Driving Urban Transitions

D2.1

Empowerment Framework for Sustainable Mobility Transitions

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Executive Summary

Cities are increasingly expected to deliver cleaner air, safer streets, healthier lifestyles, and reliable access to everyday opportunities, while facing congestion, limited space, financial constraints and growing climate risks. Many local authorities have adopted Sustainable Urban Mobility Plans and related strategies, yet progress towards sustainable mobility often remains limited. Strategies often fail to bring about changes in everyday mobility. Additionally, responsibilities for action remain fragmented across sectors, administrative units, and levels of government.

This report builds on the literature showing that these challenges cannot be addressed through technology or infrastructure investment alone. Urban mobility systems are shaped by socio-technical arrangements in which infrastructure, regulations, planning traditions, funding mechanisms, institutional responsibilities, professional routines, and everyday travel practices reinforce one another over time. These reinforcing dynamics create path dependencies and lock-ins that stabilise car-centred mobility systems and constrain the range of policy options considered feasible. As a result, many transition efforts remain incremental, reversible, or limited to technological substitution.

The report argues that mobility transition depends on the capacity of local actors to understand these system dynamics, coordinate across sectors and levels of government, and sustain action over time. This capacity is referred to here as empowerment. Without empowerment, mobility transition risks remaining fragmented, contested, and vulnerable to political and institutional turnover. Empowerment is therefore treated not as an additional objective, but as a condition for implementation.

Drawing on socio-technical transition theory, lock-in analysis, and narrative perspectives, the report shows that mobility transition is not articulated as a unified programme of change but as a heterogeneous set of partially overlapping and sometimes contradictory priorities. Scientific research, policy documents and planning tools shape how mobility problems and solutions are framed, which challenges receive attention, what counts as evidence, and who is expected to act. When these framings rely on narrow performance measures or fail to reflect lived experience and distributional impacts, they can reproduce car-oriented priorities and legitimacy risks.

To respond to these constraints, the report introduces an Empowerment Framework for Sustainable Mobility Transitions. The framework translates transition concepts into a process-oriented structure that supports diagnosis of local constraints, coordination of actors and sustained action beyond isolated projects. It consists of five interrelated steps:

1. Stakeholder Mapping and Engagement, to clarify roles, decision authority, and responsibilities
2. Identification of Local Lock-ins, focusing on institutional, procedural, economic, and behavioural constraints
3. Definition of Potential Transition Pathways, linking actions to system-level change rather than isolated measures
4. Co-Creation of Shared Visions and Narratives, to address legitimacy, distributional impacts, and coordination
5. Operationalisation and Institutionalisation of Transition Pathways, to embed transition objectives in routines, budgets and mandates

By focusing on how mobility systems are structured and maintained over time, the framework can support cities in linking projects to changes in standards, appraisal criteria, funding rules, and institutional responsibilities. This approach helps reduce reliance on isolated interventions and supports coordinated, durable, and context-specific mobility transitions that can be implemented and sustained in practice.

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1. Introduction

Cities are increasingly expected to provide cleaner air, safer streets, healthier lifestyles, and reliable access to daily opportunities (Banister, 2008). At the same time, they face congestion, limited space, financial constraints, and climate risks (Geels et al., 2011). In response, many local authorities have adopted Sustainable Urban Mobility Plans and related strategies. Despite these efforts, progress often remains limited, particularly in small and medium-sized cities and in car-oriented contexts where strategies do not translate into changes in everyday mobility and responsibilities for action remain fragmented across sectors, and levels of government (Hodson et al., 2017).

These challenges cannot be addressed through technology or infrastructure investments alone (Geels et al., 2011). Urban mobility systems are shaped by socio-technical arrangements in which infrastructures, regulations, planning traditions, market structures, professional routines, and travel habits reinforce one another over time (Geels et al., 2011). This reinforcement creates path dependencies and lock-ins that stabilise car-centred systems, restrict the range of policy options, and make experimentation and reform institutionally fragile (Unruh, 2000; Goldstein et al., 2023). Mobility transitions therefore involve changes not only in vehicles and networks, but also in governance arrangements, institutional responsibilities, power relations, and how social groups experience mobility and access in everyday life (Schwanen, 2021).

How mobility problems and solutions are framed shapes transition outcomes (Simoens et al., 2022). Scientific studies, policy documents, planning tools, indicators, and public debate shape which challenges receive attention, which solutions are considered, what counts as evidence, and who is expected to act (Simoens et al., 2022). Narrative and knowledge infrastructures that circulate through plans and metrics can mobilise support and enable learning, but they can also reproduce car-oriented priorities and inequities when they rely on narrow performance measures or fail to reflect public concerns and lived experience (Karner et al., 2020).

Research on mobility transitions has expanded, but support for local decision-making remains uneven (Nikulina et al., 2019). Approaches such as socio-technical transition theory, the Multi-Level Perspective, and lock-in analysis explain why mobility systems resist change (Geels et al., 2011; Unruh, 2000). However, these approaches are only partly translated into diagnostics, tools, and working processes that help local actors coordinate across sectors, anticipate resistance, and sustain action over time, including through attention to legitimacy and public acceptance (Nikulina et al., 2019; Simoens et al., 2022).

Given these challenges, addressing mobility transitions requires more than just technology and infrastructure; it requires an understanding of socio-technical dynamics and coordinated action across sectors. To fill this gap, the report introduces an Empowerment Framework for Sustainable Mobility Transitions, placing empowerment at the center of the process. Empowerment refers here to conditions that enable local actors to understand system dynamics, build coalitions, contest priorities, and sustain action across political cycles. The framework integrates socio-technical transition theory, lock-in analysis, and narrative perspectives into a process-oriented structure that supports diagnosis of constraints and opportunities, mobilisation of stakeholders, and co-creation of shared visions to guide transition pathways. To inform this framework, the report also analyses how peer-reviewed research constructs and evaluates “mobility transition(s)”, treating

academic discourse as empirical material to identify recurring framings, and bottlenecks. Developed within the UNLOCK15 project and informed by Learning Living Labs, the report shows how an empowerment-oriented approach can support cities in moving beyond isolated measures toward mobility transitions that are implementable in local contexts.

The report proceeds as follows. Section 2 summarises key transition concepts for planning and policy work, including socio-technical regimes, path dependency, lock-ins, and narratives. Section 3 examines how mobility transitions are framed and evaluated in peer-reviewed literature, identifying dominant discursive patterns and recurring constraints. Section 4 synthesises these insights into the Empowerment Framework and its practical steps for local application. Section 5 concludes by emphasizing the importance of coordinated, long-term efforts to achieve meaningful mobility transitions.

2. System-Level Transitions in Urban Mobility

A system-level transition in urban mobility describes a change in how access to opportunities, transport modes, and urban space are understood, organised, and governed (Geels & Schot, 2007, 2010; Svensson & Nikoleris, 2018). It refers to the scope of change involved: rather than adjusting individual measures, such transitions reconfigure the underlying structures, institutions, and shared meanings that shape mobility systems. This includes the lock-ins embedded in infrastructure provision, regulatory frameworks, funding mechanisms, professional routines, and everyday travel practices.

From a socio-technical perspective, these elements are closely interlinked and co-evolve over time. Physical networks, rules and standards, institutional responsibilities, investment criteria, and social practices reinforce one another, creating path dependencies that stabilise existing mobility regimes. Change in one part of the system often remains limited unless related elements are addressed in parallel. System-level transitions, therefore, tend to unfold through non-linear processes, in which established arrangements are questioned, contested, and gradually reworked rather than smoothly replaced.

Against this background, this section brings together key transition concepts to support context-specific analysis of why mobility transition efforts stall and which combinations of levers can make change durable. It clarifies core mechanisms and guiding questions that can be used to assess a given city context and to inform coordinated action across departments and stakeholder groups. Throughout the section, transition theories are used as diagnostic tools rather than abstract explanations. They support three closely related analytical aims: (1) identifying where resistance to change originates, (2) recognising opportunities and windows for scaling alternative mobility practices, and (3) engaging more effectively with the political, institutional, and social dynamics of sustainable and just mobility transitions. Together, these concepts provide the theoretical foundation for the empowerment-oriented framework developed later in the report, which examines how local actors can challenge dominant mobility regimes and co-create transition pathways toward more sustainable urban mobility systems.

To establish this foundation coherently, the section follows a clear analytical progression. It first describes the historical formation of urban mobility regimes. It then introduces the Multi-Level Perspective as an analytical model for examining how transitions unfold through interactions between landscape pressures, dominant regimes, and niche

innovations. Building on this, the section specifies lock-in mechanisms that help explain why car-centred regimes persist despite growing pressure for change. Finally, it examines narratives and framing as mechanisms that shape legitimacy, coordination, and contestation around mobility measures.

2.1. Historical Urban Mobility Transitions

Understanding transitions in urban mobility requires a historical and chronological perspective that situates change over time. Mobility systems do not transform abruptly; rather, they evolve through successive phases of emergence, consolidation, and decline, shaped by social, economic, technological, and institutional dynamics.

In the context of European cities, urban mobility has undergone successive transitions since the 19th century, driven by industrialisation, rapid urban growth, and waves of technological innovation. Three major phases can be distinguished (Figure 1): (1) the transition from walking and animal-powered transport to electric public transport systems; (2) the rise and consolidation of automobility as the dominant regime; and (3) the ongoing transition toward more sustainable, low-carbon, and digitally integrated mobility systems. This historical perspective provides essential context for understanding current transition efforts and the structural challenges they face.

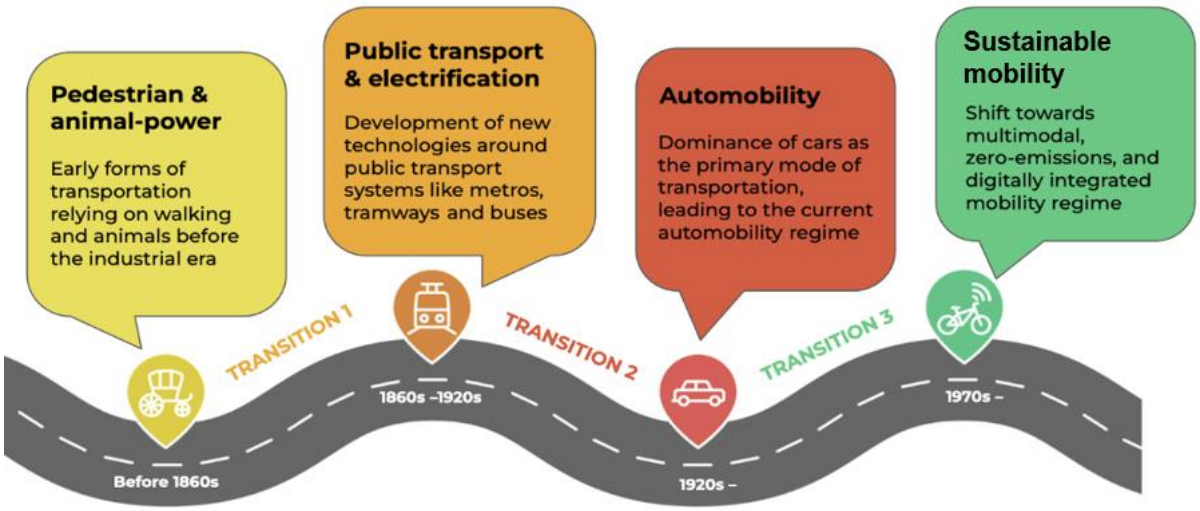

Figure 1: Historical Transitions in Urban Mobility

Transition 1 - From Pedestrian and Animal-Powered Mobility to Public Transport and Electrification

From the late nineteenth century, electric-powered tramways and subways began to emerge in European cities, offering faster and more efficient alternatives to horse-drawn transport (Figure 2). This period marked growing tensions within the dominant mobility system based on walking and animal power, as industrialisation and rapid demographic

growth reshaped urban dynamics and increased demand for high-capacity transport solutions. These conditions favoured the adoption of electric mass public transport as a response to the spatial and functional pressures of expanding industrial cities (Azouz et al., 2024; Van der Vleuten, 2019).

During the early twentieth century, electric rail-based transport systems became progressively institutionalised across many European cities. Tramway and metro networks expanded and structured urban growth along fixed transit corridors, giving rise to new urban morphologies closely linked to public transport accessibility. This consolidation phase was supported by the alignment of regulatory frameworks, technical standards, and financial mechanisms that enabled the scaling and stabilisation of rail-based infrastructures. As a result, urban mobility evolved through a reconfiguration pathway in which new technologies were integrated into existing systems rather than fully displacing them (Geels & Schot, 2007).

From the 1940s onwards, this rail-based regime entered a phase of decline as post-war economic recovery and industrial expansion fuelled the mass production of automobiles. Policies supporting road construction, suburban development, and private car ownership progressively marginalised electric public transport systems. Urban mobility shifted rapidly towards automobility, marking a transition driven by technological substitution, in which the car replaced rail-based public transport as the dominant mode of urban travel (Seto et al., 2016; Geels, 2011).

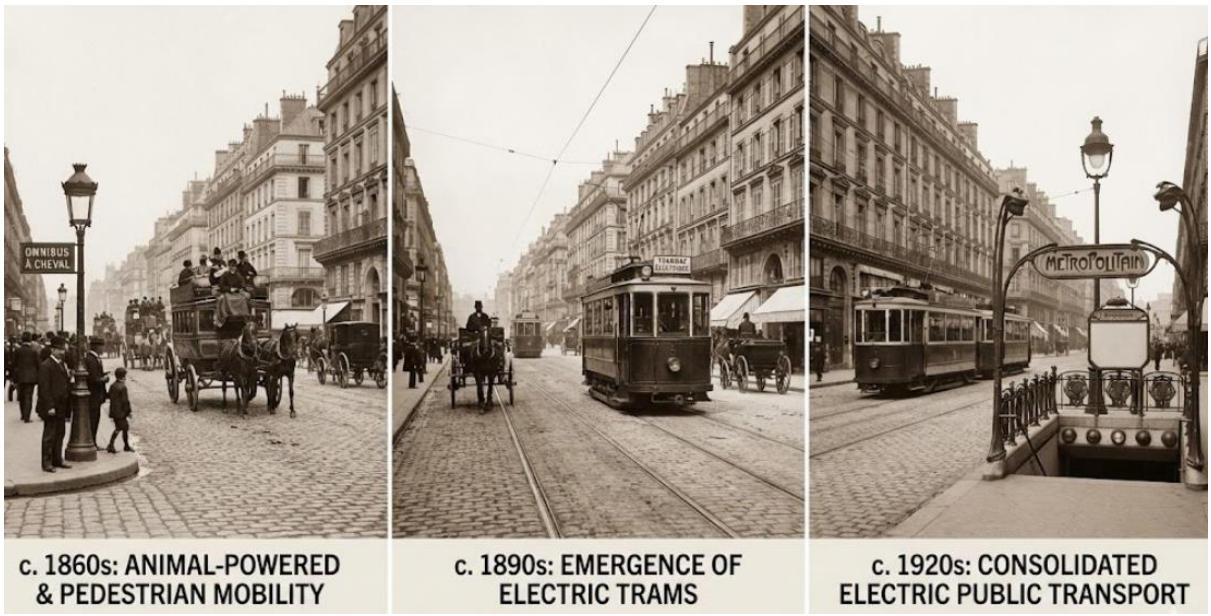

Figure 2: Transition 1 From Animal Power to Public Transport and Electrification. Figure created with assistance from Google Gemini.

