Academia) than others (e.g., NGOs and Community). Similarly, some TCEs were represented more scrupulously than others, while only a few leading policy documents were analysed in the study. These limitations are mainly linked to time constraints, as the thesis study was conducted in a few months. Similar limitations could have been addressed if the period dedicated to the study was longer.

Another study drawback is a need for more similar case studies on TCEs, particularly in the transportation sector and the chosen geographical locale. It is acknowledged that the discussion on the final results could have been richer if more similar case studies were available for comparison. Nevertheless, that also meant that the presented study is novel in many aspects and could contribute considerably to the existing bodies of academic literature.

Finally, the data collection for the research (e.g., through interviews and document analysis) was performed in Lithuanian, while the main study findings were translated and presented in English. On the one hand, conducting research in a native language allows one to consider emerging linguistic and cultural sensitivities, resulting in a more open data collection process. However, this could have also resulted in some phrases or word meanings being misinterpreted during the translation. An official phrasing of some specific Lithuanian terms was double-checked in official sources and translated correspondingly to counterbalance this limitation.

7 Conclusions and Recommendations

7.1 Conclusion on Transformative Capacities (TCs)

This study aimed to investigate how the transformative capacity building, in a form of transformative capacity elements, is exercised in the transportation sector in Vilnius to advance road transport decarbonisation forward. It is noted that the frameworks on TC building are useful conceptual tools to understand institutional and socio-technical dynamics underpinning the existing mobility systems. Similarly, it allows to identify the critical stakeholders in disrupting conventional transportation system and signal how such change could be performed collectively. The framework was particularly beneficial in recognising different barriers for climate change mitigation locally, as social, technical, infrastructural and policy characteristics of the transport system were investigated.

All reviewed TCs in the Vilnius transportation system are manifested through strategic governance and exerted within local stakeholder networks. Nevertheless, the utilisation level of different TCs within the system varies greatly. The TCs representing *core development processes* (C4-C8) required for climate governance are embedded more firmly within the system, while the TCs displaying the *agency and interaction forms* (C1-C3) are characterised by weaker signs of implementation. Above all, study findings indicate that transformative capacity building (TCB) frameworks are valuable analytical tools for understanding institutional and socio-technical dynamics underpinning the existing mobility systems, which are necessary for reinforcing local climate governance in cities.

7.2 Recommendations for Future Research

The completed research provides a detailed examination of the manifestation of different TC elements in the local governance context to further the understanding of climate change mitigation in the transportation field. Thus, myriad research opportunities emerge for similar inquiries in the future. The recommendations for the prospective research could be further categorised into three groups - 1) context-specific, 2) capacity-specific and 3) methodological recommendations. They are discussed in this section.

Regarding context-specific recommendations, future research could focus on investigating the same topic within the same context, however, providing more insights into some of the complexities deemed important in study findings. For example, it was discussed that different TCs could influence each other by having a reinforcing or weakening effect (Holshter et al., 2019; Broto et al., 2019). Thus, future research could focus on identifying these linkages between different TCs and their elements and potentially recognise the significance of such interconnectivity for road transport decarbonisation in Vilnius. This could further be used to understand how the advancement of one TC could counterbalance the incapacity in another area or vice versa. Similarly, more research could be conducted to further explore the role of local municipality as the prominent stakeholder or the influence of EU pressures as the critical driver for transformative change in local mobility. Another potential research stream is to adopt a similar research design to investigate TC utilisation in other *geographical* or *sectoral* contexts. For instance, by expanding the study scope from city to region level. This could capture new demographic and commuting dynamics as most residents in neighbouring areas travel to Vilnius daily for work. On the other hand, investigating cross-sectoral dynamics (e.g., transport-energy, transport-urban planning/buildings) could also reveal new interlinkages affecting existing capacities. Similar inquiries in other Lithuanian, Baltic or European cities would also be welcomed because, as mentioned numerous times, the practical applicability of

TC frameworks is scarce, particularly in the transport field. Finally, the academic literature on TC could also benefit from similar case studies in other CO_2-intensive sectors locally (e.g., energy sector) or by utilising the TC framework to examine the particular measures for transport decarbonisation (e.g., smart-mobility services) (Cepeliauskaite et al., 2021).

For capacity-specific recommendations, the *relational* TCs (C9-C10) could be investigated to draw comparisons between and fill in the gaps associated with the current findings on C1-C8. As Wolfram (2016) explains, *relational* TCs are concerned with building capacity across different agency levels (e.g., individual, organisations, networks, households) and at different governance levels (e.g., regional, national, and supranational). In this study, the relationality was mirrored indirectly, stemming from inductively collected insights, for instance, when reflecting on the EU influence or identifying fragmentation between local-national mobility policies. However, such research could further enhance the empirical findings on political-geographical-institutional dynamics and how they may affect transport decarbonisation at a city level. Another suggestion is to explicitly focus on one or only a few TCs and provide a rounder and more in-depth overview of their presence within the system. This has not been addressed in this study, as the research scope was set to perform a primary evaluation of all capacities at a system level.

