

## SUSTAINABLE URBAN MOBILITY TRANSITIONS: A BIBLIOMETRIC REVIEW OF GOVERNANCE, POLICY, PLANNING, AND SMART MOBILITY RESEARCH

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### Abstract

*This study explores the complex interaction between sustainable urban mobility and transition management, focusing on the critical role of integrated governance and organizational change in improving metropolitan transportation networks. Using bibliometric analysis and the VOSviewer software, this research examines thematic clusters in sustainable mobility, categorized into planning and travel behavior, policy and multilevel governance, smart mobility and digital innovation, and governance and active urban mobility. By analyzing 400 articles from the Web of Science database (2021–2026), this study identifies trends and key linkages between sustainable transport systems and urban transformation, highlighting the role of coordinated policy and infrastructure. While smart mobility and automation are discussed as facilitators of innovation and efficiency, the primary focus lies in understanding how multilevel governance, transport policy, and spatial planning drive behavioral change and overcome structural*

*bottlenecks. This paper provides information for policymakers, urban planners, and local authorities to design cohesive, behaviorally focused transition strategies that address specific infrastructural needs, ultimately contributing to sustainable, accessible, and resilient cities.*

**Keywords:** *sustainable urban mobility; transition management; bibliometric research; VOSviewer; urban governance*

**JEL Classification:** *O18, O33, Q56, R41, R58*

## **1. Introduction and context of the study**

Around the world, urban areas face transportation challenges such as traffic congestion, infrastructure limitations, air pollution, and noise (Mogire, 2026). Ensuring sustainable transportation has become a crucial and challenging goal, given the growing importance of energy conservation, environmental protection, and carbon emission reduction (Chung et al., 2023). For example, public transportation is not available to approximately 52% of people living in cities around the world. Furthermore, the transportation industry is responsible for about a quarter of global energy-related carbon emissions. These problems are sure to grow, given the forecast that the number of vehicles in the world's top 100 cities will increase by 36% by 2030 (Mogire, 2026). As environmental, social, and governance (ESG) assessments of companies' data and indicators become increasingly important, this issue is receiving growing public attention. Thus, the United Nations 2030 Agenda for Sustainable Development, through its 17 Sustainable Development Goals (SDGs), focuses on promoting "Sustainable Cities and Communities." By 2030, a key aspiration of this goal is to create a safe, affordable, and accessible transportation system that can meet everyone's needs, while simultaneously improving road safety standards (Chung et al., 2023).

Integrated transportation networks enable urban authorities to manage population growth, while the use of low-emission transportation improves people's quality of life and reduces the environmental impact (Ombati, 2026; Ribeiro & Fachinelli, 2024). The viability of modern transit technologies in densely populated urban areas is demonstrated by the implementation of strategic "Blue-Green" systems (Doost Mohammadian & Rezaie, 2020). Integrated governance and transition management are also essential for gaining insights into the need for organizational change (Turoń, 2025). Therefore, transportation planning capable of managing uncertainties is necessary due to recent environmental pressures (Turoń, 2025). The government's involvement in the implementation process facilitates a sustainable transition (Ribeiro & Fachinelli, 2024). According to the assessment of urban challenges, the integration of new technologies enhances the resilience and legitimacy of transportation in the long term (Papantoniou et al., 2025). However, there is still a lack of policy coordination, which shows that it is difficult to establish coordination among government agencies (Turoń, 2025).

Governance, institutional coordination, and behavioral change are the most common causes of mobility problems, rather than issues of technical efficiency or infrastructure. Building on this foundation, this study examines how leadership, organizational change, and transition management play a role in metropolitan initiatives. In addition, according to (İnce, 2025), the aim will be to identify and contextualize the main topics by analyzing groups of relevant keywords. According to this paper, administrative adaptation and institutional capacity are essential for achieving local and global climate goals (Ribeiro & Fachinelli, 2024).

This paper uses bibliometric analysis to examine the state of knowledge regarding green mobility. Bibliometrics is regarded in the scientific literature as a rigorous quantitative method ideally suited for identifying trends and research gaps across a wide range of disciplines (Almassawa et al., 2025). This method estimates the actual impact of publications and maps the connections between the various structural components of development (İnce, 2025).

## 1.2. Literature review

Transportation has helped increase people’s mobility and facilitate the transport of large goods over the past century. The use of the internal combustion engine has significantly increased emissions, leading to higher levels of pollution (Raihan & Said, 2022). (Ibeh et al., 2022) emphasized that, in order to meet requirements and reduce carbon emissions, local zero-emission standards and global climate goals require further modifications. The rapid development of renewable energy sources is essential for obtaining clean energy and the widespread use of sustainable fuels, as there is a significant link between technology that reduces carbon emissions and climate change mitigation (Din et al., 2023).

Increasing transportation efficiency, improving quality of life, and addressing global environmental issues require sustainable mobility strategies (Tomaszewska, 2021). These strategies often face obstacles at the local level, such as financial constraints, legal issues, and public opposition, despite their global relevance (Kramar & Sternad, 2025). To meet global climate goals, a shift toward sustainable urban mobility is necessary, requiring social and cultural changes at the local level, in addition to the physical reconstruction of infrastructure (Corais et al., 2022). According to (Turoń, 2025), transition management strategies are essential to ensure that transportation innovations develop in an equitable manner, promoting the inclusivity and sustainability of metropolitan networks. Furthermore, strong leadership and governance are fundamental to ensuring that immediate mobility actions are guided by a long-term vision based on a sense of responsibility for global commitments (Corais et al., 2022).

In this context, as noted by (Yahia et al., 2025), organizational changes implemented at the local government level have a significant impact on how cities manage transportation policies. Strategic governance, based on cooperation between various public and private actors, enables authorities to improve operational efficiency and successfully implement complex interdisciplinary projects, such as transit-oriented projects. Sustainable urban transitions propose a reconfiguration of the context of technological innovations, emphasizing how green mobility alternatives are tested and managed effectively in metropolitan areas (Hodson et al., 2017). The insights provided by (Papantoniou et al., 2025) indicate that transit infrastructure is largely built by local institutions, and that urban planning and organizational innovations must align to establish clear development trajectories and smart mobility hubs, taking into account current climate requirements. Local authorities are adopting new communication and governance frameworks as policies focused on low-carbon transport become predominant (Vale & Vale, 2025).

However, the transition process at the level of administrative structures presents significant challenges. The phenomenon of “policy layering,” along with the dysfunctions and lack of coherence that slow the widespread adoption of ecological values, are two major problems that persist in practice (Turoń, 2025). Conversely, the lack of a comprehensive set of complementary measures causes political conflicts and reduces the effectiveness of local projects, despite the fact that transition management provides very clear normative guidelines. Changing urban infrastructure solely through the use of technology, without organizational changes and participatory governance mechanisms, risks causing imbalances and long-term failures (Corais et al., 2022).

Addressing structural bottlenecks will be essential for bringing about sustainable change in how transportation operates in metropolitan areas, based on the evidence from the reviewed literature (Augenstein & Palzkill, 2015; Todorova et al., 2025). Therefore, a thorough bibliometric analysis is necessary to validate the link between mobility innovation, transition management, and urban governance.