Transition 2 - From Public Transport and Electrification to Automobility

From the early twentieth century, the invention of the automobile and the introduction of Ford's mass production model generated a powerful technological and industrial innovation that gained momentum during the two World Wars (Figure 3). This period marked the emergence of automobility as a viable alternative to rail-based urban transport systems, progressively challenging existing mobility regimes (Geels & Schot, 2007). At the same time, modernist urban planning doctrines, promoted by figures such as Le Corbusier

and formalised in the 1933 Charter of Athens, advanced a functionalist vision of the city structured around high-speed mobility, strict zoning, and high-rise development. These planning principles prioritised car accessibility through wide roads and extensive parking infrastructure, contributing to the institutionalisation of automobility as the dominant mobility paradigm (Khavarian-Garmsir et al., 2023). However, the functional separation of living, working, and recreational activities also led to fragmented urban forms, longer travel distances, and growing socio-spatial inequalities.

Following the Second World War, automobility entered a phase of consolidation as the private car became the dominant mode of transport in many cities. Urban planning and infrastructure investment increasingly catered to car-oriented development through the construction of motorways, low-density suburban expansion, and the reinforcement of functional zoning. Governments actively subsidised road infrastructure and supported oil-based economic systems, further stabilising the car-centred mobility regime. This period followed a clear substitution pathway, in which automobility progressively displaced alternative transport modes and became the prevailing form of urban mobility—a dominance that persists in many cities worldwide today (Seto et al., 2016; Goldstein et al., 2023; Pirieto-Curiel & Ospina, 2024).

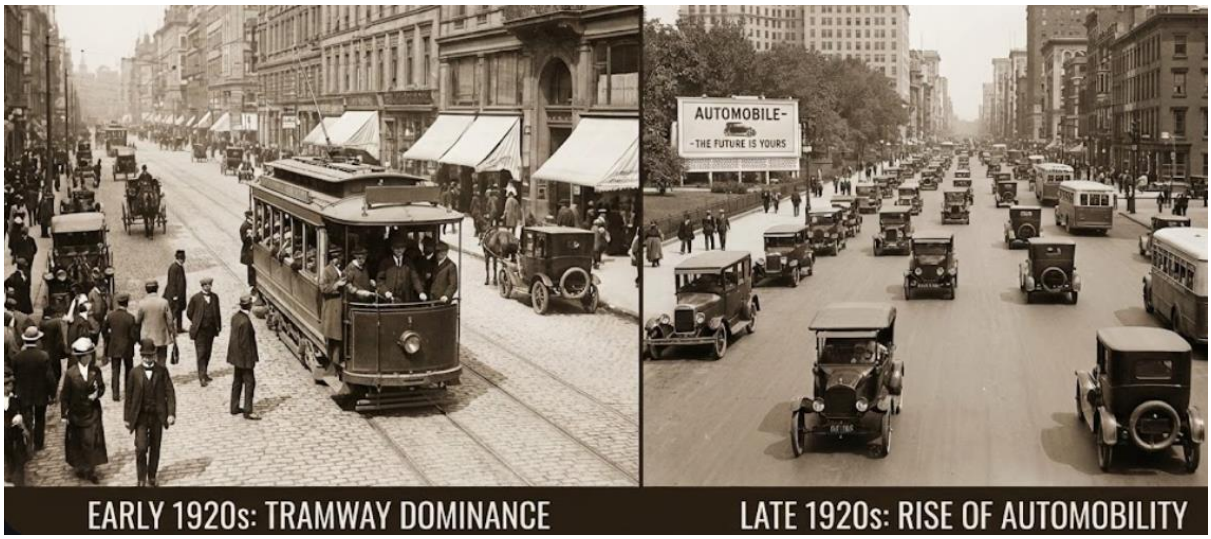

Figure 3: Transition 2 From Public Transport and Electrification to Automobility. Figure created with assistance from Google Gemini.

From the early twenty-first century onward, this car-centred regime has increasingly been challenged by mounting pressures linked to climate change, global sustainability agendas such as the United Nations' Sustainable Development Goals for 2030, and major external shocks, including the COVID-19 pandemic. These dynamics have opened windows of opportunity for alternative visions of urban development and mobility, fostering renewed interest in sustainable, low-carbon, and more inclusive mobility systems (Azouz et al., 2024; Loorbach, 2022).

Transition 3 - From Automobility to Sustainable Mobility

From the 1970s onward, growing environmental, social, and spatial challenges prompted a gradual shift away from strictly car-centric urban planning toward more human-scaled, walkable, and mixed-use environments (Figure 4). In response to the limitations of modernist planning and the fragmentation it produced, post-modern urbanists promoted

compact, walkable, and socially diverse neighbourhoods as a corrective approach. These models sought to reduce dependence on private cars by encouraging active mobility and fostering social interaction through urban design, marking the emergence of alternative planning paradigms within a predominantly car-centred mobility regime (Khavarian-Garmsir et al., 2023).

During the early twenty-first century, these ideas gained renewed momentum as cities began to partially reconfigure car dependence through the adoption of new urban and mobility strategies. Approaches such as the 15-minute city, Mobility-as-a-Service (MaaS), shared mobility, micromobility, and integrated multimodal systems have increasingly shaped planning and policy agendas. These developments are strongly supported by digital technologies and the Internet of Things (IoT), which enhance system efficiency, enable data-driven governance, and facilitate the coordination of multiple mobility services (Azouz et al., 2024; Ceder, 2021).

The COVID-19 pandemic in 2020 acted as a major landscape shock, exposing the vulnerabilities of car-dependent and functionally segregated urban systems. Public transport was widely perceived as a risk environment, while walking, cycling, and micromobility gained prominence due to their accessibility and perceived safety (Khavarian-Garmsir et al., 2023). In response, many local governments rapidly reallocated street space to support active mobility and elevated urban health and proximity to central planning objectives. This context reinforced the appeal of compact, mixed-use urban models, such as the 15-minute city, initially proposed by Carlos Moreno (2016), as both climate mitigation strategies and instruments for post-pandemic urban recovery (Loorbach, 2022).

Figure 4: Transition 3 From Automobility-Oriented to Sustainable and People-Oriented. Figure created with assistance from Google Gemini.

2.2. What is a System Level Transition: Five Defining Features

System-level mobility transitions are characterised by five interrelated features that distinguish them from incremental change (Figure 5):

1. Transformative: They generate multi-level reconfigurations of mobility practices, involving structural changes in technologies and infrastructure, policy and regulatory frameworks, as well as individual behaviours and cultural norms.
2. Disruptive: They unfold through non-linear dynamics, often marked by tipping points and ruptures with established mobility regimes rather than gradual improvements within the status quo.
3. Diverse: They involve the emergence and empowerment of actors and coalitions, including municipalities, private-sector innovators, researchers, non-governmental organisations, and grassroots civil society initiatives, which challenge existing practices and promote alternative visions.
4. Synergic: They align mobility transitions with broader transformations in other sectors such as energy, logistics, and urban planning, reinforcing their systemic nature and transformative potential.
5. Value-shifting: They reshape underlying societal values and redefine what is perceived as normal or desirable, particularly in the ways individuals and cities prioritise modes of transport.

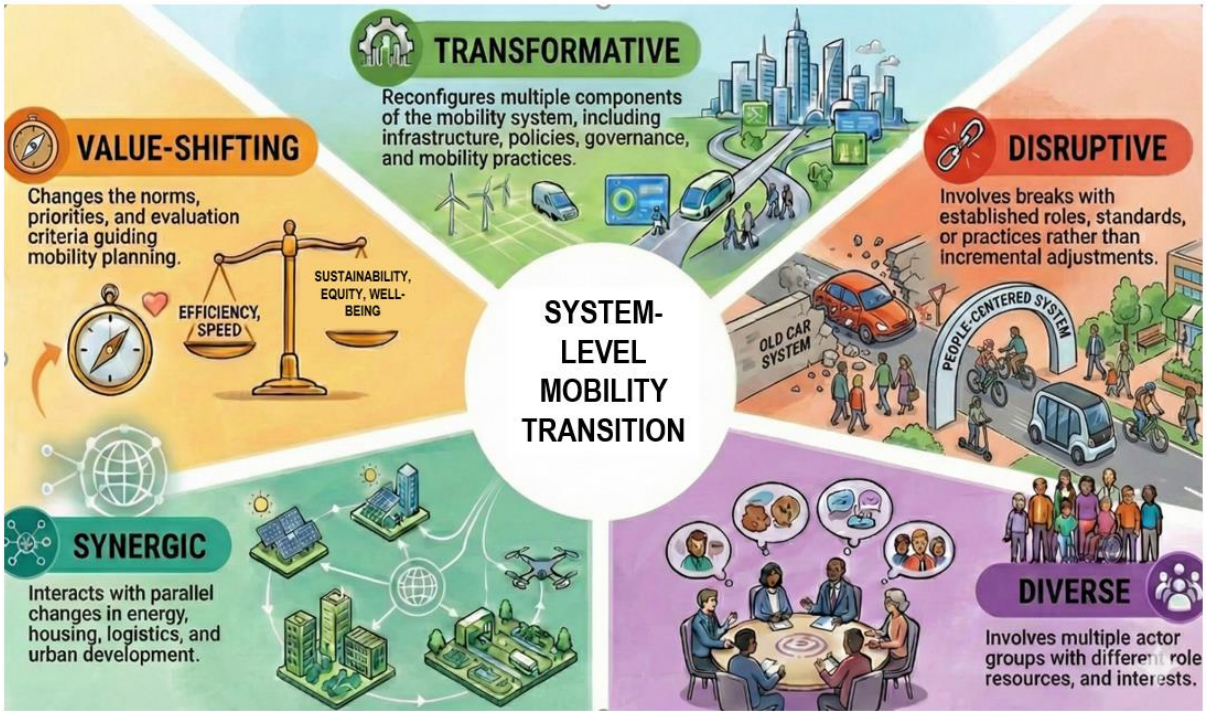

Figure 5: Key Features of System-Level Urban Mobility Transitions. Figure created with assistance from Google Gemini.

If the goal is to implement a mobility transition, understanding the five features of system-level change is essential because each of them points to a different condition that determines whether measures take hold or fade out. A transformative perspective shows

that isolated interventions will not succeed. Changes to infrastructure must be matched by shifts in rules, funding, and planning routines. Recognising disruptive dynamics helps anticipate that some transitions require deliberate breaks with established standards or allocations, rather than gradual adjustment. Acknowledging that transitions are diverse highlights the need to manage conflict, negotiate trade-offs, and build coalitions among actors with differing interests. Understanding transitions as interconnected directs attention to how mobility outcomes depend on decisions in land use, housing, energy, and other sectors that shape demand and feasibility. Finally, recognising value shifting clarifies that durable change depends on shifts in what counts as success, affecting appraisal criteria, budget decisions, and political justification. Table 1 summarises how the five defining features of system-level mobility transitions manifest across the three historical transition phases in European cities.

Table 1: Key Features in Each Transition

Feature	Transition 1	Transition 2	Transition 3
Transformative	Accessibility reorganised around tram and metro corridors, with infrastructure, land use, and governance aligned to support network-based access	Accessibility reorganised around car access, as roads, parking, zoning, and funding priorities reshaped urban mobility systems	Accessibility, street space, services, and governance increasingly targeted for reconfiguration through active modes, public transport, and shared services
Disruptive	Electric public transport replaced walking-based and animal-based systems as the main urban mobility form in many cities, disrupting existing travel patterns and street uses	Road expansion and rising car ownership displaced public transport from its central role, undermining established service regimes and institutions.	Street reallocation, parking reform, and new regulatory measures challenge existing standards and routines that have long prioritised automobility
Diverse	Municipalities, operators, utilities, engineers, and regulators coordinated system development around fixed-route electric public transport	Influence became concentrated among road authorities, automotive industries, fuel suppliers, developers, and planning institutions, consolidating a car-centred regime	Public authorities, operators, technology providers, civil society, researchers, and residents increasingly shape transition processes through participatory and experimental initiatives
Synergic	Mobility aligned with industrialisation, electricity provision, and urban growth, creating synergies between transport networks and metropolitan development	Mobility aligned with fossil energy systems, suburban housing, logistics, and land markets, reinforcing car dependence and dispersed land-use patterns	Mobility is being linked to land-use planning, energy policy, logistics, digital services, and proximity-oriented planning to support more sustainable urban forms
Value-shifting	Mobility framed around collective travel and network-based accessibility, normalising public transport as the backbone of urban movement	Mobility framed around speed, autonomy, and private vehicle use, embedding automobility in everyday aspirations and identities	Mobility increasingly framed around accessibility, safety, health, equity, and the quality and use of public space
Source	*(Hall, 2002; Schipper et al., 2009).*	*(Banister, 2008; Schwanen, 2015, Sheller & Urry, 2000).*	*(Banister, 2008; Schwanen, 2015).*

2.3. How Transitions Unfold: the Multi-Level Perspective

To analyse how mobility transitions unfold and why dominant regimes persist despite pressure for change, this report draws on the Multi-Level Perspective (MLP) on socio-technical transitions (Geels, 2002; 2005). The MLP conceptualises transitions as interactions between processes operating at three analytical levels: the socio-technical landscape, the socio-technical regime, and niche innovations (Figure 6). In practice, these levels correspond to external pressures, the current mobility system, and spaces for experimentation.