Finally, future research inquiries could experiment with different methodological approaches to derive a fuller understanding of the phenomenon or address some of the methodological limitations of this study. For example, by conducting a more comprehensive document analysis of existing policy packages. Now, the document analysis was only used as a complementary method to triangulate data. Also, as mentioned in the methodological study design considerations, interviewees were asked to self-identify which TCs they would like to discuss in interviews. It would be interesting to have a less structured approach, e.g., by allowing experts to elaborate on all TC elements and determine if any new insights emerge. Moreover, *focus group discussions* are encouraged for similar studies as they could be easily integrated with interviews. At the same time, the researcher could observe the phenomenon from an outsider's standpoint instead of taking a central role (Dwyer & Buckle, 2009). Focus groups can also help determine group dynamics and speech patterns (Nyumba et al., 2018). As this study is theory-driven and mainly focuses on deductive reasoning, more inductive insights could also bring new observations for discussion. To steer this, different TC models could be employed for similar studies (e.g., Loorbach, 2010), or a new model could be created to evaluate the presence of TCs in the transportation sector based on inductive findings. Finally, *quantitative research* (e.g., by conducting a residents' survey on TC-related perceptions) could bring a completely new methodological dynamic and potentially untangle other barriers introduced in this study, such as reasons behind high public resistance to sustainable mobility changes.

7.3 Recommendations for Vilnius Municipality

The derived study results and further discussion provide valuable insights into how the current governance models could be improved locally. Thus, a list of recommendations for local municipality was compiled to inform the internal and external reinforcement of *core development processes* and *agency and interaction forms* needed for transport system decarbonisation in the future. The immediate actions are provided to support recommendations further (⇨).

It is believed that these recommendations could inform similar inquiries undertaken by the municipality. Even more, these recommendations are compiled to contribute towards guiding practical decarbonisation efforts, which are visionary, holistic, and transformative in nature.

1. Improve self-reflection and system-monitoring practices (particularly for achieving Vilnius SUMP 2030 ambitions) - currently, assessment and evaluation tools for sustainable mobility interventions are scarcely applied and mostly in informal settings.

   ⇒ Establishing mid-progress reports for SUMP implementation on a few years basis with a reflection on ongoing decarbonisation interventions and their effectiveness (example - five-year delivery plan in Manchester, UK);
   ⇒ Creating internal guidelines to timely receive feedback from the relevant stakeholders (specifying structure, frequency, and feedback integration processes);

2. Consider the potential implications (social, economic, distributional) of transport decarbonisation measures on different societal groups - it was recognised that new interventions can negatively affect specific social groups. Further evaluation is required to account for potential rebound effects and trade-offs.

   ⇒ Social and economic impact analysis for the upcoming Low-Emission Zone (LEZ) introduction in 2024; (example - London, UK)

3. Recognising and aligning fragmented interests and visions within and between local and national government bodies - as of now, no uniform decarbonisation vision is shared among stakeholders (e.g., no clear continuity between local and national-level transportation policies), nor joint materialisation of sustainable mobility targets.

   ⇒ Ensuring transportation policy alignment at local, regional and national levels and addressing any emerging inconsistencies (example - Parkstad Limburg regional SUMP in the Netherlands);
   ⇒ Improving local responsibility sharing practices between municipality's subordinate institutions and encouraging more open and transparent communication;

4. Promoting urban experimentation forms that are multi-dimensional and address climate change alongside other social, economic and technical needs - currently, only a few forms of urban experimentation are linked to direct GHG emission reductions.

   ⇒ Encourage ongoing experimentation with EV and hydrogen technologies;
   ⇒ More pilots for Mobility-as-a-Service (MaaS) solutions;
   ⇒ Initiate Urban Living Lab (ULL) projects for sustainable mobility solutions (example - livability programme in Oslo, Norway)

5. Re-defining and reinforcing stakeholder collaboration networks - as of now, visible foundations of local and trans-national networks, but their utilisation is mostly pragmatic and does not support continuous decarbonisation progression.

   ⇒ Stimulate public-private partnerships and investment streams to fund them
   ⇒ Establish a local culture of collaboration and know-how sharing by introducing new communication and education channels;

6. Grow internal sustainability competence and stimulate knowledge diffusion - it was noted that most required professional competence is 'built-in'.