## 2. Methodology

Bibliometric analysis serves as a powerful tool for identifying keywords and tracking the evolution of central ideas, ultimately offering valuable perspectives on future research trends. Grounded in quantitative measurements and systematic investigative techniques applied to academic documents, this method allows for a comprehensive mapping of a research field.

To conduct this specific analysis, the Web of Science Core Collection database was utilized, while the VOSviewer application (version 1.6.20) was used for data processing.

Given the need to explore sustainable urban mobility beyond exclusively technical approaches, we intended to establish a correlation between mobility and the processes of transition management, organizational change, strategy, governance, and leadership, finding interconnections in the database of scientific articles within the Web of Science.

By applying tagging techniques and using specific filters from the Web of Science database, 400 relevant scientific articles were identified. By processing their specific data (article title, abstract, author keywords, and Keywords Plus), new viewpoints can be generated regarding the intercorrelation between sustainable urban mobility and transition governance.

The research was based on an analysis of scientific literature by applying comparative bibliometric analyses to 400 scientific articles that offer certain perspectives on the manifestation of this correlation. Bibliometrics, although a useful method for analyzing scientific literature, can encounter significant difficulties in capturing all relevant aspects of a research field due to the large and ever-expanding volume of information. Thus, conducting comprehensive and high-quality bibliometric analysis requires considerable effort in organizing and interpreting data, and their diversity demands substantial resources.

The search query in the Web of Science database began with keywords related to the analyzed phenomenon, such as “green mobility”, “sustainable mobility”, and “low-carbon transport”. To maximize the identified connections between sustainable mobility and transition processes, additional words were included, such as “transition management”, “organizational change”, and “governance”, while explicitly delimiting the “urban” or “metropolitan” context. The following operators facilitated this process:

- **AND Operator:** This was used to combine the primary tags with related subtopics, ensuring relevance to the core subject. For example, the query  $TS = (... \text{AND } ... \text{AND } ...)$  guarantees results that address sustainable mobility while simultaneously integrating key subtopics of transition, governance, and strategy.

- **OR Operator:** This operator expanded the search to include synonyms or closely related terms within the same conceptual block, enriching the results. For example, (“green mobility” OR “sustainable mobility” OR “urban mobility” OR “sustainable transport\*” OR “low-carbon transport\*”) expanded the scope of the search by considering alternative terminologies alongside the main keywords.

The complete search query is:

*$TS = ((\text{"green mobility"} \text{ OR } \text{"sustainable mobility"} \text{ OR } \text{"urban mobility"} \text{ OR } \text{"sustainable transport*"} \text{ OR } \text{"low-carbon transport*"})) \text{ AND } (\text{"transition management"} \text{ OR } \text{"organizational change"} \text{ OR } \text{"organizational strategy"} \text{ OR } \text{governance OR leadership}) \text{ AND } (\text{urban OR city OR metropolitan})$*

All conclusions derived from this bibliometric analysis are based on rigorous and up-to-date scientific research. This was achieved by using the following existing filters in the Web of Science database (the dataset being frozen on March 30, 2026, at 18:30 EET, to ensure transparency):

- **Document types are article and review**, because these published works provide basic empirical and conceptual contributions, filtering out searches generated by more heterogeneous document types.

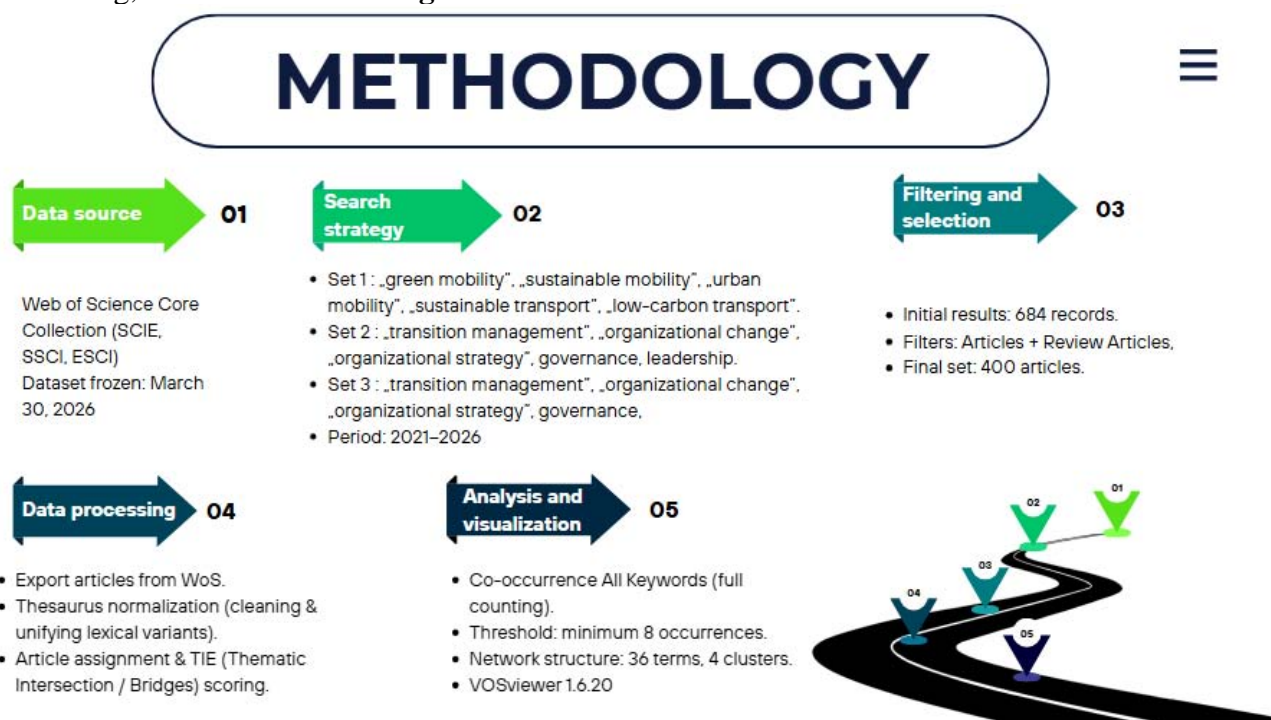
• **Publication years is 2021-2026**, because the aim was to study the recent phase of research intensification, marked by debates on decarbonization and multilevel governance (data for the year 2026 being interpreted with caution, as it is a partial year).

By applying these filters, our initial selection of 684 records was reduced to 436, and the document type filter yielded a final number of 400 articles, which was then subjected to bibliometric analysis.

To capture new aspects and conceptual structures resulting from the clustering analysis, we used the VOSviewer software to process the systematic review of the literature (Grigore et al., 2025), applying the following filters: co-occurrence of all keywords (full counting method), prior data normalization using a thesaurus file, and a minimum of 8 co-occurrences. Clusters within the VOSviewer program are generated as pairs of items. Through this process, keywords were grouped, calculating the occurrence and link strength for each keyword to determine its association with others. The link strength between terms, based on co-occurrence, allowed for the identification of clusters within the broader field of sustainable urban mobility.