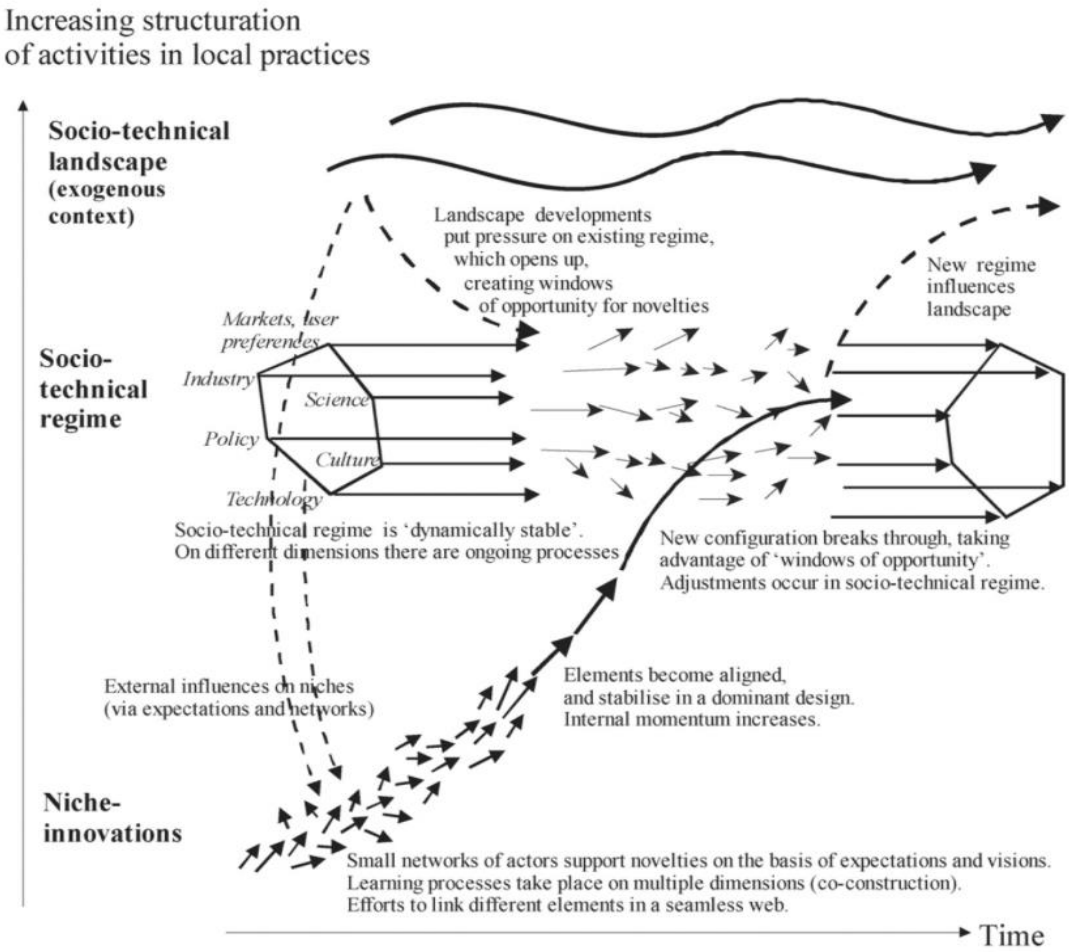

Figure 6: Multi-Level Perspective on Transitions (Geels, 2002)

The socio-technical landscape consists of broader developments that shape the context in which mobility systems operate, including climate targets, demographic change, economic cycles, geopolitical conditions, and external shocks such as pandemics or energy crises. These dynamics lie largely outside local control, but they influence political priorities, funding conditions, and decision contexts. Within the MLP, landscape developments do not determine outcomes directly; rather, they create pressures and opportunities that can destabilise existing arrangements and make alternatives more visible.

The socio-technical regime comprises infrastructures, technologies, regulations, planning standards, market arrangements, professional routines, and everyday travel behaviours. These elements reinforce one another and stabilise existing mobility patterns. Adjustments within the regime tend to follow established rules and procedures, which limits the effects of isolated changes. In many cities today, regime arrangements continue to prioritise private car use because earlier infrastructure investments, planning standards, appraisal methods, and institutional routines reinforce automobile-oriented mobility systems.

Niche innovations are spaces in which alternative mobility practices, technologies, and organisational models are developed. These include pilot projects, experimental planning approaches, grassroots initiatives, and new mobility services. Niches support testing, learning, coordination among actors, and the development of alternatives at limited scale. In the MLP, niches are important not simply because they introduce novelty, but because they can build momentum and connect with wider regime change when conditions become more favourable.

Within the MLP, transitions are not understood as fixed stages before and after change, but as processes that unfold through interactions between landscape pressures, regime responses, and niche developments over time. Change depends on how regime actors respond to pressure, including resistance, adaptation, or changes to rules, standards, and investment priorities. Geels and Schot (2007) distinguish transition pathways based on the timing and interaction of these processes, including pathways in which regimes are reconfigured, replaced, or reproduced.

In this report, the MLP is used as a diagnostic lens for local mobility analysis rather than as a predictive model. It helps identify sources of pressure for change, regime elements, such as standards, budgets, appraisal methods, or incentives, that constrain action, and niche initiatives with potential to expand. In practice, it informs three questions for local teams: (1) which external pressures affect current decisions, (2) which regime elements limit change, and (3) which innovations require institutional changes to persist and expand.

Table 2 applies the MLP to three major historical transitions in urban mobility: the emergence of electrified urban transit, the rise of automobility in the post-war period, and the current transition toward more sustainable and multimodal mobility systems. The table distinguishes between landscape pressures that shaped the decision context, regime configurations that stabilised dominant mobility systems, and niche developments through which alternative practices and technologies emerged. Examining these historical transitions helps illustrate how interactions across the three MLP levels shape mobility change over time.

Table 2: MLP Applied to Three Major Historical Transitions in Urban Mobility

MLP level	Transition 1: Emergence of Electrified Transport	Transition 2: Rise of automobility	Transition 3: Sustainable Mobility (ongoing)
Landscape	Industrialisation and urban population growth; demand for higher-capacity movement; public health and street management pressures	Post-war reconstruction and economic growth; industrial production expansion; national road programmes; fuel supply chains	Climate targets and air quality regulation; energy price and supply risks; public health concerns; debates on access and distribution; shocks such as pandemics

MLP level	Transition 1: Emergence of Electrified Transport	Transition 2: Rise of automobility	Transition 3: Sustainable Mobility (ongoing)
Regime	Walking and animal traction as dominant modes; low-speed street use; fragmented service provision; limited networked mass transport governance	Rail and tram networks as urban backbone; planning and investment routines oriented to fixed corridors; governance aligned with transit operations	Road space allocation and standards oriented to car throughput; budgets and appraisal methods favouring road capacity; procurement and routines aligned with speed and flow; travel practices shaped by dispersed land use and parking supply
Niche	Electric traction; tramway and metro pilots; networked service provision models; technical standardisation for track, power, and operations	Mass car production; road engineering and traffic management standards; parking design; zoning doctrines; highway construction models	Active mobility networks and street reallocation pilots; shared mobility and micromobility services; integrated ticketing and routing platforms; MaaS; proximity-oriented planning concepts; data governance and service integration models
Source	*Urry, 2004*	*Kellett, 1969*	*Banister, 2008*

2.4. Why Regimes Persist: Transition Pathways and Lock-In Mechanisms

Building on the MLP, Geels and Schot (2007) propose a typology of socio-technical transition pathways that explains why transitions do not follow a single, linear trajectory. Instead, transitions differ according to the timing and nature of interactions between landscape pressures, regime dynamics, and niche innovations. These pathways capture distinct patterns through which existing regimes respond to external pressures and emerging alternatives, highlighting variations in the depth of change, the role of incumbent and new actors, and the degree to which dominant structures are transformed, reconfigured, or replaced.

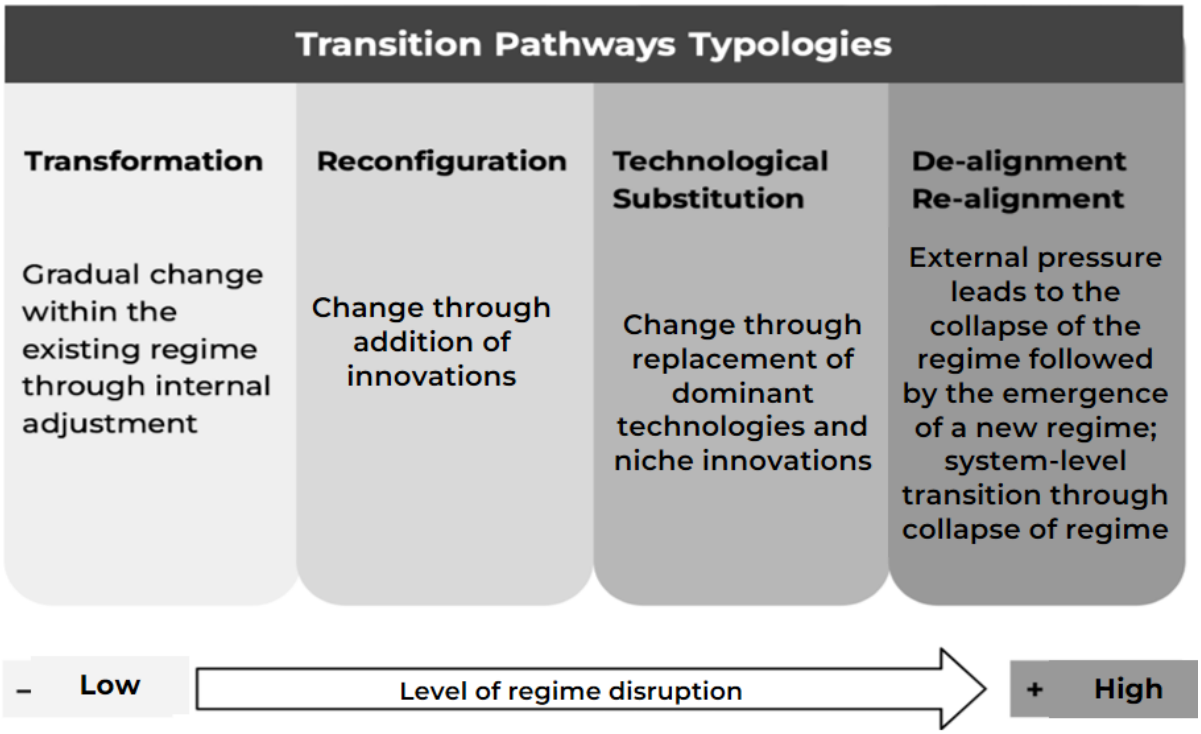

Figure 7: Transition Pathways Typologies (based on Geels et Schot, 2007)

Pathway	Urban Mobility Example	Level of regime disruption
Transformation	Switching from Gas Cars to Electric Cars (System stays the same).	Low
Reconfiguration	Adding Trams/Subways to a walking city (System stretches and changes shape).	Medium
Substitution	Cars destroying the Tram network (One technology kills the other).	High
De-alignment	COVID-19 forced cities to abandon car-centrism for mixed-use/walking (total system collapse and rebuild).	Very High

Figure 8: Example of Change of Transition Pathways

While the Multi-Level Perspective explains how transitions emerge from interactions between landscape pressures, regimes, and niche innovations, it does not explain why mobility systems remain resistant to change when alternatives exist. Lock-in theory specifies the mechanisms that stabilise dominant mobility regimes and constrain transition pathways.

Lock-ins are self-reinforcing processes that stabilise existing socio-technical regimes and make alternative pathways difficult, costly, or politically risky to pursue (Unruh, 2000). Over time, technologies, infrastructures, institutions, and practices become mutually reinforcing and increasingly difficult to change. In urban mobility, lock-ins emerge from investment choices, regulatory frameworks, planning standards, market structures, governance arrangements, and social norms that favour automobility. Once established, these

arrangements make it harder to reallocate space, change rules, shift public investment, and support the emergence of alternative mobility systems.

Lock-ins operate across four dimensions that interact in planning practice:

- Technological lock-ins stem from road networks, parking facilities, traffic management systems, and vehicle fleets that shape travel choices and constrain spatial planning.
- Institutional lock-ins stem from laws, policies, governance arrangements, political priorities, design standards, funding mechanisms, appraisal methods, and administrative procedures that collectively reinforce road capacity, traffic flow, and car access while making coordinated change more difficult.
- Economic lock-ins stem from sunk costs, revenue structures, and dependencies linked to car-oriented systems, including fuel supply chains, and automotive industries.
- Behavioural and cultural lock-ins stem from travel habits and social meanings associated with car use, including status and autonomy.

Institutional lock-ins are often reinforced by fragmented governance across local, regional, and national authorities, as well as by departmental silos within transport planning. This fragmentation makes it difficult for cities to pursue coordinated mobility transitions. For example, transport authorities may prioritise road expansion while urban planners support suburban development, creating misalignment in efforts to address systemic mobility problems. Political resistance also plays a crucial role; local politicians or industries benefiting from the status quo may resist policies that challenge car use. For example, proposals for low-emission zones or car-free areas often face backlash due to the political risk they pose, especially in cities where car ownership is high.

Lock-in analysis supports planning and policy work by shifting attention from measures to mechanisms. If a cycling corridor is added without changes to parking supply, design standards, funding rules, and maintenance responsibilities, the intervention can remain isolated. If a public transport upgrade is planned without changes to land-use decisions, pricing, and street priority, ridership gains can be limited. If electrification is pursued without changes to space allocation, trip rates, and accessibility goals, car dependence can persist.

2.5. Key Takeaway: System Structures, Lock-Ins, And Pathways for Change

Planning and decision-making for urban mobility transitions require attention to how mobility systems are structured and maintained over time. Mobility outcomes result from the interaction of infrastructure, regulations, funding mechanisms, institutional responsibilities, professional routines, and everyday travel practices. These elements reinforce one another and shape what types of interventions can be implemented, scaled, or sustained. Measures introduced without changes to related system elements tend to remain limited in effect.

Practical work on mobility transitions benefits from a historical understanding of how current systems were formed. In European cities, earlier transitions reorganised accessibility around electric public transport corridors and later around car access through road construction, parking provision, and zoning practices. These transitions were supported by aligned planning standards, governance arrangements, and investment priorities. Current efforts to support active mobility, public transport, shared services, and proximity-oriented planning take place within systems shaped by these earlier decisions, which continue to influence street design, appraisal methods, and land-use patterns.

System-level change requires consideration of how different dimensions of the mobility system are addressed together. Changes to infrastructure need to be aligned with changes in design standards, regulatory frameworks, funding rules, and operational responsibilities. Introducing new services or reallocating street space without adjustments to parking policy, traffic management rules, or maintenance arrangements limits their persistence. Planning practice therefore involves identifying which rules and routines support existing mobility patterns and how they interact with proposed measures.

Analysis of mobility transitions can be structured using three analytical levels. Landscape pressures such as climate targets, public health concerns, and economic conditions shape the context in which decisions are made. Regime elements, including infrastructure networks, legal frameworks, budgeting practices, and professional norms, stabilise dominant mobility patterns. Niche initiatives, such as pilot projects, experimental street designs, and new mobility services, provide spaces to test alternative practices. Practical assessment focuses on how regime elements respond to external pressures and which institutional changes are required for niche initiatives to move beyond pilot status.

Practical considerations for transition-oriented mobility planning include identifying which lock-ins are most relevant in a given city context, which external pressures create opportunities for change, and which institutional adjustments are required to support alternative mobility practices. This involves linking projects to changes in standards, appraisal criteria, budget allocations, and departmental responsibilities. Focusing on these mechanisms supports coordinated action across sectors and reduces reliance on isolated interventions.

3. Understanding the Actual Transition: Narratives in Scientific Communication

Local authorities face the question of how to accelerate mobility transitions in contexts shaped by established responsibilities, planning routines, and coordination limits. Transition theory and lock-in research explain why change is difficult, but they do not, on their own, show how to assess the transition dynamics reflected in existing knowledge or how such knowledge frames possibilities for intervention in practice (Geels et al., 2011; Unruh, 2000; Simoens et al., 2022). Although peer-reviewed research on mobility transitions has advanced, there is little systematic analysis of how this literature frames the current state of mobility transitions and the conditions under which acceleration is presented as possible. Studies are rarely examined as a corpus to identify patterns in how transition dynamics are framed, how agency and responsibility are attributed, which sources of delay are emphasised, and how proposed responses are evaluated, limiting the use of scientific knowledge as a diagnostic resource for local transition work.