   ⇒ Stimulate collaboration with local and international universities and other knowledge institutions to attract new talents;
   ⇒ Ensure ongoing sustainability training and workshops for all professionals;

7. Focus on public transportation development and multi-modal transportation - improving public transportation was identified as the leading measure for decarbonisation while multi-modality can support integration of alternative modes.
    - ⇒ Boost attractiveness of public transportation by improving convenience, comfort and affordability alongside public awareness raising (example - enhance connectivity between urban-suburban city areas)
    - ⇒ Ensure comprehensive multi-modality planning (MORE project in Lisbon)
8. Support a large-scale renewable energy integration in the city for sustainable mobility transition - currently, renewable energy accessibility is very limited, and there a visible insufficiency of grid availability for system-level electrification.
    - ⇒ Map out renewable energy integration possibilities in the city with consideration to the existing transport infrastructure;
    - ⇒ Urgently improve low-carbon electricity generation in the local grid;
9. Integrate transportation planning with land use practices.
    - ⇒ Long-term infrastructure planning should be focused on ensuring optimised service provision within the city to avoid unnecessary travels (example - MaxLupo project in Swedish cities)

7.4 Recommendations for Practitioners

Similar to recommendations for Vilnius municipality, a list of suggestions is compiled for local practitioners working with sustainable mobility and climate change mitigation topics. It is believed that the below provided points of advice can inform and encourage broader TC integration across the entire transportation sector. The proposed actions from other European cities are provided to support recommendations further (⇨).

1. Enhance local business engagement in decarbonisation, both practical (in terms of strategic prioritisation) and collaborative (with other stakeholders).
    - ⇒ Focus on providing a business case for sustainable mobility and communicate other benefits that could be acquired by engaging in decarbonisation;
    - ⇒ Create additional funding and engagement opportunities for SMEs (example - "Mobility Management for Companies" competition for in Graz, Austria);
    - ⇒ Stimulate public-private partnerships and investment streams to fund them;
2. Build a local climate change narrative to align decarbonisation visions between stakeholders and increase public support/engagement - it was recognised that there is a strong public resistance to sustainable mobility interventions.
    - ⇒ Engage in public sustainability education and build additional communication/information channels for sustainable mobility mainstreaming (example - sustainable mobility app that rewards citizens in Bologna, Italy);
    - ⇒ Establish clear guidelines/procedures and encourage actions for community involvement in decision-making (example - participatory model for introducing congestion tax in Milan, Italy);
    - ⇒ Encourage the emergence of bottom-up governance through support of grassroot initiatives, start-ups and NGOs;
3. Encourage practical learning between sustainable mobility practitioners to stimulate commonly shared 'how-to' knowledge.
    - ⇒ Build local and regional clusters for innovation, R&D and knowledge exchange;
    - ⇒ Create new networking opportunities via forums, webinars and conferences;
    - ⇒ Employee training and workshops;
4. Foster cross-sectoral and transdisciplinary learning by reinforcing the existing and creating new knowledge institutions.
    - ⇒ Increasing popularity of sustainability and transportation-related disciplines in schools and universities (example - compulsory climate education in Italy);
    - ⇒ Establishing new public sustainability knowledge centres (example - Mobility Monitoring centre in Thessaloniki, Greece);
    - ⇒ Encourage practical learning from city residents and other stakeholders (example - data collection by residents, WeCount pilot in Ljubljana, Slovenia);
5. Optimise organisational and delivery efficiency in urban logistics companies
    - ⇒ Encourage digitalisation/creating online mobility databases/ITS;
    - ⇒ Route optimisation;
    - ⇒ Optimise loading and unloading times of goods;
    - ⇒ Optimise last-mile deliveries by switching to EVs or establishing local logistics centres (Micro Hubs in Hamburg, Germany);
    - ⇒ Sector-level standartisation;

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Appendix A - Interview Guide

The individualised interview guides were prepared for every interview and tailored based on the interviewee's expertise and expressed preferences for the discussion. While each interview guide differed, some general parts were used in all interviews (e.g., parts 1-3 and 7). Below, an example of the interview guide is provided, focusing on the discussion of three capacity elements: inclusive and multi-form governance (C1), transformative leadership (C2) and effective sustainability innovations embedding (C7).

Interview Guide Nr. 20

1. **Greetings and Introduction**
    - Greeting the interviewee, thanking them for their time;
    - Briefly introducing myself, revising research aim, topic and its significance, interview purpose;
    - Signing online consent form and receiving approval to record the interview;

2. **Interviewee Background**
    - What is your current role within the *X* organisation?
    - How is your work related (directly or indirectly) to transport decarbonisation?

3. **General Transport Decarbonisation Tendencies**
    - How do you view the current road transport decarbonisation situation in Vilnius?
        - Is this topic receiving increased attention? If yes, why?
        - Is it strategically prioritised?
        - What measures are being implemented?
    - Any major changes/tendencies recently noticed in terms of transport decarbonisation?
    - How do you view the city's transport decarbonisation ambitions until 2030 as introduced in Vilnius SUMP?

4. **Multi-form Governance (C1)**
    - Which stakeholder groups are the most important when discussing road transport decarbonisation?
        - To what extent are these stakeholders involved in decision-making?
        - Which stakeholders are less involved (whose involvement is necessary)
    - Are current governing forms cohesive and aligned with stakeholder needs?
        - How the existing governing forms could be improved?
    - Is there any visible bottom-up engagement?
    - Are there any visible networks of collaboration for joint action?