The dataset generated a network of 36 terms grouped into four primary clusters: Cluster 1 (12 terms), Cluster 2 (10 terms), Cluster 3 (7 terms), and Cluster 4 (7 terms). Furthermore, to capture the convergences of this interdisciplinary field, a Thematic Intersection (TIE) rule was introduced.

The sequential steps of the research design, including data collection, filtering, and processing, are summarized in **Figure 1**.



**Figure 1. Methodological framework and data selection process**

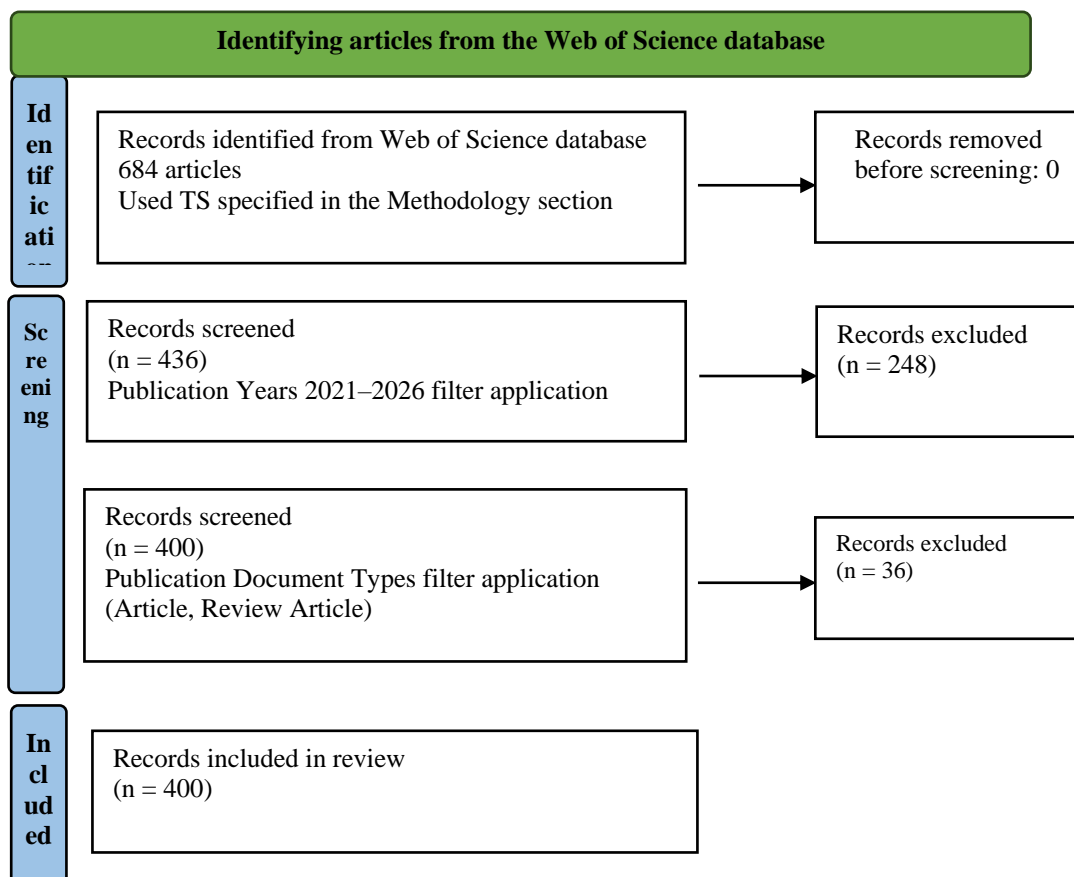
Source: Created by the authors using Canva

Articles with the same maximum score in multiple clusters were not artificially forced into a single category but were classified as bridges. Thus, 127 articles formed the thematic intersection, confirming that Cluster 4 functions as a central articulating node. Each cluster comprises terms related to specific thematic areas, highlighting aspects such as transition strategies, organizational change, and planning convergences.

The objective of this bibliometric analysis is to examine key themes in sustainable mobility research, including transition management, governance, and strategy, while also considering the complex convergences between policies and urban planning in facilitating these outcomes.

### 3. Results

The Web of Science query was designed to frame the transition to sustainable urban mobility not merely as an infrastructural or technical challenge, but as a complex issue rooted in governance, strategic coordination, organizational change, and leadership.

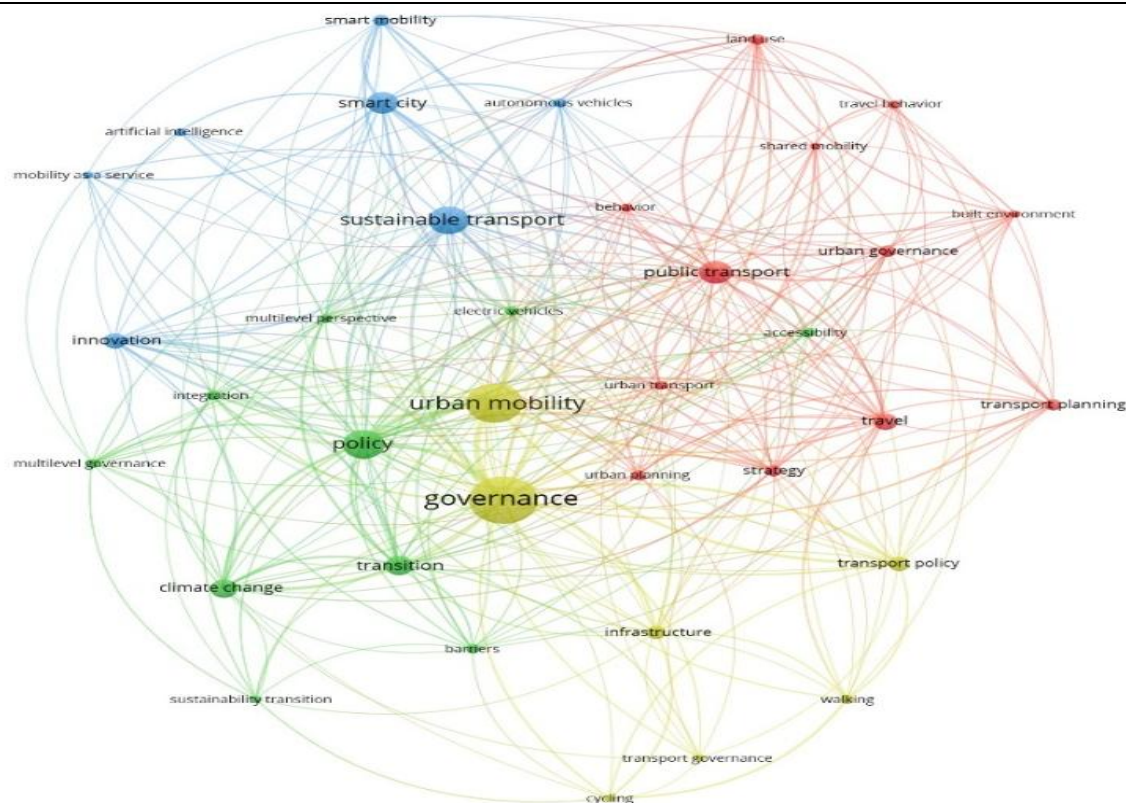


**Figure 1. PRISMA 2020 flow chart for applying filters from the Web of Science database**

Source: Made by the authors using the PRISMA 2020 chart and data selected from the Web of Science database (accessed on 2026-03-30).