Scientific publications shape understandings of mobility transitions through the ways they define problems, select analytical concepts, describe causal mechanisms, and position actors, instruments, and outcomes within accounts of change. Through these framings, the literature influences which transition pathways are foregrounded, which constraints are treated as relevant, and which forms of action are presented as feasible or legitimate in planning and policy contexts (Karner et al., 2020; Simoens et al., 2022).

This chapter analyses peer-reviewed publications that employ the term “mobility transitions”. It examines how transition processes are described at the sentence level. The analysis focuses on patterns in thematic framing and evaluative language across the literature, rather than on individual policy recommendations or case studies. The results inform the Empowerment Framework for Sustainable Mobility Transitions by identifying recurring ways in which transition dynamics are framed, how different forms of intervention are linked to specific problem definitions, and how local actors are positioned in relation to institutional constraints and coordination.

3.1. Methodology

This study applies a sequential mixed-methods design to examine how mobility transition(s) are framed and evaluated in peer-reviewed academic literature. The methodological framework integrates systematic bibliometric retrieval with sentence-level Natural Language Processing (NLP), combining automated sentiment analysis and embedding-based unsupervised clustering with qualitative content analysis. The analysis proceeds from corpus construction using Scopus-indexed publications to sentence extraction and concept-focused filtering, followed by sentiment estimation using a calibrated lexicon-and-transformer approach, semantic clustering to organise the corpus, and qualitative analysis of narrative functions and thematic foci. The workflow advances sequentially from data acquisition to granular sentence-level interpretation and is summarised in Figure 8.

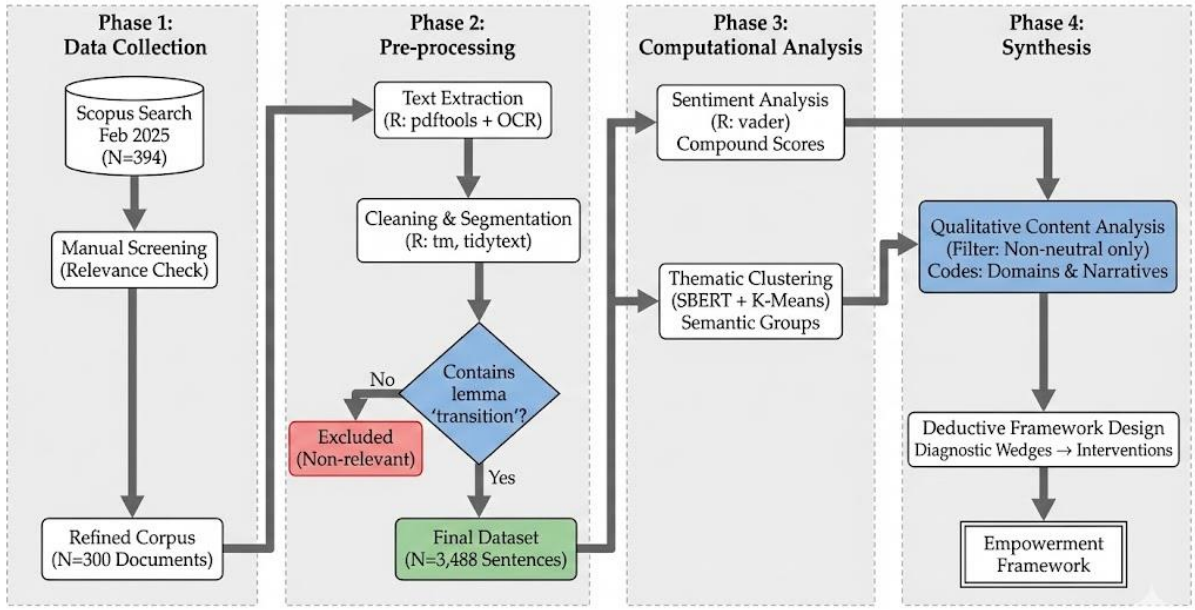

Figure 9: Methodological Workflow Illustrating the Sequential Mixed-Methods Design. Figure created with assistance from Google Gemini.

A. Data Collection and Corpus Construction

The primary dataset was compiled through a systematic literature search in the Elsevier Scopus citation database, conducted in February 2025. Scopus was selected due to its broad coverage of peer-reviewed interdisciplinary research relevant to transport, urban studies, planning, policy, and sustainability transitions. A targeted Boolean query was used to identify publications explicitly engaging with the concept of mobility transition(s): TITLE-ABS-KEY(("mobility transition") OR ("mobility transitions")). The query was applied to titles, abstracts, and keywords, with no restrictions on publication year, geographical focus, or disciplinary category.

The initial search returned 394 records. To ensure analytical relevance to sociotechnical transition processes in mobility systems, all records were screened manually based on titles, abstracts, and keywords. Publications were excluded when the term was used only tangentially or in a non-transition-theoretical sense. Following this screening process, a refined corpus of 300 papers was retained. Full-text PDFs were retrieved through institutional access.

To focus the analysis on how transition processes are articulated in academic writing rather than on general mobility topics, all documents were processed at the sentence level. Text was extracted from machine-readable PDFs and, where necessary, from image-based documents using optical character recognition (Fan et al., 2023). References, tables, figures, equations, captions, and other non-linguistic elements were removed prior to analysis. The remaining text was normalised through lower-case conversion, whitespace standardisation, and correction of encoding artefacts.

In R, the process was automated using several packages. The pdftools package was employed to extract text from the PDFs. Text was then cleaned and prepared by removing unwanted metadata using the stringr and dplyr packages (R Core Team, 2021). The tm (text mining) and tidytext packages were used for text preprocessing, including normalization and sentence segmentation. Documents were split into sentences using a custom rule-

based segmentation function adapted to academic writing conventions, accounting for common abbreviations and citation formats (Jockers, 2014).

To operationalize the study's focus on explicit linguistic constructions of transition processes, only sentences containing the lemma "transition", including inflected forms such as "transitions", were retained. This was done using the stringr package, which enabled pattern matching to filter the relevant sentences. This filtering step defines the analytical object as explicit textual references to transition processes within literature that already engage with mobility transition(s) at the metadata level.

The resulting dataset comprised 3,488 unique sentences, which constitute the unit of analysis in all subsequent stages. These sentences span publications from 1967 to early 2025, with the majority concentrated in the period from 2018 to 2024. The dataset was then exported and saved in CSV format for further analysis.

B. Sentiment Analysis

To examine evaluative orientations within academic discourse on mobility transitions, sentiment analysis was conducted at the sentence level using a two-stage approach that combined lexicon-based scoring with supervised classification. This methodology provides an interpretable baseline while allowing for the incorporation of more advanced techniques to address the limitations of lexicon-based analysis in the context of academic writing (Hutto & Gilbert, 2014).

As an interpretable baseline, each sentence was analyzed using VADER (Valence Aware Dictionary and sEntiment Reasoner), a lexicon- and rule-based sentiment analysis method that estimates both polarity and intensity (Hutto & Gilbert, 2014). VADER produces a normalized compound score ranging from −1.0, indicating strongly negative sentiment, to +1.0, indicating strongly positive sentiment, with values close to zero representing neutral evaluations. Compound sentiment scores were computed for all 3,488 sentences and were used to describe sentiment distributions across the corpus and to compare sentiment patterns across different publication periods using distribution-based visualizations. The vader package in R was employed to perform this lexicon-based sentiment analysis (R Core Team, 2021).

C. Quantitative Thematic Clustering

To structure the corpus by semantic similarity prior to qualitative interpretation, sentences were represented as dense contextual embeddings and grouped using unsupervised clustering. The unit of analysis remained the individual sentence. Each sentence was converted into a fixed-length numerical vector using a pre-trained Sentence-BERT model (Reimers & Gurevych, 2019), which generates embeddings optimised for semantic similarity. All sentences were embedded using an identical model configuration to ensure comparability across the corpus. Embeddings were normalised prior to clustering to ensure distance comparability in high-dimensional space.

Unsupervised clustering was performed using the K-Means algorithm, selected for its computational efficiency and its suitability for identifying compact, semantically coherent groups in embedding spaces. K-Means clustering was applied using the stats package in R, with multiple solutions tested across different cluster counts. Multiple clustering solutions were computed across a predefined range of cluster counts and were evaluated using quantitative measures of separation and internal coherence, including silhouette scores and within-cluster dispersion. In addition, representative sentences located near cluster centroids were examined to assess semantic consistency and interpretability.

D. Qualitative Content Analysis Quotes for Methodology

Following computational clustering, a qualitative content analysis was conducted to interpret how mobility transitions are framed within the academic discourse. The unit of analysis was the sentence, selected from full-text publications and analysed with reference to its source document to preserve contextual meaning during interpretation.

A structured codebook was applied deductively, drawing on scholarship on sociotechnical transitions (Miles et. al, 2019). Each sentence was coded along two analytical dimensions. First, sentences were assigned to one sociotechnical domain (governance and social impact, business and economy, technology, environment) reflecting the context in which the transition was discussed. Second, sentences were coded according to their narrative function within transition accounts. Narrative function codes captured whether a sentence articulated a driver of transition processes, identified a barrier to change, expressed a risk or negative externality, criticised the existing mobility regime, or described a benefit or goal associated with transition pathways.

Clusters (based on positive, neutral and negative sentiments) were used to organise the corpus for systematic reading, while narrative functions and sociotechnical domains guided interpretation. Only sentences with non-neutral sentiment were coded. Coding decisions focused on what the sentence contributed to an explanation, justification, or critique of mobility transitions, rather than on topic frequency or lexical similarity.

Coded sentences were then grouped into three periods marked by distinct narratives (pre-2018, 2019–2021, and 2022–2025). Examining changes in the distribution and co-occurrence of sociotechnical domains and narrative functions across periods allowed an assessment of shifts in how mobility transitions were framed over time.

3.2. Sentiment and Thematic Clustering

The temporal distribution of publications reveals a distinct trajectory in academic interest, quantifiable by the frequency of the term “mobility transition” (Figure 10). Prior to 2010, the field remained relatively dormant, with only sporadic mentions. A clear change can be observed around 2017–2018, when mentions begin to increase rapidly. The number of relevant files spiked significantly in recent years, with the highest concentration appearing in 2024 (60 files) and a strong upward trend continuing into early 2025. This growth suggests that mobility transition has evolved from a niche conceptual discussion into a mainstream academic priority. This shift likely correlates with increasing global policy pressure related to climate change and the maturation of disruptive technologies such as electric vehicles (EVs). The discourse is currently in a boom phase, characterised by a proliferation of diverse narratives and competing definitions of what the transition entails.

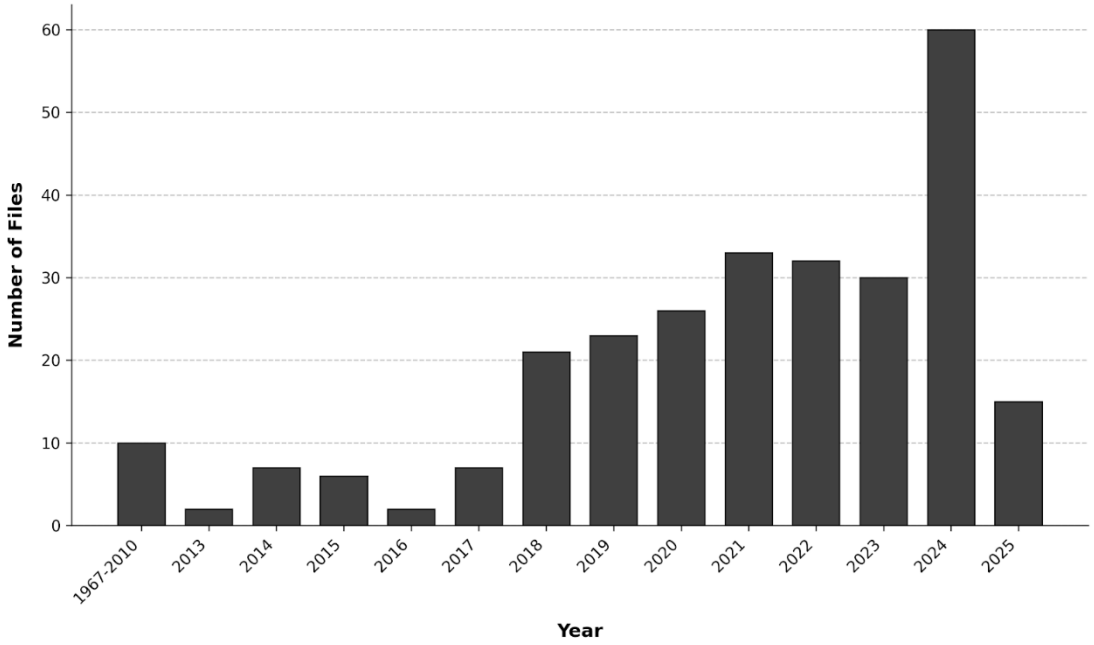

Figure 10: Annual Number of Peer-Reviewed Publications Indexed in Scopus That Explicitly Refer To "Mobility Transition(S)" In Titles, Abstracts, Or Keywords. Data Retrieved in February 2025. The Lower Count In 2025 Reflects Partial-Year Indexing.

To examine the emotional valence of the discourse, VADER sentiment analysis was applied to the 3,488 extracted sentences. The results, visualised through violin plots, reveal an emotional landscape that has evolved over time.

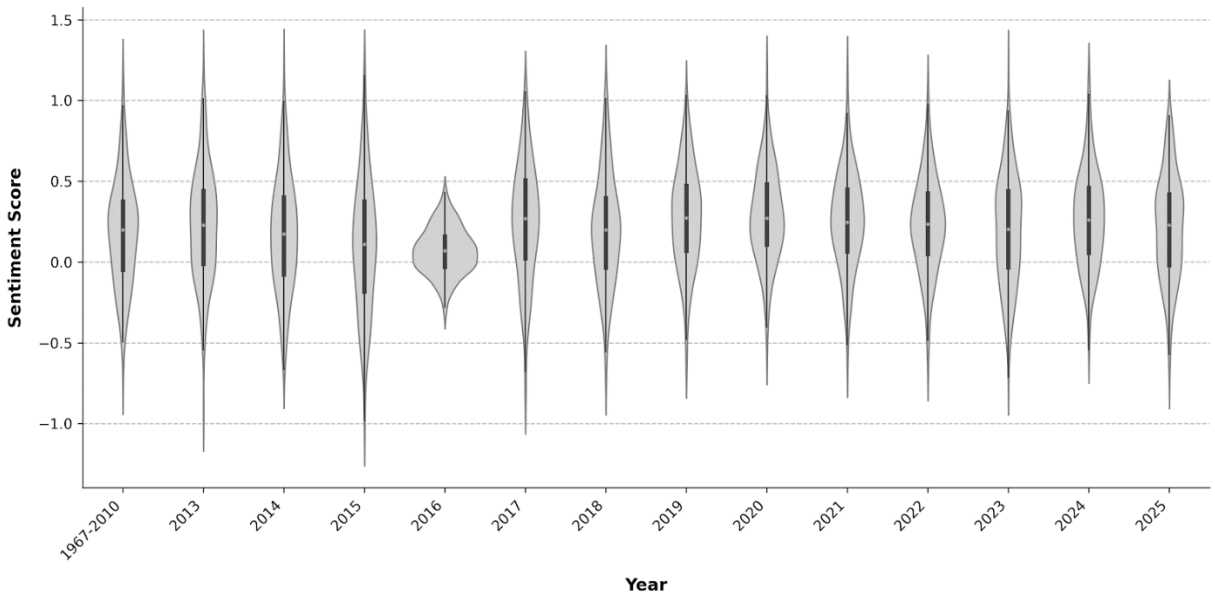

Figure 11: Distribution of Sentiment Scores by Year

Two main patterns emerge from the sentiment analysis. First, the discourse becomes increasingly polarised after 2018, with a bimodal distribution in which many sentences cluster around neutral sentiment, reflecting descriptive or technical statements, while pronounced tails extend toward both positive and negative values. Second, the period from 2020 to 2024 shows a widening of negative sentiment compared to earlier literature, which more often contained optimistic or normative statements about transition potential. This shift indicates growing attention to implementation challenges, barriers, and sources of social friction within mobility transitions.