5. **Transformative Leadership (C2)**
    - Is there a leading narrative for road transport decarbonisation?
        - Who leads this narrative?
        - How is this narrative exercised and communicated to society?

- Could you identify any stakeholders as potential leaders for system-level decarbonisation?
  - What leadership forms are missing?
  - What values/visions are needed to reinforce the existing leadership?

6. Effective Sustainability Innovations Embedding (C7)

- Are there any new emerging technologies for road transport decarbonisation?
  - What are they?
  - How did they emerge?
  - Who initiated them?
  - In what ways is their governance supported?
- What innovations are needed for long-term decarbonisation?

7. Ending the Interview

- Express appreciation for their time
- Any uncertainties/follow-up questions about the research
- Ask if there is anyone else who would be worthwhile to interview*;
- Remind contact information;
- Mention that I will keep them updated about study results;

**[if the person is only partly involved in transport decarbonisation area, ask who the most influential stakeholder is]*

Appendix B - Interview Consent Form

[The original form was written in Lithuanian. Thus, the translated version is provided here for study purposes]

A Consent Form for the Voluntary Participation in the Final Year Master's Thesis Research on Transformative Capacity Building for Road Transport Decarbonisation in Vilnius

Thank you for expressing your willingness to participate in the interview and contribute to the university research project conducted at the International Institute for Industrial Environmental Economics (IIIEE) as part of the M.Sc. programme at Lund University in Sweden. The work's full title: (in English) is "Assessing the Transformative Capacity Building for Sustainable Mobility Transitions in Cities: A Case Study of Road Transport Decarbonisation in Vilnius, Lithuania".

The proposed research project seeks to investigate the topic of road transport decarbonisation in the context of Vilnius city, examining the current trends, governance mechanisms and potential measures to achieving long-term transport decarbonisation. The main aim of the research project is to identify the signs of transformative capacities which could enhance road transport decarbonisation locally. As mentioned, eight transformative capacity elements were identified and investigated under this project. Different stakeholder groups are consulted throughout the research process, including local and national governing bodies, transport companies, city planners, academics, non-governmental organisations and other specialists working with climate change and/or transportation projects locally.

During the interview, we will have a chance to discuss some of the transformative capacity elements (C1-C8). This includes their visibility in a local context (e.g., to what extent they are integrated into the existing governance models) and how these transformative capacity elements could be strengthened to drive a system-level change.

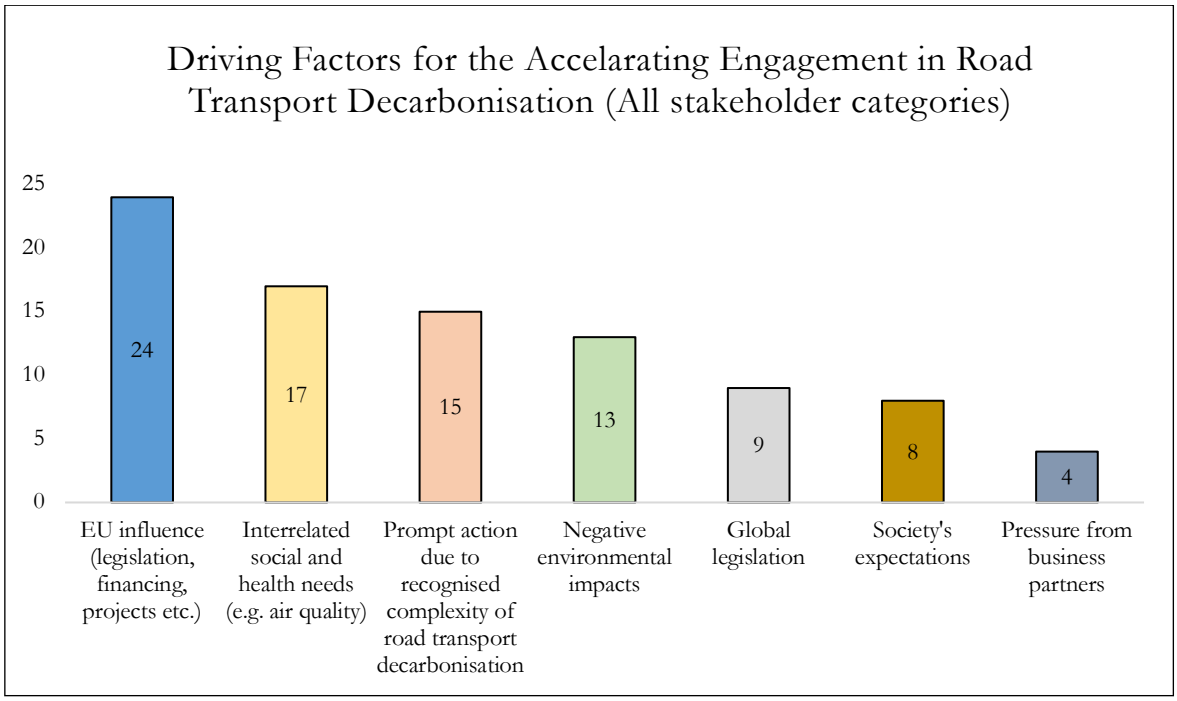
The results of this research will be only used for educational purposes while paying great attention to the anonymity of the participants and their personal information. For any additional questions regarding the study, do not hesitate to get in touch:

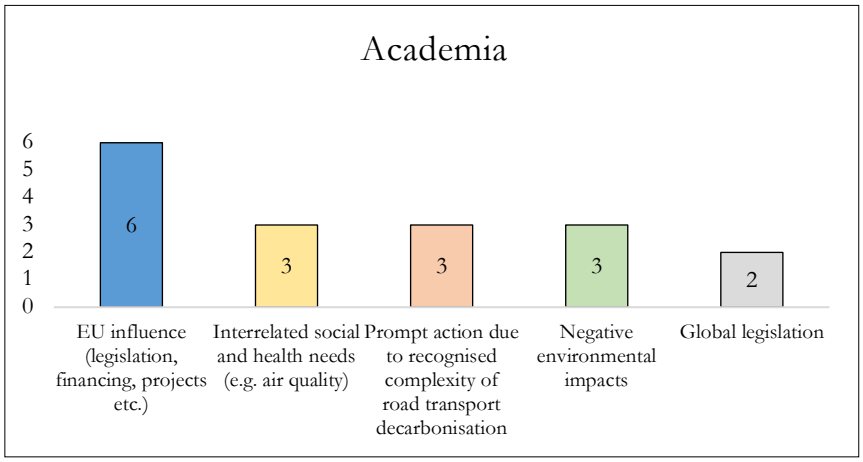
Researcher: Markas Ąžuolas
Contact information: markas.azuolas.work@gmail.com; ma7075az-s@lu.se

□ Name
□ Surname
□ Current Workplace
□ Email Address
□ By filling out this form, I agree to participate in the interview voluntarily and, with my answers, contribute to the final master's thesis project for the EMP master's programme at IIIEE, as introduced above. At any time, I have the full right to withdraw from the study without providing any further explanation.
□ By filling out this form, I agree that the interview will be recorded for research analysis purposes (no personal information about the participant nor the recording of the interview will be made public anywhere, and the names of the participants will not be mentioned).

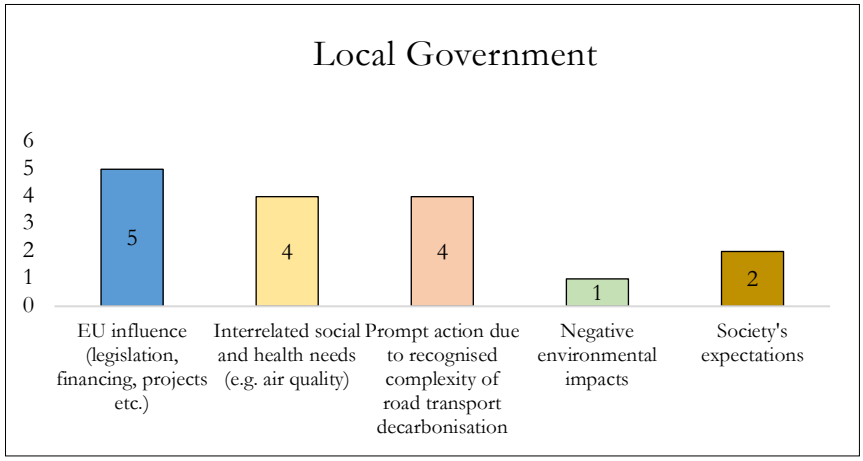
Appendix C - Extended Results on Drivers for Road Transport Decarbonisation in Vilnius, Lithuania

(Based on Different Stakeholder Categories)