By apply the PRIMSA 2020 flow with specific filters publication years 2021-2026 and document types restricted to articles and reviews, a final dataset of 400 relevant records was selected for bibliometric analysis.

The keyword co-occurrence analysis generated a network of 36 terms divided into four distinct clusters, illustrating a thematic structure that is compact yet diverse enough to capture the major trends in sustainable urban mobility, policy, sustainable transport, and public transport. A graphical representation of the cluster elements is shown in Figure 2, and the table 1 below lists the contents of each cluster.



**Figure 2. Distribution and relationships among the 36 terms**

Source: Created by the authors using VOSviewer

This configuration suggests that the literature is driven by a logic of coordinated urban transformation, where policies, institutions, and mobility services are fundamentally interdependent.

The distribution of articles reveals a strong concentration in Cluster 4 (136 articles) and a robust Thematic Intersection (TIE) zone containing 127 articles, followed by Cluster 2 (70 articles), Cluster 1 (56 articles), Cluster 3 (11 articles). This highlights two main characteristics of the field. A dominant core focused on urban mobility, governance, policy, infrastructure, and active modes. And a highly interconnected body of literature where boundaries between planning, policy, smart mobility, and mobility solution.

To systematically map the intellectual structure of the sustainable urban mobility field, a keyword co-occurrence analysis was conducted.

The resulting network comprises 36 core terms distributed across four distinct clusters.

**Table 1. VOSviewer clusters and related colors.**

Cluster 1	Cluster 2
travel behavior	multilevel perspective
land use	electric vehicles
shared mobility	accessibility
Behavior	integration
urban governance	policy
built environment	multilevel governance
public transport	transition
urban transport	climate change
transport planning	barriers

travel urban planning Strategy	sustainability transition
<b>Cluster 3</b>	<b>Cluster 4</b>
smart mobility smart city autonomous vehicles artificial intelligence mobility as a service Innovation sustainable transport	urban mobility governance transport policy infrastructure walking transport governance cycling

Table 2 details the specific components of this network, presenting each term alongside its frequency of occurrence (O) and its total link strength (T). These metrics are crucial for identifying the most influential concepts, as the occurrence highlights the volume of research dedicated to a specific topic, while the link strength measures its degree of interconnectivity with other themes in the academic discourse.

**Table 2. Frequency of occurrences (O) and links (T).**

Cluster id	Term	Occurrences	Total link strength
C1	Behavior	10	23
C1	built environment	8	28
C1	land use	13	38
C1	public transport	33	71
C1	shared mobility	9	24
C1	Strategy	15	38
C1	transport planning	14	26
C1	Travel	23	48
C1	travel behavior	10	19
C1	urban governance	15	28
C1	urban planning	13	23
C1	urban transport	12	29
C2	Accessibility	12	25
C2	Barriers	12	25
C2	climate change	26	53
C2	electric vehicles	12	22
C2	Integration	12	32
C2	multilevel governance	12	26
C2	multilevel perspective	10	28
C2	Policy	45	107
C2	sustainability transition	9	15
C2	Transition	27	54
C3	artificial intelligence	10	13
C3	autonomous vehicles	12	25
C3	Innovation	21	55
C3	mobility as a service	9	17
C3	smart city	32	49
C3	smart mobility	15	29
C3	sustainable transport	43	73
C4	Cycling	9	18
C4	Governance	81	144
C4	Infrastructure	17	32
C4	transport governance	8	13

Cluster id	Term	Occurrences	Total link strength
C4	transport policy	19	41
C4	urban mobility	64	106
C4	Walking	12	19

An analysis of the data presented in Table 2 reveals that the field is anchored by a few highly central nodes that dictate the research agenda. Terms such as governance (81 occurrences; 144 link strength), urban mobility (64 occurrences; 106 link strength), and policy (45 occurrences; 107 link strength) exhibit both the highest frequencies and the strongest structural connectivity. This quantitative distribution confirms that the literature is not organized around isolated technical solutions, but rather around the coordinated implementation, policy frameworks, and systemic governance of urban mobility. These key nodes function as the conceptual glue that binds the clusters together, laying the groundwork for the detailed thematic and temporal analyses that follow.

Consequently, the network functions as an intellectual structure with dominant nodes and frequent bridges, where governance and institutional coordination act as the binding agents for planning, policy and mobility solutions.

The annual distribution of articles across the four clusters and the Thematic Intersection (TIE) zone is presented in the Table 3. The data indicates that the period between 2021 and 2024 was marked by a gradual consolidation, characterized by a moderate and relatively balanced publication volumes. This phase was followed by a sharp acceleration in 2025, during which all component of the network experienced simultaneous growth. Specifically, 2025 recorded the highest values for C1 (17), C2 (27), C3 (3), C4(52) and TIE (51). This surge confirms a recently intensified academic interest in sustainable urban mobility, particularly regarding issues of planning, governance, and transition. It is worth noting that the values for 2026 should be interpreted with caution, as the year was incomplete at the time the dataset was frozen.

The most spectacular evolution is seen in C4, which grew from 14 articles in 2021 to 52 in 2025, followed by a still-high value of 22 in the partial year of 2026. This dynamic suggests that the literature has rapidly shifted towards topics such as urban mobility, transport policy, infrastructure, cycling, walking, and governance, which represent the applied core of urban mobility transformation.

**Table 3. Annual distribution (2021–2026) by cluster and TIE (N = 400)**

Year	C1	C2	C3	C4	TIE	Total
2021	9	6	2	14	16	47
2022	4	8	1	15	17	45
2023	7	10	1	10	12	40
2024	9	7	3	23	23	65
2025	17	27	3	52	51	150
2026	10	12	1	22	8	53
Total	56	70	11	136	127	400