A quantitative examination of the top 10% most positive and most negative sentences highlights the themes of extreme sentiment. Negative sentiment is predominantly associated with themes of injustice, conflict, and policy failure. The most negative sentence (−0.727) addresses the risk that "underlying injustice can lead to reluctance to transition" (Hidayati & Tan, 2025) Other high negative scores refer to "unending disagreements on what precisely the problems are" (Ertelt & Hawxwell, 2025) (−0.67) and the "negative impact of the prevailing regime on climate change" (Ertelt & Hawxwell, 2025) (−0.572). A particularly illustrative sentence states: "As a result, the seemingly just and sustainable transition was negatively construed by the public as a symbol of elitist arrogance" (Hidayati & Tan, 2025), (−0.527). This demonstrates that negative sentiment is driven not only by technical shortcomings but also by societal backlash and perceptions of the transition as exclusionary and top-down. Positive sentiment is more commonly associated with normative goals and technological potential, though these statements are frequently contextualised by references to barriers elsewhere in the text.

Following K-means clustering and sentiment mapping, the quantitative analysis organised the mobility transition discourse into four analytical dimensions: governance and social impact, technology, business and economy and environment. Within each dimension, clustered narratives were interpreted as drivers (predominantly positive sentiment) or barriers and risk framings (predominantly negative sentiment). Here, sentiment is treated as an indicator of how topics are framed in the literature (enabling vs constraining narratives), rather than as evidence of empirical effectiveness or normative desirability.

Technology-related narratives feature prominently on both the positive and negative sides of the discourse. On the positive side, emerging technologies such as autonomous vehicles, smart systems, data-driven planning, and electric vehicles are framed as key enablers of low-carbon and efficient mobility transitions. On the negative side, critiques focus on the dominance of techno-centric and commercially driven solutions, including automation and platform-based innovations, questioning their relevance to everyday urban mobility needs. This contrast suggests that the literature predominantly frames mobility transition as a matter of technological deployment, reflecting a solution-oriented discursive bias in which technological change is foregrounded while enabling conditions and second-order effects receive comparatively less attention. More critical reflections on technological substitution, rebound effects, governance dependence, and continued car dependence remain comparatively underdeveloped.

The social dimension constitutes the most polarised arena within the sentiment mapping. Positive sentiment clusters emphasise justice, inclusion, accessibility, and social development as central normative objectives of mobility transitions, positioning equity and redistribution as key sources of legitimacy. At the same time, negative clusters foreground concerns about neglected vulnerable populations and the uneven distribution of benefits and burdens, highlighting risks of exclusion when transition pathways privilege higher-income groups, digitally connected users, or already well-served neighbourhoods. Together, these contrasting narratives position social justice as a central site of tension, where mobility transitions are simultaneously justified and problematised and where perceived fairness may shape legitimacy, acceptance, and potential contestation of transition measures.

Governance-related narratives are represented exclusively through barrier-oriented framings, including institutional fragmentation, unclear responsibilities, weak coordination across governance levels, and the underuse of political and data-driven capacities. Where governance appears in positive narratives, it is largely implicit or treated as a supporting precondition for technological or market-led solutions rather than as a primary enabling driver in its own right. Rather than functioning as an enabling condition, governance is primarily portrayed as a structural bottleneck that constrains implementation, continuity, and the scaling of mobility transition measures.

Economy-related narratives appear predominantly in positive sentiment clusters, emphasising economic opportunities, market readiness, and private-sector engagement, suggesting a perception of relative momentum on the solution side. In contrast, environmental narratives are dominated by negative sentiment, focusing on the complexity of achieving low-carbon mobility goals and pointing to unresolved systemic challenges and structural lock-ins. Taken together, this distribution reveals a marked imbalance within the discourse: technology and economy are framed as comparatively "ready" solution domains, governance and environmental constraints are framed as persistent bottlenecks, and social justice emerges as the principal arena in which the legitimacy, inclusiveness, and distributional consequences of mobility transitions are contested. This indicates a potential misalignment between economic optimism about transition pathways and the reality of social and environmental challenges.

Consolidated Codebook: Thematic Analysis of Mobility Transition Discourse

Sent.	Domain	Theme	*n*	Substantives	Representative Examples (Source File)
(+)	Governance	Smart Strategy	1045	policy, smart, strategy	(2) "The key to a successful transition to smart mobility is to connect data from different sources." (Almaghlouth et al., 2024); "Future mobility systems are not only technological artifacts but are actively shaped through governance and policy decisions" (Rhoden et al., 2023); "(...) automated and digital systems require new governance approaches and regulatory strategies" (Nemoto et al., 2023); "In this vein, one of the most pressing challenges concerns the governance of increasingly complex and data-intensive systems" (Song et al., 2023)
	Social Impact	Justice	182	justice, support, social	"A recognitional justice perspective helps us to study and identify demands for the recognition of social, political, cultural, and territorial rights(...)" (Prause and Dietz, 2022)
	Technology	Tech Readiness	87	readiness, driving, factors	"Wide acceptance of car sharing and public transport could enable the transition." (Köhler et al., 2020); "People living in digitally enabled cities interact differently with mobility services." (Moglia et al., 2021)
		Socio-Tech	112	systems, dynamics, socio	"A transition to low carbon mobility involves technological and social or behavioural change." (Köhler et al., 2020); "There is a broad consensus (...) that digitalization and other technological advances can enable a changed transport system, and that this transition has already begun." (Sjöman et al., 2020)
		Innovation	540	pathways, change, actors	"Concurrently, the founding of the National Platform Future of Mobility by the German government aimed to reduce transport emissions, and the increased production and marked availability of German EVs prompted the prominence of storylines advocating for a drivetrain transition in the form of EVs." (Ertelt and Hawxwell, 2025a); "The measures that have been implemented so far to reduce road traffic and reclaim public space for citizens have strengthened the transition to low-carbon mobility in many European cities." (Gil-Alonso and López-Villanueva, 2023)
(-)	Governance	Regime Tension	118	regime, change, tension	"These examples show how having overlapping responsibilities coupled with contested visions among government organisations may create tensions and disputes which may hamper AVs regulation and transition." (Shammut and Imran, 2024); "Moreover, given the tensions between the need to mobilise massive resources, and the fragmentation of jurisdictional authorities in current governance systems, we argue that the interactions between different governing entities should be critically investigated in studying transition policy mixes." (Song et al., 2023)
	Social Impact	Spatial Inequity	18	rural, neglect, residents	"(...) concerns about the negative impacts of mobility transitions on low-income groups and socially disadvantaged populations are increasingly articulated in public discourse." (Ertelt and Hawxwell, 2025a) "The transition risks reinforcing social inequities if policies disproportionately benefit urban populations while neglecting rural mobility needs." (Allert and Reese, 2023)
	Business	Resistance	235	blueprint, energy, battle	(1) "Consequently, the factory is rejected as a blueprint for how the mobility and energy transition should unfold." (Thierauf, 2024);
		Operational Capability	103	scale, fleet, problem	(1) "(...)the fleet renewal problem becomes large-scale quickly because long time horizons and multiple technologies are considered obligatorily." (Winkelmann et al., 2024);
	Environment	Carbon Transition	50	carbon, hurdles, context	"(...) the transformation of the car-based mobility systems poses one of the biggest challenges in the transition to decarbonised societies." (Kohler and Manderscheid, 2024) (2) "The transition to sustainable urban mobility depends on, or is limited by, local context, place-based approaches, and technological or political path interconnect?" (Galanakis et al., 2024)

3.3. Discursive Patterns in Mobility Transition Research

Clustered narratives were organised into five analytical dimensions: governance, social impact, technology, business and economy, and environment (Table 3). Within each dimension, narratives were classified according to whether they enable or constrain mobility transition pathways. In Table 3, enabling dynamics are presented as drivers and opportunities, while constraining dynamics are presented as barriers and challenges. In this classification, drivers refer to factors described in the dataset as supporting or advancing mobility transition, while opportunities refer to openings or conditions that may be used to support transition. Barriers refer to factors described as obstructing mobility transition, while challenges refer to difficulties that complicate implementation. These categories capture how mobility transition is framed and debated in the dataset, rather than evaluating actual outcomes. Overall, mobility transition emerges not as a coherent programme but as a fragmented set of priorities, with recurring references to disagreement and lack of coordination undermining implementation.

Table 3: Drivers, Barriers, Opportunities, and Challenges of Mobility Transitions Across Domains

Domain	Drivers	Barriers	Opportunities	Challenges
Governance	Shared understanding of mobility transition; Regulations that steer mobility systems; Systems thinking in planning; Ability to mobilise actors for regulatory change	No unified concept of mobility transition; Weak systems understanding; Awareness not translated into planning; Car dependence embedded in institutions and lifestyles	Multi-stakeholder collaboration; Context-specific solutions; Policy mixes (rules, incentives, investments)	Many actors with competing agendas; Overall complexity of transitions; Administrative boundaries leading to misaligned transition approaches; Limited financing for transition measures
Social impact	User involvement in design and decisions	Poor understanding of user motivations; Viewing users only as consumers; Private-sector dominance; Technology-first approaches	Citizen pressure on policymakers	Unequal impacts of mobility transitions; Job losses linked to automation; Profit-driven business models overriding social aims; Strengthened inequality through exclusion of user groups
Technology	Integration into everyday lifestyles; High-quality mobility data; Carsharing and EVs encouraging other green habits	Profit-first evaluation of technologies	Local openings for niche experiments; IoT and accessible mobility data supporting system integration	EVs and AVs reinforcing car-centric lifestyles and regimes; Micromobility not substituting car trips
Business and economy	—	Competition between providers; Transition perceived as less profitable than the status quo	Can initiate a transition when governance is not yet ready	Competition with public services; Data monopolies due to lack of IoT regulation
Environment	Environmental awareness is presented as a driver of political pressure and policy action	A mobility transition focused on replacing conventional cars with electric cars continues the current prioritisation of individualised transport	Interventions such as emissions zones, space reallocation, and investment in active modes and public transport; Engagement with one environmental technology may increase	Cars take up too much space; are difficult to recycle; use up finite resources extracted at a high environmental and human cost

Domain	Drivers	Barriers	Opportunities	Challenges
			openness to other sustainability measures	

Governance

Governance concentrates debates on responsibility, legitimacy, and implementation capacity. Across the literature, governance is treated not as a background condition but as a factor shaping mobility transition trajectories. A recurring barrier is the absence of a shared and operational definition of mobility transition, which allows the concept to function as an aspiration rather than a programme. This enables alignment at the level of rhetoric while deferring distributive choices, instrument selection, and responsibility allocation. The problem is framed as a coordination failure:

"The discourse related to a 'modal transition' and 'mobility transformation' future still lack the dominance or the strategic unity required to materialise in policy action" (Ertelt & Hawxwell, 2025).

Different actor groups advance priorities that include technological substitution, network optimisation, equity, accessibility, and spatial reallocation. This translates into competing problem definitions and success criteria and undermines coordination across departments and scales of government. It also weakens accountability by diffusing decision ownership and shifting blame across mandates. It increases exposure to political cycles through mandate turnover and budget reprogramming. Some sources treat this ambiguity as a coalition strategy that avoids conflict while keeping trade-offs unresolved:

"(...) the ambiguous nature of floating signifiers within the discourse dynamics of transition processes (...) they represent common terms that create grounds for consensus-building yet simultaneously pose the risk of strategic exploitation and can cause discursive fragmentation that might delay policy action." (Ertelt & Tom Hawxwell, 2025)

The governance discourse also foregrounds constraints on local action. Automobility is described as embedded in practices and reinforced through routines, standards, and budget logics. Administrative boundaries and fragmented responsibilities obstruct systemic approaches where mobility outcomes depend on land use, housing, public space, energy, or social policy outside transport departments. Financing is framed as a mismatch between stated goals and resource allocation, including scale, continuity, earmarking, and capacity for maintenance and enforcement beyond pilots.

The literature also identifies governance drivers. Regulatory frameworks and policy mixes are presented as conditions for changing incentives and reallocating space, where single instruments do not shift the regime. Transition efforts are linked to collaboration that is durable, case-specific, and anchored in institutions through mandates, budgets, and monitoring systems. Across the dataset, governance is framed as an arena where feasibility, fairness, and legitimacy are contested and translated into criteria, funding rules, and spatial decisions.

Social Impact

Social narratives foreground justice, rights, and the distribution of benefits and burdens. The literature argues for understanding users' motivations beyond their role as consumers and emphasises mobility as a social right tied to participation, accessibility, and dignity. This framing highlights that environmental goals can lose legitimacy if pursued through policies that increase costs, reduce access, or marginalise groups with fewer resources or

fewer mobility alternatives. In this sense, the social narrative does not reject environmental transition, but insists that sustainability and justice must be co-produced through governance choices, design priorities, and the criteria used to define "successful" mobility transition. Some authors warn that transitions driven primarily by private-sector interests or consumer-oriented framings risk narrowing mobility to a market commodity (Davis, 2018).

Within this dimension, risk narratives focus on injustice as an outcome of governance choices. Distributional risks concern cost burdens, benefit allocation, and exposure to displacement. Procedural risks concern agenda-setting, participation rules, and access to decision venues. Disciplinary risks concern surveillance, behavioural compliance demands, and moralised user expectations. Several sources frame inequity not as a side effect but as a product of policy design, procurement, pricing, and enforcement. One source characterises mobility transition as involving the "construction of a newly excluded and delegitimated group" (Tyfield, 2014), linking legitimacy to governance arrangements rather than to environmental justification.

Technology

The technological narrative is structured around a tension between innovation claims and critiques of technological determinism. Technologies are framed as instruments for integration, efficiency, and service coordination, while the literature cautions against treating technological change as transition in itself. This produces an evaluative split in which technology is presented as required for implementation but insufficient as a strategy when detached from governance arrangements, spatial reallocation, and behaviour change.