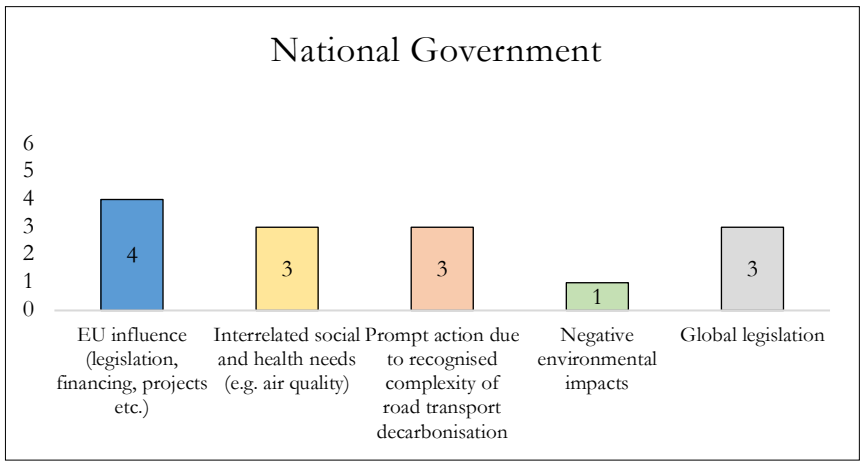




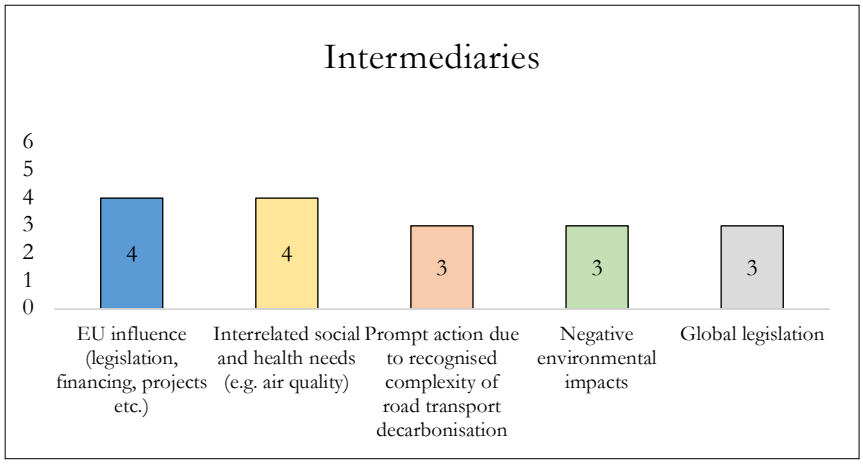
(Out of 6 respondents)



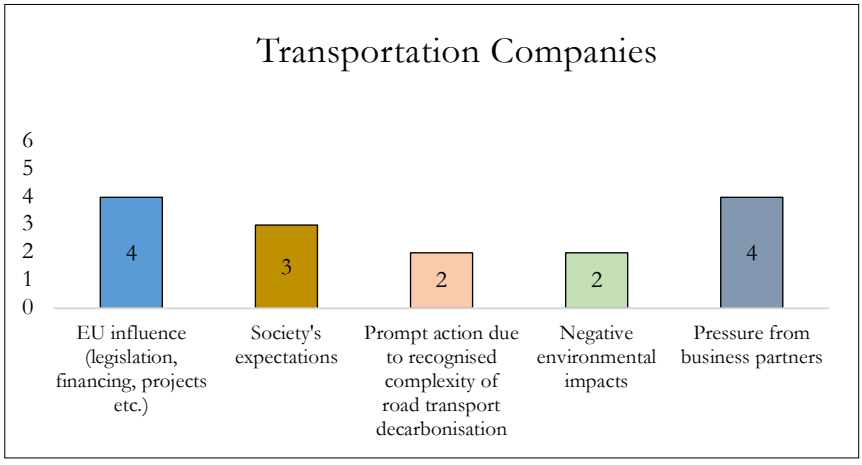
(Out of 5 respondents)



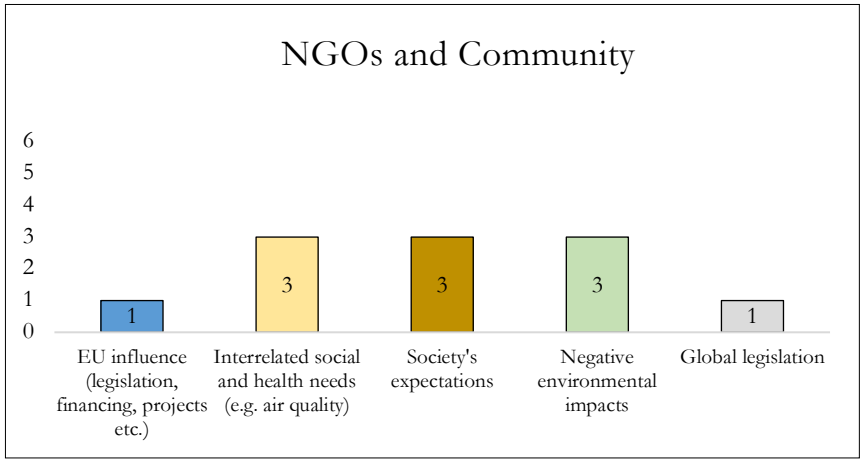
(Out of 4 respondents)



(Out of 4 respondents)



(Out of 4 respondents)



(Out of 3 respondents)

Appendix D - A List of Transformative Capacity Criteria and Sub-criteria for Data Analysis

(Authors own, based on Wolfram, 2016, some adjustment made in accordance with Broto et al. (2019) and Witzell et al. (2022).