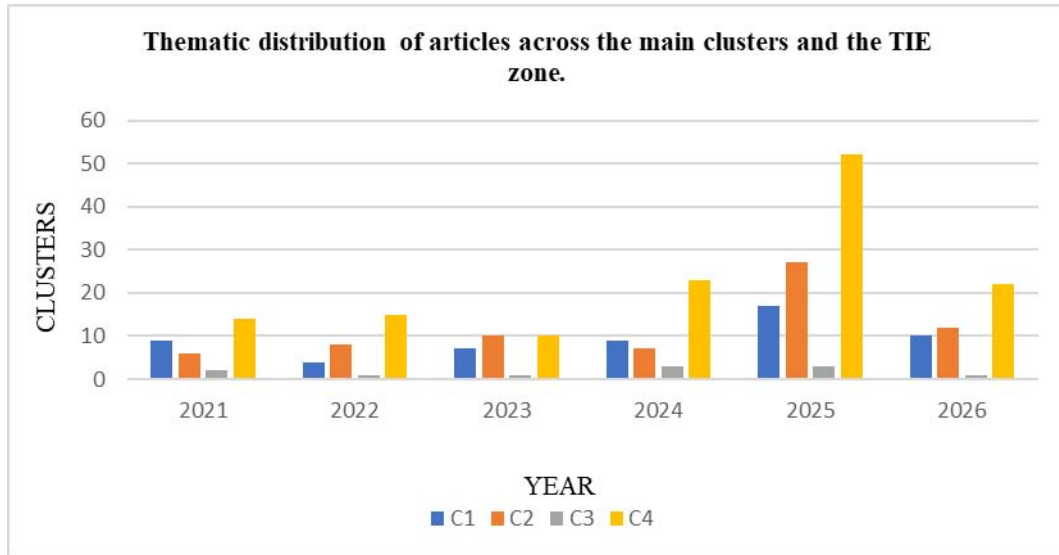
Concurrently, C2 also registered a visible increase, rising from 6 articles in 2021 to 27 in 2025. This points to the maturation of the subfield focused on policy mixes, multilevel governance, sustainability transitions, and electric vehicles.

On the other hand, C1 showed more moderate but constant progress, while C3 remained the smallest cluster. This indicates that the area covering smart mobility, AI, and autonomous vehicles is conceptually important, but still narrower in volume compared to policy and urban governance.

Particularly significant is the dynamic of the TIE zone, which reached 23 articles in 2024 and jumped to 51 in 2025. The pronounced growth of these thematic bridges indicates not only a quantitative expansion of the field but also a substantial increase in thematic interconnectedness among the clusters. In other words, as the field matures, the literature increasingly synthesizes

planning, governance, technology, active mobility, and transition policies into integrated analytical frameworks. This trend aligns with recent comprehensive reviews that highlight the convergence of behavior, technology, and policy-governance within sustainable mobility research.

To better illustrate the structural and temporal characteristics of the analyzed corpus, the graphs in Figure 3 provide a visual representation of the bibliometric data. These visualizations capture both the thematic weight of each identified cluster and the field's chronological evolution between 2021 and 2026, offering a clear perspective on how research on sustainable urban mobility has expanded and interconnected over time.

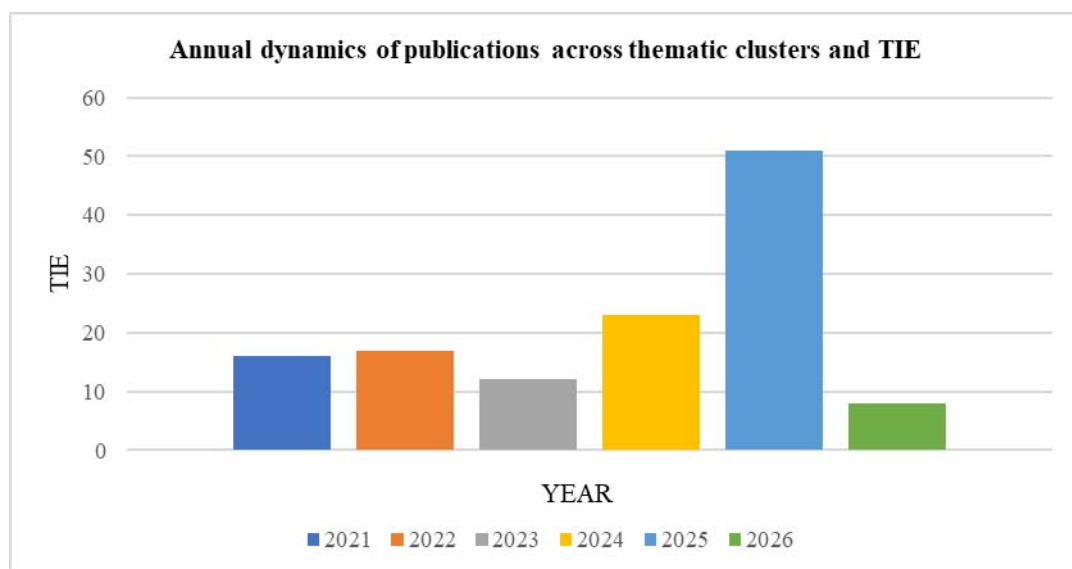


**Figure 3.** Thematic distribution of articles across the main clusters and the TIE zone.

Source: Created by the authors using Microsoft Excell

As the chart clearly demonstrates, the research landscape is heavily dominated by Cluster 4 (Governance, transport policy, and active urban mobility) and the TIE zone. This visual distribution confirms that the field is not highly fragmented into isolated technological or behavioral niches; rather, it is deeply interconnected.

Beyond the overall structural distribution, capturing the momentum of the field requires an analysis of its recent temporal evolution. The graph in Figure 4 shows annual trends in publications for the period 2021–2026, breaking down the number of articles by specific group and TIE area to highlight how various subtopics have experienced accelerated growth over time.



**Figure 4.** Annual dynamics of publications across thematic clusters and TIE (2021–2026).

Source: Created by the authors using Microsoft Excell

The Figure 4. reveals a period of steady consolidation between 2021 and 2024, followed by a sharp and significant acceleration in 2025 across all network components. This upward trend is primarily driven by the rapid expansion of Cluster 4 and the TIE zone. Ultimately, this dynamic trajectory indicates a maturing field that is rapidly shifting its focus away from general sustainability debates and towards applied, integrated solutions for urban mobility implementation.

### **Cluster 1: Planning, travel behavior and urban transport systems**

Cluster 1 (C1) brings together terms such as behavior, built environment, land use, public transport, shared mobility, strategy, transport planning, travel, travel behavior, urban governance, urban planning, and urban transport. The semantic configuration reveals a thematic core centered on the relationship between urban structure, mobility behavior, and the architecture of transport services. It is not merely about mobility as a physical flow, but rather about mobility as the outcome of interactions between urban morphology, mode availability, user preferences, and local planning mechanisms. The simultaneous presence of terms like land use, urban planning, and travel behavior highlights a body of literature focused on how urban form and local governance influence modal choice and a city's ability to reduce car dependency.

Thematically, C1 captures a research area where sustainable mobility is approached through the lens of compatibility between urban planning and travel behavior. The focus is on integrating public transportation, shared mobility, and urban policies capable of changing daily commuting practices. In this cluster, the transition is defined primarily not by electrification or digitalization, but by the reorganization of the structural conditions of mobility: the distribution of urban functions, spatial design, multi-criteria optimization, access to public transportation, and the availability of alternative services (Arghira et al., 2022).

The supporting literature firmly corroborates this interpretation. Research shows that sustainable mobility and land-use transitions tend to rely on common planning and governance factors, particularly in rapidly developing cities. Studies also highlight the interplay between attitudes, modal choices, urban form, and urban governance, suggesting that mobility cannot be divorced from its socio-spatial context. The relevance of the shared mobility subtheme is confirmed by findings demonstrating that carsharing literature revolves around user behavior, service models, operational challenges, and their connection to sustainable urban transport. Similarly, it is argued that the development of car-sharing services depends on local authorities' capacity to orchestrate collaboration with operators, while demand segmentation and ridesharing service design are linked to policies that encourage reducing private car usage. Furthermore, evidence suggests that in scenarios involving the rapid reconfiguration of urban mobility, institutional and non-institutional initiatives can jointly play a crucial role in reorganizing public transport services.