A recurring barrier is the dominance of techno-centric framings that prioritise electrification and automation. Several texts argue that a focus on electric or autonomous vehicles diverts attention from demand reduction, modal shift, and urban space reorganisation. The replacement of conventional vehicles with electric ones preserves individualised transport and reproduces car-oriented planning logics under a low-carbon frame:

"Thus, rather than representing a transition from the entrenched system of automobility, the introduction of EVs may, at best, reinforce, and, at worst, strengthen the system." (Anfinsen, 2021)

In parallel, limits in cycling networks, pedestrian environments, and public transport provision constrain non-car mobility outcomes regardless of technological deployment, contributing to observations that micromobility often fails to substitute car trips.

Risk narratives focus on technological determinism and its political-economic implications. Technologies are assessed through profitability, scalability, and market uptake rather than accessibility, equity, or emissions reduction. One source underlines that "the value of IT-led innovations in transport must be judged by criteria other than their profit-making potential." (Davis, 2018). This evaluation logic links innovation pathways to industry priorities and weakens alignment with public objectives. It also conditions governance capacity by narrowing accountability to market performance rather than transition outcomes. Technology functions as a transition driver only when embedded in accountability structures that prioritise public value.

Further risks include the stigmatisation of micromobility users, which shapes regulation, enforcement, and social acceptance:

"Conflict between different micromobilities often serves as a distraction from the real issue: the need to radically reduce automobility and systematically facilitate micromobility." (Glachant & Behrendt, 2024)

Technology is treated as a site where power relations, legitimacy claims, and distributional outcomes are produced through design, evaluation, and regulation rather than as a neutral instrument.

Within this framing, technology is described as a driver for transition when positioned as an enabling layer rather than a substitute for structural change. Platforms, shared data infrastructures, and coordination tools support service integration and operational decision-making when linked to governance reform, spatial reconfiguration, and behaviour change. Local innovations embedded in experimentation, institutional learning, and community processes are presented as mechanisms for challenging existing routines and enabling system reconfiguration.

Business and Economy

Economy-related narratives focus on the tension between established automotive business models and service-oriented approaches that frame mobility as a bundled or platform-based offering. They also include an economic component, asking if transition pathways are investable and compatible with existing revenue structures, with profitability and incentive alignment framed as constraints on transition pace and direction.

A central barrier identified across the literature is economic viability under current market conditions. It is noteworthy that „while the transition to a MaaS system and the expansion of public transport and bicycle modal shares are certainly associated with economic development prospects, the potential for capital accumulation and employment is much lower than in the predominant system dominated by the automobile and the automotive industry" (Haas, 2021). Value capture remains tied to vehicle sales, fuel systems, parking provision, and car-oriented development, while transition measures such as walking and cycling infrastructure, space reallocation, or fare integration generate benefits that are not readily monetised. This mismatch between societal value and market value shapes which innovations are scaled and which remain marginal. It poses a barrier to incumbent actors' interest to support disruptive change.

Risk narratives highlight market concentration and monopoly formation, particularly where control over data, platforms, and algorithmic coordination is weakly regulated. Docherty, Marsden, and Anable (2018) frame these dynamics as governance challenges with distributional consequences, affecting pricing, access, accountability, and public steering capacity:

"A critical asset that the state needs to exert some form of control over in order to avoid anti-competitive practices and other negative externalities is the data upon which the Smart Transition depends."

"Without effective regulation, preventing anti-competitive behaviour such as a global-scale company providing mobility services from strangling new market entrants at birth through price attacks could be well-nigh impossible."

At the same time, business is also framed as a driver of experimentation and regulatory disruption. Ride-sourcing and platform-based services are cited as examples of innovation that forced institutional adaptation:

"The introduction of ridesourcing owed to a combination of leadership strategies and political tactics; although in this case, private-sector firms initiated the process by

engaging public sector actors in a shared effort to challenge and eventually alter a series of long-standing regulatory frameworks governing personal transportation services." (Davis, 2018)

These dynamics are assessed ambivalently, recognising both the potential for experimentation and the risk of shifting control away from public institutions without sufficient regulatory capacity.

Environment

Environmental narratives provide the normative foundation for mobility transition discourse, anchored in climate mitigation, air quality, and resource constraints. Automobile-dominated systems are criticised not only for emissions and pollution but also for their spatial dominance and impacts on urban liveability:

"Objections criticise that a mobility transition focused on replacing conventional cars with electric cars continues the current prioritisation of individualised transport, in cars that take up too much space, are difficult to recycle, use up finite resources extracted at a high environmental and human cost (…)"(Mercante Thierauf, 2024)

Environmental awareness is presented as a driver of political pressure and policy action, supporting interventions such as emissions zones, space reallocation, and investment in active modes and public transport. Some narratives suggest that engagement with one environmental technology, such as electric vehicles, can increase openness to other sustainability measures, although this is framed as a contingent enabling condition rather than a guarantee of transition:

"Recent studies into the cultural aspects of the Norwegian EV transition suggest that EVs also play an important role in trans forming broader mobility culture, practices of driving, and that EV experiences are contributing to an increase in many Norwegians' interest in other green technologies such as solar panels." (Skjølsvold & Ryghaug, 2020)

3.4. Evolution of Mobility Transition Discourse (2013–2025)

This section identifies a three-phase evolution in mobility transition discourse between 2013 and 2025 (Table 4). Its contribution is not simply to show a shift from early optimism to later realism, but to demonstrate a change in what the literature treats as the binding constraint on transition. Across this period, the discourse moves from emphasizing individual readiness and niche experimentation, to focusing on regime rules and governance capacity, and finally to foregrounding justice, scale, and cross-system coordination. The section therefore contributes more than a chronological overview: it shows how the literature progressively relocates the core challenge of mobility transition from innovation uptake to the governance capacity required to define goals, resolve conflicts, coordinate across levels and sectors, and sustain implementation beyond pilots and political cycles.

Table 4: Evolution of Mobility Transition Discourse and Shifting Constraints (2013–2025)

Period	Visual cue / level	Core logic	Main binding constraint	Guiding question
Pre-2018	Lab / Micro	Innovation and behaviour change	Low readiness, weak uptake, difficulty scaling niche experiments	Can we make it work?
2019–2021	Street / Meso	Coordination and implementation	Regime persistence, governance fragmentation, auto-oriented power structures	How do we scale it?
2022–2025	State / Macro	Justice and political economy	Cross-system coordination, contested scope, funding gaps, unequal access, distributional conflict	Who pays and who decides?

Pre-2018, the literature largely frames mobility transition through niche innovation, micro-level initiatives, and context-specific planning. Governance is discussed in person-centred terms, with emphasis on learning from local initiatives, combining policy mixes with auxiliary measures, and securing stable long-term incentives. In this phase, barriers are primarily framed as low readiness, one-size-fits-all policy failure, the lifestyle entrenchment of automobility, and the absence of a unified mobility transition concept. Technology narratives focus on ICT and Web 2.0 integration in electric vehicles, EV promotion in policy plans, locally tested battery electric vehicle niches, and innovations such as car-sharing, demand-responsive mobility, and IoT/data applications.

At the same time, early critiques already indicate the limits of this framing. “Good mobile subject” narratives exclude parts of the population (Sheller, 2015), auxiliary measures are often absent, and technological pathways are shaped by profit logics that may generate monopoly risks and legitimacy problems (Davis, 2018). Automobility therefore remains the persistent baseline condition, described as ubiquitous and resistant to strategic action (Kent & Dowling, 2018). In this phase, the literature largely treats the central constraint on transition as weak readiness, limited uptake, and the difficulty of scaling niche experimentation beyond local contexts.

Between 2019 and 2021, the discourse shifts away from niche experimentation toward the durability of regime structures. Governance is increasingly framed in terms of participatory policy, co-creation, socio-technical embedding, and the need for multi-level and multi-stakeholder coordination (Whittle et al., 2019; Sørensen & Paulsson, 2020). However, the literature also highlights persistent uncertainty regarding how transition should be implemented in practice, and notes that responsibility for change is often shifted to users under conditions of fiscal austerity (Whittle et al., 2019; Sørensen & Paulsson, 2020; Kinigadner et al., 2024).

In this phase, the central barriers are no longer primarily readiness or innovation uptake, but the cultural dominance of car use, auto-oriented power structures, and the persistence of regime rules. Electric vehicles are presented ambivalently: while they may reshape mobility culture, they can also reinforce rather than transform automobility, with grid operators adapting to their diffusion in ways that strengthen rather than displace the regime (Anfinsen, 2021). Political economy also becomes more explicit in the literature. Authors argue that mobility transition is often less profitable than the existing automobility system, and that capitalist investment dynamics can therefore resist or slow transition processes (Freudendal-Pedersen et al., 2020). As a result, governance capacity, institutional power, and investment criteria become central explanatory factors. The main diagnosis of constraint thus shifts toward regime persistence, governance fragmentation, and the political-economic limits of implementation.

From 2022 to 2025, the discourse increasingly focuses on implementation at scale, justice, and coordination across systems. Governance is framed through concrete physical interventions, regulation, clarified state roles, scale-aware policy mixes, early actor involvement, and street experiments led by frontrunners using push–pull approaches (Mahzouni, 2022; Song et al., 2023). The literature also places growing emphasis on justice-related critiques, including the neglect of the Global South, risks of widening digital divides, unequal access, labour impacts, infrastructure deficits, national funding gaps, institutional overlap, and resistance from affected actors (Prause & Dietz, 2022; Shammut & Imran, 2024).

During this period, disagreement over the scope of transition becomes more visible, particularly in debates over whether mobility transition refers primarily to modal shift or to broader mobility transformation. The discourse records continued conceptual fragmentation, with mobility transition sometimes described as elitist, unevenly defined, and difficult to prioritise in policy. Technology remains central, but increasingly as an object of contestation rather than a straightforward solution. On-demand mobility may expand access and reduce car dependence, while micromobility introduces new conflicts, big data remains poorly integrated into mobility governance, and EV-centred strategies are criticised for sustaining automobility even while being promoted as transition drivers (Shammut & Imran, 2024). Environmental critiques also sharpen, with growing insistence that propulsion substitution alone is insufficient and that meaningful transition depends on governance decisions about coordination, funding, and space reallocation rather than technology deployment alone (Mahzouni, 2022).

Taken together, this periodisation shows that technologies can diffuse into the mainstream without fundamentally altering regime rules, and may even reproduce new forms of exclusion through labour impacts, digital divides, and unequal access. The broader contribution of this section is therefore to demonstrate that the decisive problem in mobility transition discourse is not innovation supply alone, but the governance challenge of aligning policy mixes, infrastructure provision, evaluation criteria, and multi-level coordination. Only when these elements are coordinated can transition outcomes be defined, contested trade-offs resolved, and implementation sustained beyond pilots and political cycles (Song et al., 2023).

Key Take Away

Mobility transition is widely referenced in policy and planning, yet the literature shows that system change remains limited. The main constraint is not technical capacity but institutional design. Here, system-level mobility transition means sustained reductions in car dependence through coordinated changes in governance, infrastructure, business models and everyday practices. The mixed-method evidence and the evolution of the mobility transition discourse (2013–2025) indicate that stalling is explained less by a lack of innovation supply than by recurring governance and legitimacy constraints that keep action on low-change pathways.

In line with Chapter 2, these recurring constraints can be understood as lock-ins: self-reinforcing arrangements that stabilise existing socio-technical systems and make alternative pathways difficult, costly, or politically risky to pursue. In the context of mobility transition, lock-ins do not refer to a separate concept from the barriers discussed earlier, but to the mechanisms through which existing car-oriented systems are reproduced over time. The following analysis therefore applies the lock-in concept introduced earlier to the empirical findings, distinguishing governance, social, technological, and economic dimensions of path dependence.

A first lock-in is governance and institutional design. The absence of a shared, operational definition of mobility transition persists across the corpus and continues to be described as a coordination failure. This allows agreement at the level of goals while deferring

distributive decisions on street-space allocation, investment priorities, responsibilities and instruments. As described in the governance discourse, fragmented mandates across departments and levels weaken coordination and dilute accountability. Budget structures and political cycles favour projects over structural change and limit integration with land use, housing, public space and social policy. The result is a set of reversible interventions that are not embedded in standards, budgets or administrative routines, limiting scaling mechanisms beyond pilots.

A second lock-in is social and legitimacy-related. Negative sentiment clusters around equity, and qualitative findings link this to perceptions of an elitist transition. In line with the social justice narrative, inequality is not a side effect but a result of policy design, including procurement rules, pricing, enforcement and access criteria. Procedural exclusion reduces participation and influence, while behavioural framings and compliance approaches based on control and surveillance generate resistance, particularly among groups with fewer mobility options. This resistance creates political risk and encourages retreat into low-conflict measures, which structurally favours substitution over redistribution. Transition outcomes, therefore, depend on how costs and benefits are distributed and how decisions are made, and one should pay attention to the inclusion of all social groups.

A third lock-in is technological. The technological narrative reflects optimism versus determinism, with a recurring barrier being the dominance of techno-centric framings that equate transition with electrification or automation. This preserves car-oriented planning logics and shifts attention away from demand reduction, modal shift and space reallocation. Technologies are assessed through profitability, scalability and market uptake rather than public value, equity or system-wide emissions reduction, consistent with critiques that new technologies are judged by profit-making potential instead of mobility transition potential. Where walking, cycling and public transport infrastructure remain insufficient, technological change does not enable substitution, contributing to observations that micromobility often fails to substitute car trips. Car dependence continues under a low-carbon frame.

A fourth lock-in is economic and related to business models. The business and economic models dimension emphasises a mismatch between societal value and market value. Many transition benefits, health, accessibility, public space, safety and emissions reduction, are collective and difficult to monetise, while dominant revenue streams depend on vehicle sales, fuels, parking and car-oriented development. Several sources argue that mobility transition is not as lucrative as the status quo, weakening incentives for incumbents to support disruptive change and marginalising non-market interventions. Risk narratives further highlight monopolies building when access to mobility data is not regulated, linking market concentration to reduced public steering capacity.

Together, these lock-ins explain why the mobility transition described in the literature follows a low system level pathway. Change occurs through partial adjustments while the system structure remains intact. Technological substitution, with electrification as the main strategy, dominates because it fits existing mandates, funding streams and political timeframes. Measures that require redistribution of space, demand reduction or institutional reform are less developed and framed as politically difficult, reinforcing the discourse shift from the need for transition to the politics of implementation. Feasibility depends on coordination capacity; legitimacy depends on distributional outcomes.

Within the Multi-Level Perspective, the dynamic is consistent across levels. At the landscape level, climate targets and air quality regulation, energy transition pressures, public health concerns, urban liveability, justice discourses, digitalisation and shocks such as pandemics create urgency without setting direction. These pressures weaken the legitimacy of automobility but do not break lock-ins, enabling responses such as electric vehicle adoption that signal compliance without structural change.