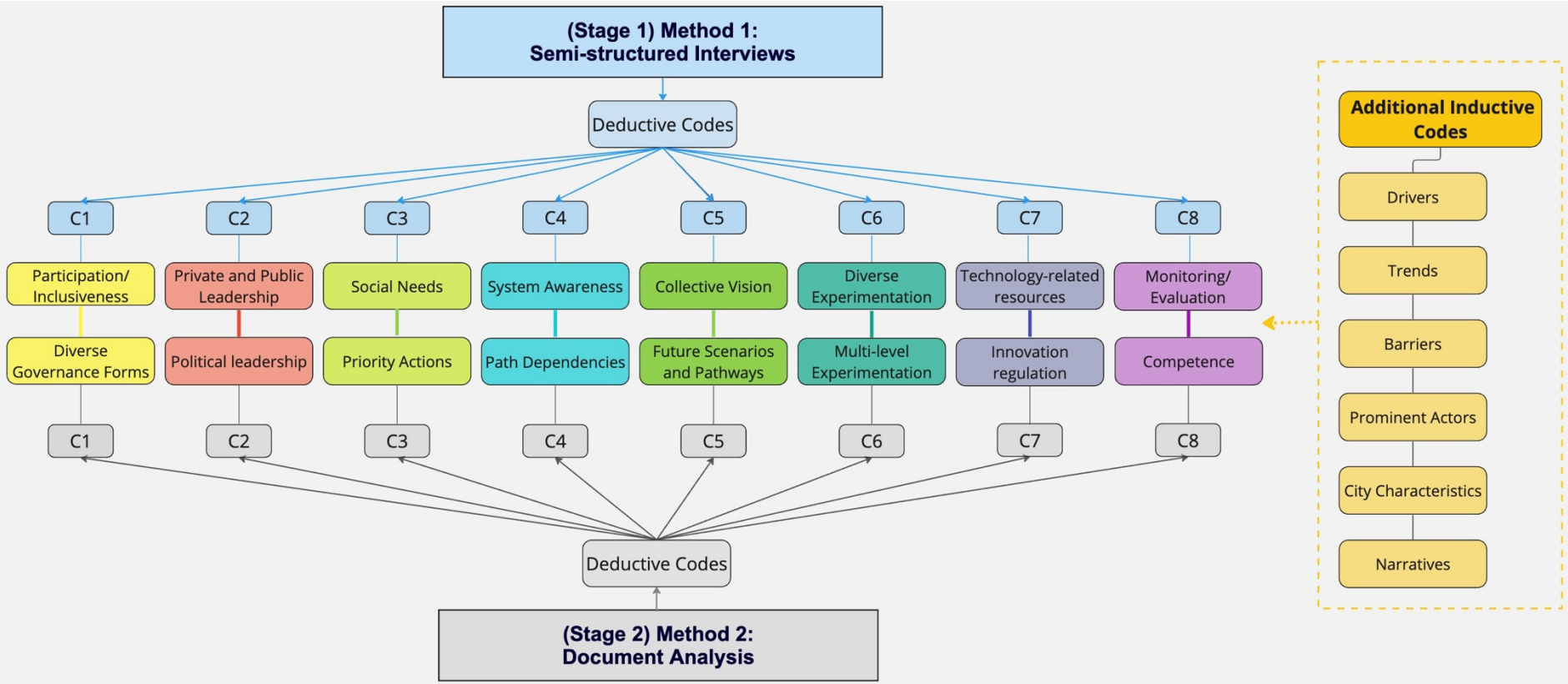
Transformative capacity element code	Transformative capacity/ sub-capacity groups	The criterion was deemed satisfied when evidence found for *either of* the following indicators	Key references for the criteria and sub-criteria	The method(-s) by which the criterion was investigated	
				Semi-structured interviews	*Document analysis*
[C1]	**Inclusive & Multiform Urban Governance**				
C1.1	Participation/inclusiveness	1.1.1. Citizens and civil society organisations, as well as private businesses and their representations, participate directly in the deliberation of actions with state actors (government, administration)	Innes & Booher (2003) Pahl-Wostl (2009)	X	
		1.1.2. Formerly excluded stakeholders are involved actively and supported to enable their contribution		X	
C1.2	Diverse governance modes/networks	1.2.1. There is diversity of formal and informal actor networks and governance modes	Innes & Booher (2003) Ubels et al. (2010) Rijke et al. (2012)	X	
		1.2.2. There is diversity of centralized and decentralized actor networks and governance modes (top-down/bottom-up; hierarchy/market/negotiation)		X	X
		1.2.3. Overall actor network density (number of ties between actors involved) and cohesion (alignment of their interests) are balanced and not extreme (very high/low)		X	X
[C2]	**Transformative leadership**				
C2.1	Private and Public leadership	2.1.1. There is place-based and/or issue-driven leadership, oriented at systemic change for sustainability	Olsson et al. (2010) Sotarauta et al. (2012) Mader (2013)	X	
		2.1.2. Leadership feeds local issues into regional/national/global arenas and processes		X	
C2.2	Political leadership	2.2.1. There is political leadership and commitment to systemic change for sustainability		X	X