Overall, C1 can be interpreted as the cluster representing the adaptation of urban transport systems through planning, services, and behavioral change. It demonstrates that sustainable urban mobility is supported not only by technology or regulation, but also by how cities interlink land use, public transport, and travel behavior within a coherent transformational logic. Consequently, C1 provides a vital foundation for understanding the operational and territorial dimensions of the transition.

From an interpretative standpoint, C1 suggests that transforming urban mobility relies on a coherence between planning and behavior, rather than just the provision of alternative modes. The primary challenge is not simply the availability of sustainable options, but the capacity of urban systems to turn these options into viable, stable choices. Within the journal's scope, this theme holds significant economic and managerial relevance, as it illustrates that the efficiency of mobility

investments depends heavily on the coordination of infrastructure, services, and user decision-making.

### **Cluster 2: Policy, transition and multilevel governance**

Cluster 2 (C2) comprises the terms accessibility, barriers, climate change, electric vehicles, integration, multilevel governance, multilevel perspective, policy, sustainability transition, and transition. Evidently, this is the cluster where sustainable urban mobility is explicitly treated as a transition process governed by policies, multi-level coordination, and the management of implementation barriers. The co-occurrence of terms like transition, policy, multilevel governance, and electric vehicles indicates that the literature here is concerned not only with the strategic direction of change but also with the concrete difficulties of coordinating local, regional, and national levels.

Conceptually, C2 reflects a shift from descriptive approaches of sustainable mobility towards a literature deeply engaged with policy mixes, institutional coherence, implementation roadblocks, and the role of public actors in accelerating the transition. The fact that barriers and accessibility coexist with multilevel perspective and policy suggests that transition is viewed here as an equally technical, institutional, and social process, where success hinges on the quality of interactions among policies, infrastructures, and target groups.

The bibliographical support is highly cohesive. Studies emphasize the role of cities in coordinating interactions between mobility regimes and stimulating niche innovations within the sustainability transition. It is further pointed out that multilevel governance structures can bolster the design and implementation of sustainable mobility plans by clarifying responsibilities and facilitating access to resources and networks. Evidence proves that interventions aimed at reducing car usage can serve as highly effective transition experiments when backed by credible policy packages and local collaboration. Regarding electrification, it is argued that electric vehicle policies only yield sustainable outcomes if they are embedded within a coherent multilevel governance logic and coordinated across decision-making tiers.

In summary, C2 represents the cluster of transition regulated by policy and institutional coordination. It shows that sustainable urban mobility cannot be reduced to spontaneous technological change, as it fundamentally relies on policy configuration, stakeholder articulation, and the management of implementation barriers. The strong focus on multilevel governance and transition makes this cluster one of the most closely aligned with public policy and management agendas.

C2 indicates that the success of the transition depends on the institutional capacity to integrate policies, resources, and responsibilities. The central tension lies not abstractly between change and inertia, but between fragmented visions and governance frameworks capable of orchestrating the transformation. From an economic perspective, this cluster is vital because it reveals that transition inefficiencies frequently stem from the vertical and horizontal misalignment of policies.

### **Cluster 3: Smart mobility, digital innovation and automation**

Artificial intelligence, self-driving cars, innovation, mobility as a service, smart cities, smart mobility, and sustainable transportation make up Cluster 3 (C3). This cluster is smaller than the others and has a clearer focus on the digital and technological aspects of urban mobility change. The phrases AI, autonomous vehicles, and MaaS point to a corpus of research that examines sustainable mobility from the prisms of integrated services, smart infrastructure, and new digital architectures for transportation systems.

However, C3 is more than just a technology cluster. The connection between the terms smart mobility and sustainable transport suggests that the conversation is about the connections between innovation, governance, and sustainable outcomes rather than just the technical

performance of digital solutions. In this way, the cluster represents a still-developing corpus of literature that critically assesses the potential of automation, efficiency, and optimization considering systemic integration and the more general objectives of urban mobility.

The supporting articles confirm this duality between technological promise and the need for governance. Research shows that smart mobility and sustainable mobility are not entirely overlapping concepts and that the data-driven orientation of the former does not automatically guarantee sustainable outcomes. Organizations that can integrate AI into their IT asset lifecycle management (ITALM) strategies can achieve their sustainability goals much more easily (Crasoveanu et al., 2024). Other studies discuss the concept of Autonomous Shuttle-as-a-Service, emphasizing that autonomous local services can expand sustainable mobility but simultaneously raise challenges related to governance, acceptance, and integration into existing urban systems. Furthermore, the literature on MaaS within the broader intersection of these fields shows that the integration of services, data, and algorithms becomes relevant only when evaluated alongside implications for sustainability, coordination, and the urban services model. Following the same logic, recent research on the use of AI and Big Data in urban mobility warns that technocentric solutions may miss sustainability goals if they are detached from planning needs and the involvement of institutional actors.

Therefore, C3 can be understood as a cluster of mobility-oriented digital innovation, but one that is still in a phase of conceptual negotiation between technological efficiency and sustainable relevance. Its small size in terms of semantically assigned articles does not indicate a lack of importance, but rather that this area is still less established and more dependent on its connections with the other clusters.

C3 demonstrates that mobility digitalization shouldn't be viewed as a conclusion. The capacity to steer clear of a purely technocentric shift and connect AI, automation, and MaaS to a more general public goals will determine the managerial and economic usefulness of smart mobility. Practically speaking, the cluster indicates that smart mobility's future will rely more on its integration into reliable forms of government and services than on technological innovation.

#### **Cluster 4: Governance, transport policy and active urban mobility**

Walking, urban mobility, transportation policy, infrastructure, cycling, and governance make up the fourth grouping. This cluster can be considered the main core of the field because it has the largest share in the categorized corpus. Cluster 4 (C4) concentrates on urban mobility governance as a matter of infrastructure, policy, and the reconfiguration of active modes, in contrast to C1, which emphasizes the connection between planning and behavior, or C3, which emphasizes digital innovation.

The thematic significance of the cluster derives from the proximity between governance, transport policy, urban mobility, and walking/cycling. This combination indicates that current literature places increasing importance on the concrete transformation of urban space through policies and infrastructure that support active mobility, reduce dependence on cars, and seek to institutionalize new modal hierarchies. In this cluster, sustainable mobility appears less as a modeling issue and more as a matter of implementation, coordination, and urban prioritization.

The literature review is substantial. Research shows that the formulation and implementation of urban mobility policies often suffer from poor coordination, limited resources, and excessive prioritization of large-scale projects, without improvements that users can feel. Evidence indicates that the delivery of infrastructure for active travel depends on polycentric governance processes and coordination across jurisdictions. It is further suggested that micromobility often remains caught in a “policy vacuum,” where governance tools are reactive rather than transformative. Active mobility is explicitly linked to urban regeneration and the redesign of open space, while systemic analyses of the future of urban mobility highlight the interdependence between infrastructure, participation, policy, and sustainability. In the same vein,

studies show that strategies for walking and cycling are increasingly present in contemporary urban mobility policies.