At the regime level, stability is maintained through car-oriented planning standards, siloed governance arrangements, budget routines and short political cycles that favour discrete projects, and evaluation criteria that prioritise throughput, level of service, market uptake and financial viability. These institutional carriers convert pressure into incremental optimisation and substitution, while making redistribution, sufficiency and institutional reform appear exceptional, risky or infeasible. At the niche level, micromobility, shared mobility, walking and cycling interventions, service integration platforms, participatory planning and governance pilots introduce alternative logics, but their impact remains limited by short-term funding, weak institutional anchoring, lack of scaling mechanisms, evaluation through regime metrics, regulatory uncertainty, social stigma and limited influence over land-use and space allocation. When treated as add-ons or pilots, niches may stabilise the regime rather than transform it.

4. Empowerment Framework for Mobility Transitions

The empowerment-oriented framework translates findings on mobility transition dynamics into a set of governance tasks that support system-level change. It responds to evidence that transition efforts stall because decision authority is fragmented, lock-ins reinforce existing regimes, and evaluation routines privilege continuity, and institutional anchoring remains weak. The framework therefore starts from the conditions that determine what becomes actionable in a given city context, rather than from goal-setting.

The framework is organised around mechanisms that shape which transition pathways become feasible and durable. Governance arrangements, appraisal routines, legitimacy, and institutionalisation are treated as constraints that filter ambitions into specific pathways. When standards, budgeting rules, success metrics, and administrative responsibilities remain unchanged, transition agendas are absorbed into pathways that preserve regime structures.

The framework consists of five linked tasks (Table 5). The first task, Stakeholders Mapping and Engagement, addresses fragmented governance and unclear responsibility allocation by identifying mandates and accountability structures. The second task, Identification of Local Lock-ins, examines institutional, procedural, economic, and behavioural mechanisms embedded in infrastructure provision, legal standards, funding mechanisms, appraisal routines, and professional practices. The third task, Definition of Potential Transition Pathways, links mobility objectives to combinations of measures that affect multiple system elements rather than partial adjustments within existing arrangements. The fourth task, Co-creation of Shared Visions and Narratives addresses conflicts related to distributional impacts and perceived exclusion that influence acceptance and political feasibility. The fifth task, Development and Implementation of Empowerment Tools, focuses on translating transition pathways into administrative routines through aligned participation formats, capacity-building measures, access mechanisms, regulatory changes, and infrastructure provision.

The framework aligns with socio-technical transition perspectives by recognising the stabilising role of regimes and lock-ins and the need to enable alternative practices to persist and scale through institutional change. By linking each task to a specific empirical problem and justification, as shown in Table 5, the framework provides a structure for governing system-level mobility transitions under conditions of institutional constraint and political turnover.

Table 5: Empowerment Framework for Mobility Transitions

Step	*Empirical problem covered*	*Justification based on empirical results*
1. Stakeholders Mapping and Engagement	*Fragmented governance and unclear responsibility allocation*	*The absence of a shared operational definition of mobility transition allows agreement on ambition while diffusing decision authority and accountability across departments and levels.*
2. Identification of Local Lock-ins	*Reinforcing institutional, procedural, economic, and behavioural lock-ins*	*Lock-ins in standards, funding mechanisms, appraisal routines, and professional practices are identified as the primary explanation for the persistence of car-dependent mobility systems.*
3. Definition of Potential Transition Pathways	*Partial adjustments that leave system architecture unchanged*	*Transition strategies commonly consist of isolated or incremental measures that optimise existing practices without reconfiguring underlying system structures.*
4. Co-creation of Shared Visions and Narratives	*Legitimacy conflicts linked to perceived elitism and distributional impacts*	*Sentiment and qualitative analyses reveal that negative evaluations cluster around governance and social equity, reflecting legitimacy challenges when distributional consequences are not openly negotiated.*
5. Operationalisation and Institutionalisation of Transition Pathways	*Weak operationalisation and institutional anchoring of selected transition pathways*	*The results show that substitution strategies prevail because they align with existing mandates and funding logics, while redistributive measures require coordinated policy mixes that are rarely in place.*

Step 1: Stakeholders Mapping and Engagement

The purpose of this first step is to identify, understand, and actively engage the stakeholders that shape local urban mobility and might influence the direction and pace of mobility transitions. Urban mobility transitions are inherently multi-actor processes, involving public institutions, private stakeholders, civil society organisations, NGOs, academia, and users, each with different levels of power, resources, interests, and capacities to act and with different degrees of decision authority and accountability.

From an empowerment perspective, this step aims to strengthen the capacity of local actors to recognise their roles within the mobility system, to understand existing power relations, and to initiate forms of collaboration that go beyond sectoral silos. Early and inclusive engagement is essential to avoid exclusive top-down approaches, and to ensure that transition processes are socially legitimate, politically feasible, and context-sensitive by making participation and representation a feasibility condition for implementation rather than a communication activity after decisions are made.

Beyond identification of actors, this step explicitly integrates engagement as a core component of empowerment. It seeks to move from a static mapping of actors toward an understanding of how actors interact, influence one another, and can be mobilised to support transition processes while clarifying where decision authority sits, how mandates interact, and how responsibility for action can be coordinated across levels of government and administrative boundaries.

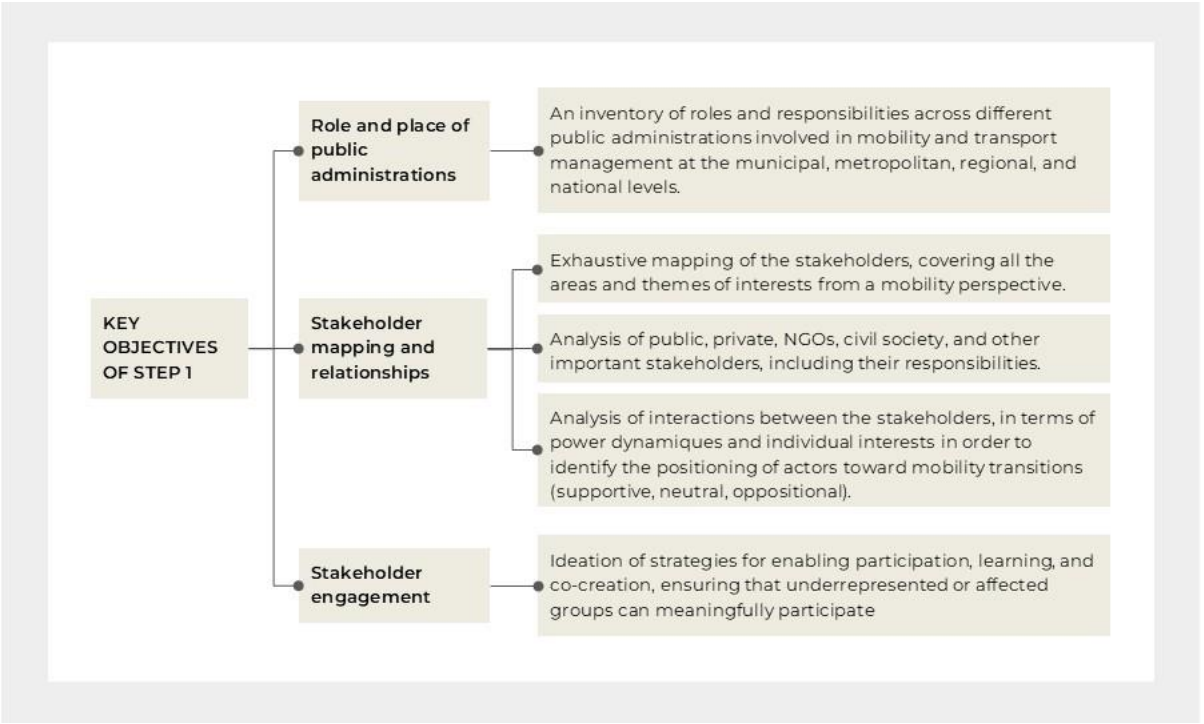

Figure 12: Key Objectives of Stakeholders Mapping and Engagement

Key questions:

- Who are the key actors influencing the urban mobility system at local, metropolitan, and regional levels?
- What formal and informal roles do these actors play in decision-making, implementation, and everyday mobility practices?
- Which actors have the power to enable or block change, and which groups are currently underrepresented or excluded?
- What interests, incentives, tensions and conflicts shape actors' positions toward mobility transitions?
- How can engagement be structured to support informed decision-making and collective action and to reduce fragmentation in responsibilities and accountability?

Expected outputs

- A comprehensive actor map identifying key stakeholders and their roles within the mobility system.
- A power–interest matrix highlighting actors' influence and positioning toward mobility transitions.
- Identification of missing or marginalised actors, particularly user groups affected by mobility inequalities.
- An initial engagement strategy, outlining how and when different actors should be involved in subsequent steps of the framework.

Step 2: Identification of Local Lock-ins

This step focuses on the analysis of local lock-ins through the identification and characterisation of the structural mechanisms that constrain urban mobility transitions at the local level. As explained in the theoretical background chapter, lock-ins refer to interrelated institutional, technological, and behavioural dynamics that stabilise the automobility regime and hinder change, even when alternatives are technically feasible or politically desirable. It also considers how economic incentives, evaluation routines, and planning standards reproduce car-oriented priorities by shaping what is treated as fundable, defensible, and feasible in day-to-day administration.

From an empowerment perspective, this step aims to make lock-ins visible and intelligible to local actors. Rather than treating barriers as abstract or external constraints, the analysis focuses on how lock-ins are actively produced and maintained through governance arrangements, actor interests, infrastructures, and dominant narratives. This step is essential for enabling local stakeholders to identify leverage points for change and to distinguish between barriers that can be addressed through projects and barriers that require institutional reform, revised appraisal criteria, or changes to mandates and budget routines.

Step 2 provides a direct input for Step 3 (Definition of transition pathways) by clarifying which structural barriers must be challenged, bypassed, or gradually dismantled. It also supports Step 4 by identifying legitimacy risks and distributional fault lines linked to lock-ins (for example, where costs and benefits are unevenly allocated or where enforcement and pricing create exclusion).

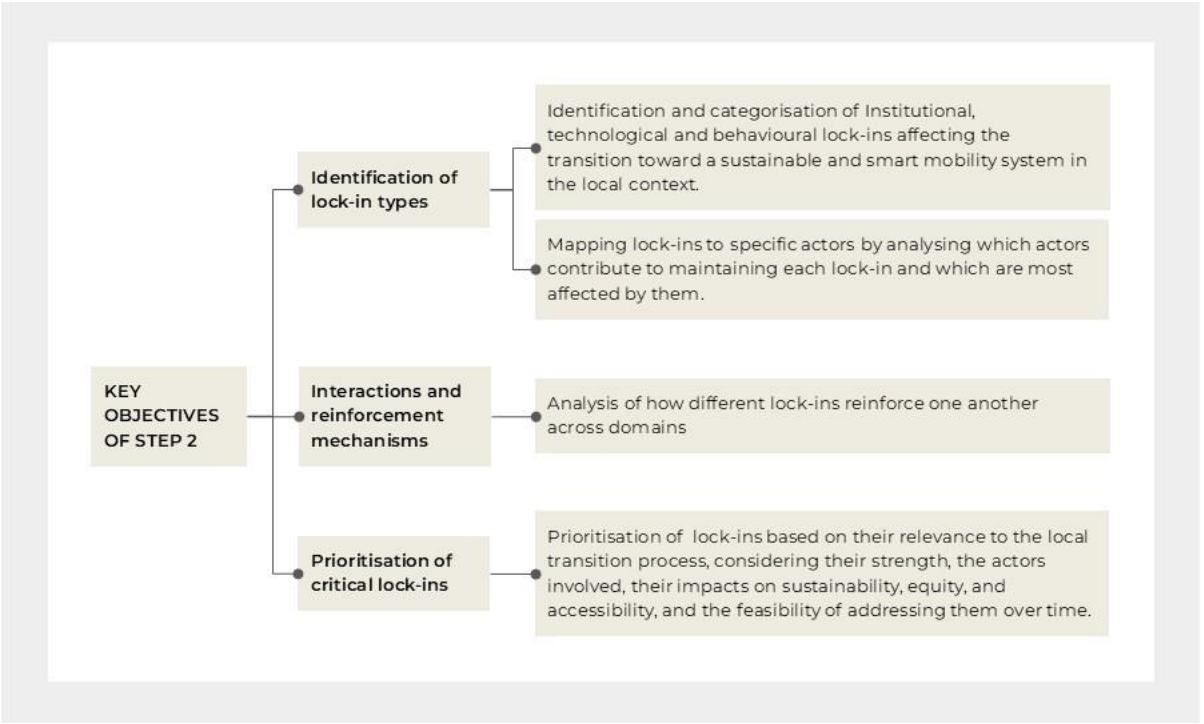

Figure 13 : Key Objectives of Identifications of Local Lock-ins

Key questions:

- What types of lock-ins constrain the transition toward sustainable mobility in the local context?
- Which actors benefit from, reproduce, or contest existing lock-ins?
- How do different lock-ins interact and reinforce one another across domains?
- Which lock-ins represent the most critical barriers to initiating or accelerating transition pathways?
- Which governance routines, standards, funding mechanisms, and evaluation criteria reproduce these lock-ins in practice?

Expected outputs

- A structured inventory of lock-ins affecting the local transition for a sustainable and smart mobility.
- A lock-in matrix linking lock-in types to actors, sectors, and governance levels.
- Identification of reinforcing mechanisms and feedback loops.
- A prioritised list of critical lock-ins to be addressed in subsequent steps.

Step 3: Definition of Potential Transition Pathways

Step 3 defines transition pathways that can guide the overcoming of the local lock-ins identified in Step 2. This is the step in the framework that addresses how a city can move from its current mobility regime toward a more sustainable future configuration. Transition pathways capture different types and intensities of change through which cities can progressively move from the prevailing automobility regime toward more sustainable mobility configurations. Rather than listing isolated measures, this step identifies a coherent route of change, including the sequencing of actions, the institutional reforms required, and the conditions under which pilots, investments, and governance changes can

accumulate into system-level transformation. The step explicitly addresses the tendency for transition strategies to remain isolated, incremental, or substitution-oriented by supporting cities to define pathways that reshape system configuration rather than optimise the status quo.

This step supports local actors in shifting from diagnosis to strategic orientation by helping them identify feasible routes for change that acknowledge existing constraints while creating space for innovation and experimentation. Rather than prescribing a single optimal solution, it enables the identification of multiple context-sensitive pathways, adapted to local capacities, political conditions, and temporal horizons. It also encourages explicit consideration of sequencing and institutionalisation, recognising that pilots only contribute to transition when pathways for scaling, funding continuity, and administrative integration are defined.

Step 3 provides a critical input for Step 4 (Co-creation of shared visions and narratives) by offering concrete strategic options around which collective imaginaries can be built. It also informs Step 5 (Development and implementation of empowerment tools) by highlighting key actions that are most likely to unlock systemic change and by clarifying which policy mixes and governance reforms are required for those actions to persist beyond project cycles.