		2.2.2. Leadership articulates visions, emphasizes values and inspires enthusiasm	Bos & Brown (2014)	X	
[C3]	**Empowered and autonomous communities of practice**				
C3.1	Addressing social needs and motives	3.1.1. Communities of practice (CoP) genuinely articulate social needs	Halpin & Daugbjerg, 2008 Moulaert et al., 2013 Otsuki, 2015	X	
		3.1.2. Strategies seeking to improve the wellbeing and quality of life of urban citizens that also pay particular attention to questions of social justice		X	X
		3.1.3. Explicit references to local social agendas, in particular those that addressed vulnerable groups and issues of social marginalisation		X	X
C3.2	Action priorities	3.2.1. The development of measures is prioritised based on the articulated social needs by the communities of practice (CoP)		X	X
[C4]	**System awareness and memory**				
C4.1	System awareness	4.1.1. Strategic knowledge management is carried out to enable transfers between different forms of knowledge (implicit/explicit; simple/complex; systemic/sectoral) and temporalities of knowledge (past, present, future)	Garud & Nayyar, 1994 Gottschick, 2013	X	X
		4.1.2. All knowledge about urban systems is open source and widely shared, helping to create collective self-awareness and memory			X
		4.1.3. Analysis aims to move from status description towards a systemic explanation, and ultimately anticipation, of (non-)change dynamics (barriers/drivers)			X
C4.2	Recognition of path dependencies	4.2.1. Stakeholders explicitly recognize different degrees of obduracy/changeability within current systems (e.g., concerning institutions, regulations, infrastructures, built environment, routines, values).		X	
		4.2.2. Explicit strategies to overcome these path dependencies		X	X

[C5]	**Sustainability foresight**				
C5.1	Collective vision for radical sustainability changes	5.1.1. Long-term change is conceived of as a 'radical' departure from the current state and development path of multiple urban SES and STS	Wittmayer et al., 2014 Olsson et al., 2014 Patterson et al. (2017) Pahl-Wostl, 2009	X	X
		5.1.2. There is an explicit future vision, widely shared among stakeholders, reflecting the social needs identified and the existing diversity of values		X	
		5.1.3. The vision has a strong motivating effect on stakeholders to contribute to its achievement		X	
C5.2	Alternative scenarios and future pathways	5.2.1. Scenarios of future urban development are created that reflect co-evolutionary processes (mutual shaping of social, ecological, economic, and technological dimensions)		X	X
		5.2.2. Scenarios clarify options for action, their preconditions, and implications for the relevant stakeholders, specifying objectives and critical milestones (thresholds)		X	X
[C6]	**Urban experimentation with disruptive solutions**				
C6.1	Diversity of forms	6.1.1. Experiments deal with disruptive urban sustainability solutions, seeking to rebalance economic, social, and ecological development	Friedmann, 1992 Dolata, 2009 Wittmayer et al., 2014	X	X
C6.2	Level of multidimensionality	6.2.1. Experiments are multi-dimensional, simultaneously addressing innovations in urban environments, cultures, institutions, governance, markets and technology			X
[C7]	**Innovation embedding and coupling**				
C7.1	Access to resources for capacity development	7.1.1. Stakeholders share and/or enable access to basic resources for transformative capacity development (C1-6) and technological development incl. Human-, knowledge-, time-, financial-, technical- and organizational resources	Dolata, 2009 Wang et al., 2012 Ferguson et al., 2013 Carter et al., 2015 Otsuki, 2015	X	
		7.1.2. Practical approaches for coalition building and decision making procedures that enable innovation embedding are developed systematically			X

C7.2	Regulatory support	7.2.1. Pertinent regulations are aligned with the vision and adjusted to support transformative actions		X	X
		7.2.2. Pertinent regulations leave room for alternative solutions and context-specific interpretation and implementation		X	X
[C8]	**Reflexivity and social learning**				
C8.1	Reflexive monitoring	8.1.1. Reflexive monitoring is carried out on all dimensions of urban transformative capacity development (C1-7)	Garud & Nayyar, 1994 Watson, 2006	X	
		8.1.2. Wider stakeholder and leadership reflexivity is enabled through diverse formal and informal interaction formats, providing room for critically questioning progress towards the vision		X	
C8.2	Competence	8.2.1. Practical know-how for initiating and performing radical change for sustainability (i.e., transformational knowledge) is visible and managed systematically			X
		8.2.2. Participants in experiments and other initiatives have methodical and practical skills for enabling reflexivity (monitoring, assessment, evaluation)		X	X

Appendix E - Coding Blocks



Overall, 22 codes were generated for the analysis (16 deductively and 6 inductively)