In general, C4 represents an area where land use, infrastructure, and mode prioritization are directly impacted by the treatment of sustainable urban mobility as a concrete urban governance issue. As a result, its high percentage in the corpus is not accidental; rather, it indicates the shift in research toward implementation-related issues and the successful reconfiguration of urban systems.

C4 is most likely the cluster with the most management and policy relevance. It shows that for the urban mobility shift to be credible, infrastructure, laws, and coordinating processes that effectively change travel conditions are required. This perspective holds that active mobility is not a soft addition to transportation policy, but rather one of the fundamental areas where the urban system is reoriented.

### TIE: Bridges between clusters

There is substantial thematic overlap in the literature on sustainable urban mobility, as evidenced by the 127 articles in the TIE category, nearly one-third of the corpus. Table 4 shows the most common combinations, which are C2-C4 (41 articles), C1-C4 (22), C3-C4 (17), and C1-C2 (12). These are followed by more complicated combinations, including C1-C2-C4 (88) or C2-C3-C4 (77).

**Table 4. Links within the TIE section**

Bridge type	Number articles
C3-C4	17
C2-C4	41
C2-C3-C4	7
C2-C3	6
C1-C4	22
C1-C3-C4	3
C1-C3	2
C1-C2-C4	8
C1-C2-C3-C4	9
C1-C2	12
<b>Total</b>	<b>127</b>

This profile makes it evident that C4 serves as a hub linking the other clusters: planning and smart mobility typically join the dominating field through bridges relating to governance and implementation, while policy and transition frequently link with urban mobility and infrastructure.

From an interpretive standpoint, the most important link is C2-C4. This indicates that recent literature does not rigidly separate transition policies from urban infrastructure and transportation policy but rather discusses them together. For example, research shows that mobility hubs only make sense if they are addressed simultaneously as issues of modal integration and multi-stakeholder governance. Following the same logic, other studies demonstrate that climate leadership and integrated policy packages for urban mobility depend on governance frameworks capable of linking institutional coordination to concrete intervention tools.

Bridge C1-C4 indicates the relationship between planning/behavior and governance/infrastructure. Here, review and integrative analysis studies show that the redesign of urban mobility requires a connection between planning, land use, shared mobility, and policy instruments applied at the urban level. Bridge C3-C4 suggests that smart mobility and digitalization are addressed in literature primarily when discussed in conjunction with governance and implementation issues. Studies show that the relationship between smart mobility and car sharing is

structurally complex, precisely because it combines technology, service models, and policy intervention. Finally, the C1-C2 link highlights the connection between behavioral change and policy experiments, which is consistent with broader reviews on micro-mobility and interventions to reduce car use.

Overall, TIE shows that the field’s structure is better described as a network of convergences than as a set of rigid compartments. This is an important finding for RQ2, as it suggests that the field’s evolution cannot be understood solely through the analysis of clusters in isolation, but also through the analysis of the bridges between them.

TIE is essential for interpreting the field, as it shows where the most relevant conceptual articulations occur. If C4 is the dominant core, TIE shows how this core connects with transition, planning, and smart mobility. In analytical terms, the bridges indicate that future strong contributions will likely be those that succeed in combining policy, infrastructure, behavior, and technology into an integrated framework, not those that treat these themes separately.

#### **4. Discussion**

The results demonstrate a conceptual framework that simultaneously addresses sustainable urban mobility as a problem of digital innovation, multilevel governance, behavioral modification, spatial planning, and transition strategies. This arrangement demonstrates that the straightforward dichotomy between technical and policy approaches is no longer sufficient to comprehend contemporary literature.

Instead, the area is moving toward an integrated logic that discusses smart solutions, public transit, active mobility, urban planning, and electrification in connection to institutional capacity for coordination and execution. To put it another way, research now focuses on how technologies and measures are developed, regulated, and successfully implemented rather than just what they are.

The four clusters show that the field has a relatively clear but not rigid conceptual core. C1 brings together the literature on the relationship between urban form, public transport, shared mobility, and travel behavior, suggesting that the transformation of mobility depends on the compatibility between the city’s spatial configuration and users’ daily choices. C2 shifts the focus toward policy mixes, transition, and multilevel governance, indicating that sustainable mobility is increasingly treated explicitly as an issue of institutional coordination and policy coherence. C3 focuses the discussion on smart mobility, AI, MaaS, and automation, but in a still cautious manner, in which digital promises are evaluated in relation to sustainability and systemic integration. C4, the dominant cluster, brings together urban mobility, governance, transport policy, infrastructure, cycling, and walking, and reflects the field’s shift toward issues of implementation, modal prioritization, and the redesign of urban space.

Consequently, the intellectual framework of the field suggests a process of maturation. While in an earlier phase sustainable mobility could be discussed in terms of general promises of emissions reduction or efficiency, recent literature is more concerned with the concrete mechanisms of the transition: who coordinates, what instruments are used, how decision-making levels are articulated, what role planning plays, and where implementation bottlenecks arise and how decisions are made under conditions of uncertainty and risk (Doltu, 2006). This finding is consistent with recent syntheses showing that sustainable mobility research is increasingly becoming a field of interactions between technology, behavior, and governance, rather than a set of parallel research strands.

The TIE analysis clearly shows that the relationships between clusters are substantial, not marginal. The strongest link, C2-C4, indicates that policy and transition are constantly connected to urban mobility, transport policy, and infrastructure. In other words, the literature does not discuss transition in the abstract, but links it to instruments, plans, infrastructure, and modal hierarchies. This is evident in works that discuss mobility hubs, climate leadership, policy packages, or electric

mobility in relation to multi-level governance frameworks and the concrete implementation of change.

Bridge C1-C4 shows that urban planning and travel behavior cannot be separated from infrastructure and governance. In this intersection, questions about land use, public transport, and shared mobility intersect with those regarding spatial allocation, stakeholder coordination, and the implementation of local strategies. Here it becomes clear that behavioral change is not merely a matter of individual preferences, but also a consequence of how cities configure mobility systems and the rules governing access to them. Similarly, the C3-C4 link shows that smart mobility becomes relevant when connected to issues of governance, publicness, and urban organization, not just technological performance.

One significant consequence of this interconnectedness is that the clusters must be regarded collectively. For instance, an isolated interpretation of C3 might point to an AI, MaaS, and autonomous car-dominated future. Its links to C2 and C4, however, demonstrate how regulation, integration, and public goals affect these solutions' acceptability and efficacy. Similarly, as C1 depends heavily on planning, policy, and infrastructure, it should not be reduced to research on travel behavior.

TIE is one of the most valuable components of the study because it functions as an internal validation of the field's structure. The fact that 127 of the 400 articles are located at the intersection of clusters shows that sustainable urban mobility is a field of convergence, where the most relevant issues do not arise within thematic silos, but at the boundary between them. This result supports the answer to the question about the links between subfields: policy, infrastructure, planning, and smart mobility co-evolve.