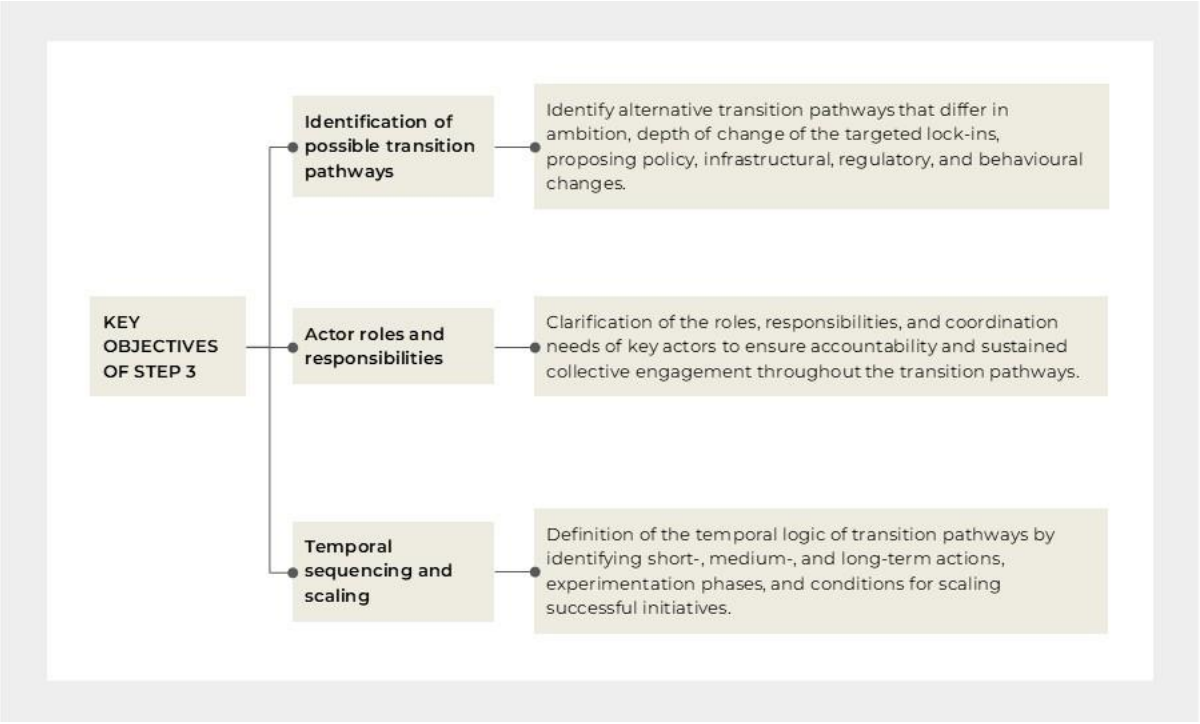

Figure 14 : Key Objectives of Definition of Potential Transition Pathways

Key questions:

- Which transition pathways are feasible given the identified lock-ins and actor configurations?
- What types of change are required (incremental, reconfigurational, or transformative)?
- What kind of actions in the short-term could contribute to longer-term structural change?
- Which actions require redistribution of space, demand reduction, or institutional reform, and how will conflict and trade-offs be managed?

Expected outputs

- A selection of a potential transition pathway, adapted to the local context.
- Identification of priority actions and sequencing logic.
- A shared strategic orientation that can guide subsequent co-creation and innovation efforts.

Step 4: Co-creation of Shared Visions and Narratives

Step 4 gives meaning, direction, and legitimacy to the transition pathways identified in Step 3 through a collective creation process of shared visions and narratives. Urban mobility transitions should not be driven by top-down strategies and measures alone; they also depend on how futures are imagined, communicated, and collectively understood by different actors. Because legitimacy and perceived fairness condition political feasibility, this step treats narratives not only as communication outputs, but as a mechanism for negotiating distributional consequences, responsibilities, and contested priorities around the proposed pathway

This step aims to align diverse actors around a common vision of change, while acknowledging differences in interests, values, and priorities. By co-producing narratives rather than imposing predefined messages, this step supports collective ownership, reduces resistance, and strengthens the social and political acceptance of transition processes. It also supports reframing transition away from purely techno-centric substitution narratives toward system reconfiguration that links sustainability with accessibility, safety, equity, and the quality and use of public space.

Step 4 builds directly on Step 3 (Definition of transition pathways) by providing the narrative and symbolic dimension needed to legitimise strategic choices. As transitions evolve, visions and narratives may be revisited to reflect learning, changing conditions, or emerging societal priorities.

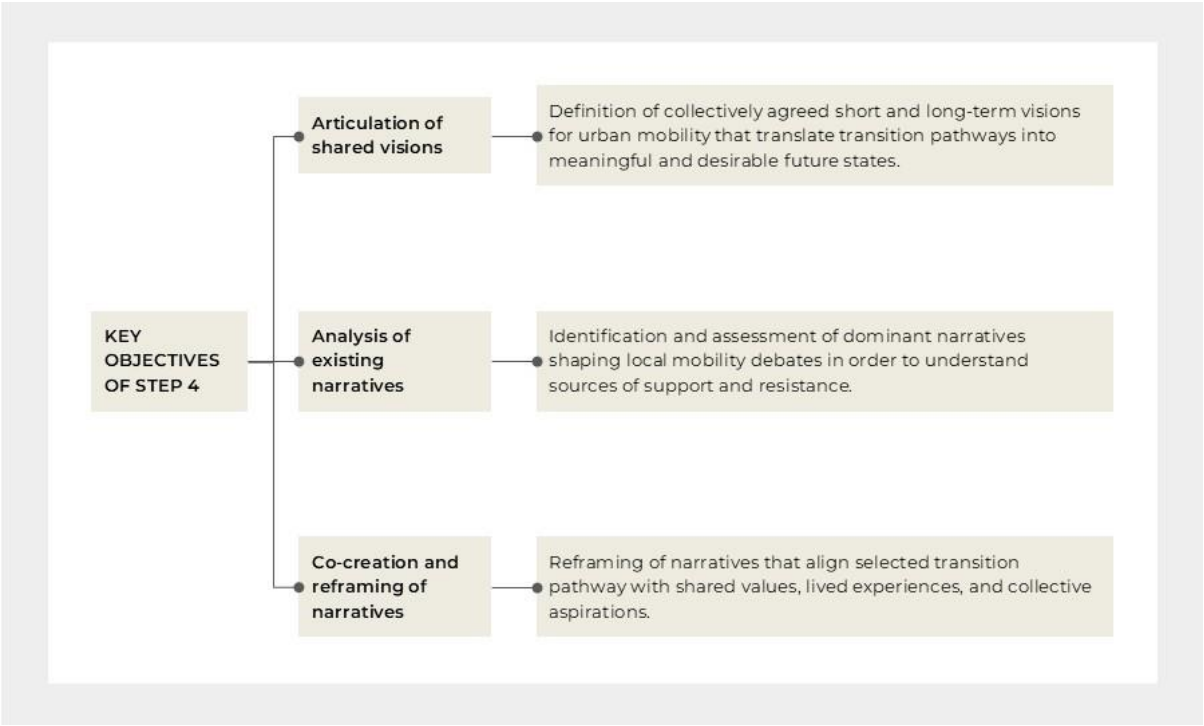

Figure 15: Key Objectives of Co-creation of Shared Visions and Narratives

Key questions:

- What future mobility system do we collectively aspire to build, and why?
- How can transition pathways be translated into narratives that resonate with different audiences?
- Which dominant narratives support or oppose mobility transitions in the local context?
- How can conflicting or polarising narratives be reframed or negotiated?
- How will distributional impacts (costs, access, burdens, benefits) and procedural fairness be made explicit to strengthen legitimacy and reduce backlash?

Expected outputs

- A shared vision statement for sustainable urban mobility in the local context.
- A set of co-created narratives tailored to different audiences (policymakers, practitioners, citizens).
- Identification of conflicting narratives and strategies to address them.
- Communication elements that support mobilisation and collective engagement, including legitimacy-sensitive framing that clarifies who benefits, who bears costs, and how decisions are made and justified

Step 5: Operationalisation and Institutionalisation of Transition Pathways

Step 5 identifies, adapts, and develops empowerment tools that support the implementation, learning, institutionalisation, and consolidation of the transition pathway defined in Step 3 and legitimised in Step 4. Empowerment tools are understood as practical instruments, methodological, institutional, regulatory, financial, and communicative, that enable actors to act, coordinate, and sustain change over time. These tools are not the pathway itself. Rather, they are the means through which the selected pathway is

operationalised in practice and embedded into mandates, budgets, routines, and policy mixes. The step responds to evidence that transitions often stall because strategic orientations are not translated into administrative and political arrangements that can be executed and maintained beyond pilots.

This step translates the selected transition pathway into concrete capacities for action, ensuring that local actors are equipped not only with visions and plans, but also with the instruments required to implement, coordinate, and scale the pathway over time. It emphasises coordinated policy mixes, rules, incentives, investments, standards, enforcement, and monitoring, and the institutional anchoring needed to shift evaluation criteria away from regime-biased metrics (for example, throughput and level of service) toward accessibility, sufficiency, and public value.

This final step consolidates the framework by operationalising the outcomes of Steps 1–5 into actionable instruments. It feeds back into Step 1 (Actor mapping and engagement) by strengthening actor capacities, and into Step 2 (Lock-ins diagnosis) by enabling targeted interventions that progressively dismantle structural barriers. As such, this step closes the loop of the framework while supporting its iterative and adaptive application over time.

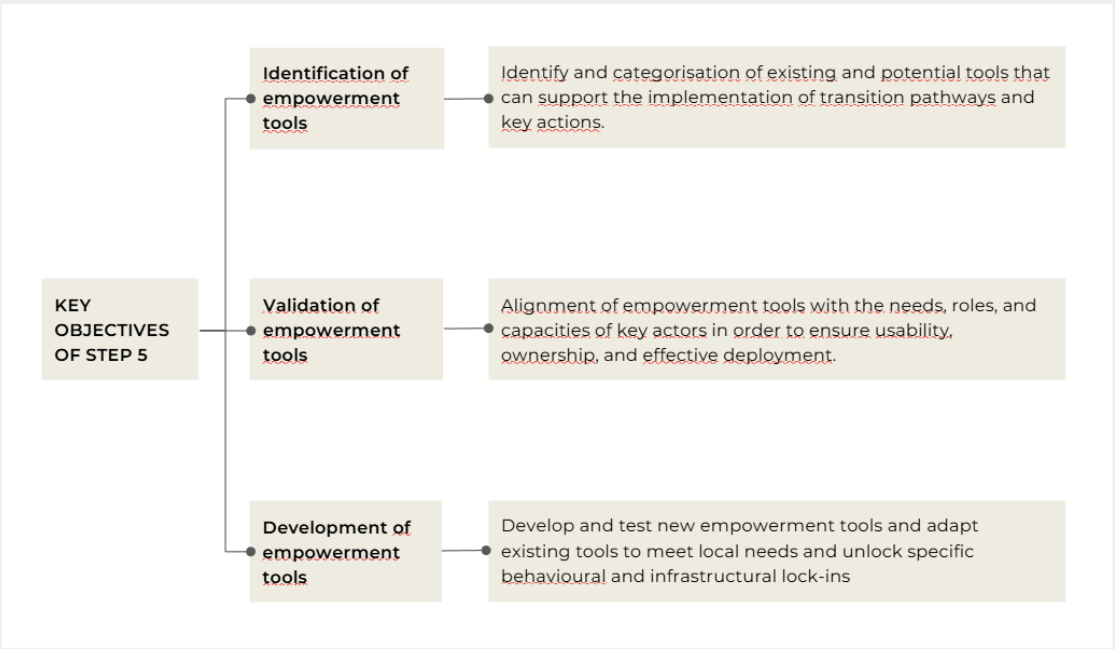

Figure 16: Key Objectives of Development and Implementation of Empowerment Tools

Key questions:

- Which tools are needed to implement and institutionalise the transition pathway defined in Step 3 and supported through the shared visions and narratives developed in Step 4?
- What types of empowerment (participation and collective action, capacity building and education, and access to resources) should these tools reinforce?
- Which existing tools can be adapted, and where are new tools required?
- Who is responsible for developing, deploying, and maintaining these tools?

- How can tools support learning, feedback, and long-term institutionalisation?
- How will tools be embedded into administrative routines (mandates, budgets, procurement, monitoring) so that actions persist across political cycles?

Expected outputs

- An inventory of empowerment tools linked to facilitate participation and collective action, capacity building and education, and access to resources.
- Mapping of target groups in relation to specific empowerment tools
- Guidelines for the deployment and monitoring of empowerment tools, including responsibilities, resourcing, and criteria for institutionalisation and scaling

Limitations

Despite its empirical grounding and alignment with socio-technical transition theory, the proposed empowerment framework has several limitations that should be acknowledged. The framework is diagnostic and governance-oriented rather than predictive. It is designed to explain why mobility transition efforts tend to stall and to structure coordinated action in response to empirically observed constraints. It does not predict transition outcomes, rates of change, or the likelihood that specific pathways will succeed under given conditions. As such, it complements rather than replaces quantitative modelling, forecasting, or scenario-based planning tools commonly used in transport policy and infrastructure appraisal.

The framework is also context-dependent. It is derived from a synthesis of peer-reviewed literature with a strong focus on European and Global North urban contexts, where formal planning systems, fragmented governance structures, and established appraisal routines shape transition dynamics. While many of the identified mechanisms, including lock-ins, evaluation bias, and legitimacy challenges, are likely to be relevant in other settings, the framework may require adaptation in contexts characterised by different institutional capacities, informal governance arrangements, or socio-economic conditions. Its direct transferability should therefore not be assumed.

A further limitation lies in the framework's emphasis on governance arrangements and institutional mechanisms. Although landscape pressures such as energy crises, economic downturns, or rapid technological change are acknowledged, they are treated primarily as contextual conditions rather than as direct drivers of change. In contexts where material scarcity, fiscal constraints, or external shocks dominate decision-making, governance-focused interventions may have more limited leverage than the framework implies.

While legitimacy and equity are foregrounded as structural conditions shaping feasibility, the framework does not prescribe specific methods for resolving distributional conflicts or achieving social consensus. Co-creation and procedural inclusion are treated as necessary mechanisms, but their effectiveness depends on local political cultures, power relations, and administrative capacities that the framework does not explicitly model. The framework can therefore improve conditions for negotiating trade-offs but cannot guarantee conflict resolution or public acceptance.

The framework operates at a strategic and meso-institutional level, focusing on coordination across departments, evaluation criteria, and policy instrument mixes. It

provides limited guidance on micro-level design decisions, operational implementation, or behavioural interventions. Practitioners must complement it with sector-specific design standards, technical guidelines, and operational planning tools to translate strategic alignment into concrete interventions.

Finally, the framework reflects the limitations of its empirical basis. It is grounded in discourse analysis and synthesis of academic literature rather than in direct observation of policy processes within specific cities. While this approach enables identification of recurring patterns and mechanisms across contexts, it may overlook locally specific dynamics, informal practices, and tacit knowledge that shape implementation in practice. The framework should therefore be understood as a structuring device for diagnosis and coordination rather than as a comprehensive representation of all factors influencing mobility transition outcomes.

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