Furthermore, TIE also highlights an epistemological feature of the field: the most compelling literature is increasingly the kind that combines multiple perspectives. For example, recent reviews on smart mobility and car sharing, or on sustainable mobility and transportation as a whole, no longer operate with separate categories but instead seek to map the very relationships between technology, behavior, and governance.

A primary tension is that between performance and accountability. Digital solutions, AI, automation, and smart systems are frequently presented as effective responses to congestion, optimization, and coordination. However, the literature shows that these solutions can exacerbate problems of integration, equity, or dependence on technocentric logics if they are not properly governed. In other words, operational performance does not automatically guarantee sustainability, and the literature is increasingly attentive to the institutional and social costs of seemingly neutral efficiency. A second tension concerns the relationship between personalization and public interest. MaaS, car sharing, and smart services tend to personalize the mobility experience and tailor the offering to user preferences. But this personalization can conflict with systemic goals of reducing traffic, supporting public transport, and ensuring equitable access. For this reason, studies in the field of MaaS and smart mobility emphasize the risk that algorithmic nudging, imperfect integration of the service offering, or dominant business models may undermine sustainable outcomes in the absence of clear public objectives and coordination rules. A third tension is that between electrification/decarbonization and genuine systemic change. Several studies show that electric vehicles or charging infrastructure can play an important role in reducing emissions, but they do not, on their own, solve the problems of car dependency, urban fragmentation, or rigid modal hierarchies. This means that electrification without policy reform, without integration with public transit, and without active mobility risks producing an incomplete transition: cleaner in terms of energy, but not necessarily more efficient or more equitable in urban settings.

For urban practitioners and administrators, the study's findings suggest that sustainable mobility management must move beyond a piecemeal approach. Decisions regarding infrastructure, services, data, active mobility, or electrification should not be treated in isolation, as the literature shows that their value depends on the overall coherence of the system. For this reason, effective

urban management requires coordination between transportation planning, land use, public transportation, and shared mobility, as well as the development of coordination mechanisms among operators, authorities, and other stakeholders.

A second managerial implication concerns the need for institutional design of the transition. It is not enough to have strategies or plans; the literature shows that barriers persist precisely when institutional roles are unclear, funding is narrowly focused, and coordination across levels is weak. In practical terms, this means that public and urban managers must treat sustainable mobility as a matter of orchestration, not just delivery.

At the policy level, the study supports the idea that sustainable urban mobility requires integrated, multilevel frameworks. Local policies are crucial, but their effectiveness depends on their compatibility with financial, regulatory, and strategic instruments at higher levels. Therefore, inconsistent policy mixes or contradictions between local objectives and national mechanisms can slow down the transition, even when there is political will at the urban level.

Furthermore, the results show that the governance of active mobility and urban infrastructure must be taken much more seriously. Walking, cycling, and micromobility do not appear in the network as peripheral themes, but as parts of the dominant core, alongside governance and transport policy.

### **Future research agenda**

The future research agenda should explore at least four areas in greater depth. The first is a more detailed analysis of implementation mechanisms: many studies identify strategies and objectives, but few explain in detail why some institutional arrangements succeed and others fail. The second direction is the relationship between smart mobility and effective sustainability, particularly regarding AI, MaaS, platformization, and data governance. The third concerns spatial equity and accessibility, themes that appear in the network but are still less developed than policy or technology. The fourth direction is the development of comparative research on the thematic bridges identified by TIE, particularly between C2-C4 and C1-C4, to better understand how planning, policy, and active mobility combine in different urban contexts.

In conclusion, the discussion validates the field of sustainable urban mobility. For this reason, this study is valuable not just because it describes the clusters but also because it shows how coordination, implementation, and integration issues are becoming more and more prominent in the literature. In actuality, here is where the revolution lies, not in the presence of distinct solutions, but rather in the ability of urban systems to integrate them.

### **5. Conclusion**

The analyses carried out in this article emphasize the importance of grouping in understanding the various components of sustainable urban mobility. The content of the four clusters planning and travel behavior, policy and multilevel governance, smart mobility, and governance and active mobility captures key areas of focus in the field, reflecting a spectrum of transition needs. Sustainable mobility extends beyond technical infrastructure to include institutional coordination, policy integration, and behavioral change. Policymakers and urban administrators can leverage these insights to design frameworks that address the full spectrum of urban transformation, contributing to a sustainable and well-governed metropolitan environment. Thus, some suggestions are required for future urban mobility strategies:

- Urban planning initiatives should focus on fundamental areas such as integrating public transport, shared mobility, and land-use policies, ensuring that spatial design actively encourages positive behavioral shifts and reduces private car dependency.
- Local and regional authorities should develop governance frameworks that emphasize policy coherence, including strategies for multilevel coordination to bridge the gap between

local climate actions and national regulatory mechanisms. Programs could also integrate collaborative mechanisms to address financial and legal implementation barriers.

- Smart mobility and technological actors should embed digital innovations (such as AI, autonomous vehicles, and Mobility as a Service) within clear public objectives. These solutions must prioritize spatial equity, systemic integration, and sustainable outcomes over purely technocentric efficiency.
- Supporting the development of comprehensive, tailored infrastructure for active modes (walking and cycling) that addresses the specific needs of the urban environment. These interventions should be treated not as peripheral additions, but as core components of urban regeneration, reducing transport emissions, and promoting systemic resilience.

This study underscores the multifaceted nature of the transition to sustainable mobility, linking it to infrastructure, policy, and behavioral adaptation. While digital innovation and electric vehicles provide essential tools that support these outcomes, the core emphasis remains on integrated governance as a driver of institutional change and systemic resilience. Policymakers and urban planners should prioritize cohesive mobility plans that address local structural bottlenecks, leveraging multilevel coordination to enhance implementation and impact.

By analyzing 400 scientific articles using bibliometric methods and the VOSviewer software, this study identified key thematic clusters that highlight the various aspects of sustainable mobility and its integration into urban governance. Cities are increasingly moving beyond isolated pilot projects, adopting comprehensive frameworks that combine spatial planning, policy mixes, and smart mobility hubs. Collaborative initiatives between public authorities, private operators, and the community provide the necessary alignment to test, manage, and scale these complex interdisciplinary projects successfully.

In conclusion, the sustainable transition of urban mobility is often hindered by a combination of "policy layering," institutional fragmentation, and a lack of coordination. Addressing these barriers requires coordinated efforts by local governments, planning institutions, and operators to prioritize sustainable infrastructure and recognize its critical role in meeting both local needs and global climate goals. Overcoming these challenges requires coordinated efforts among decision-makers to ensure equitable access to alternative mobility options and the coherent adoption of green technologies.

The intersection of transition management and urban planning is a dynamic and evolving field with the potential to drive both environmental sustainability and societal progress. By using integrated strategies to address infrastructural and behavioral gaps, institutions and governments can foster a mobile population, enhance urban quality of life, and build resilience in the face of global pressures. Future research should explore deeper interconnections, particularly the thematic bridges between active mobility, policy, and planning, and develop comparative studies to understand how these elements combine in diverse metropolitan contexts.

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