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Assessing the impact of Mobility-as-a-Service (MaaS) on sustainable urban travel behaviors: a systematic literature review

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Mobility-as-a-Service (MaaS) is widely promoted as a way to reduce car dependency and encourage sustainable urban mobility, yet its actual environmental contribution remains unclear. This article presents a systematic literature review of 85 studies conducted in line with PRISMA guidelines to identify and analyze the elements within the MaaS ecosystem that influence sustainable travel behaviors. The evidence base spans multiple disciplines including psychology and behavioral sciences, sustainable development, urban planning, and transportation engineering, with most studies adopting cross-sectional survey approaches rather than examining longitudinal behavioral change or multimodal system integration. Findings show that adoption is consistently driven by convenience, affordability, technological appeal, and service reliability, while explicit sustainability motivations play a secondary role. Public transport integration, pricing structures that favor low-emission modes, and targeted subsidies for disadvantaged groups are linked with positive sustainability outcomes, whereas shared mobility services such as bike-sharing, e-scooters, and ride-hailing often substitute for existing low-emission modes rather than replacing private cars. Moreover, MaaS bundles that include car-based services can unintentionally stimulate car use, showing that measures designed to encourage adoption may work against sustainability goals. To address these challenges, the paper develops a conceptual framework that illustrates how governance arrangements, economic incentives, service design choices, and user engagement strategies interact to shape both platform uptake and environmental impacts. This framework emphasizes that adoption and sustainability are driven by different mechanisms and often work against each other, which highlighting the need for coordination to ensure that MaaS strengthens, rather than undermines, transitions toward sustainable urban mobility.

KEYWORDS

Mobility-as-a-Service (MaaS), sustainable urban mobility, shared mobility, travel behavior, systematic literature review (SLR)

1 Introduction

With the advancement of Information and Communication Technologies (ICTs), Mobility-as-a-Service (MaaS) has emerged as a response to the increasing demand for diverse and seamless travel experiences, driven by innovations in digital mobility services (Cruz and Sarmento, 2020; Maas, 2022; Militão et al., 2025). MaaS integrates various mobility services, such as car-sharing, bike-sharing, e-bike-sharing, and ride-hailing, into a cohesive digital platform, facilitating a shift away from private vehicle ownership and toward shared, accessible transportation solutions (Caiati, 2024; Lopez-Carreiro et al., 2020). Designed to offer flexible and personalized travel options, MaaS provides tailored mobility packages that accommodate diverse user needs, including business travel, family outings, and urban commuting (Expósito-Izquierdo et al., 2017; Giesecke et al., 2016; Hesselgren et al., 2020). At its core, MaaS employs ICT-driven service bundling, collaboration, and interconnectivity to create an integrated mobility ecosystem that connects transport providers and users in real time (Jittrapirom et al., 2017; Li, 2022; Lopez-Carreiro et al., 2023).

While significant attention has been given to the environmental, social, and economic benefits of MaaS, there is a growing recognition of the need to explore how these integrated benefits collectively shape individual travel behavior, establishing MaaS as a key driver of sustainable transportation (Alyavina et al., 2020; Carbonara et al., 2024; Cruz and Sarmento, 2020; Dadashzadeh et al., 2024; Labee et al., 2022). In line with global sustainability objectives, including the United Nations Sustainable Development Goals (SDGs), in particular SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), MaaS has been identified as an effective strategy for reducing reliance on private vehicles and reducing carbon emissions (ERTICO - ITS Europe, 2019; International Transport Forum (ITF), 2021). By facilitating multimodal travel and reducing reliance on private cars, MaaS has the potential to encourage more sustainable travel patterns (Mulley et al., 2018; Nikitas, 2018; Pritchard, 2022). Beyond immediate behavioral choices, MaaS can foster long-term shifts toward shared mobility, reinforcing sustainability-oriented travel habits (Decker et al., 2023). However, despite increasing recognition of MaaS's potential, existing research often examines its behavioral impacts in isolation, focusing on specific factors such as social norms, user perceptions, and service design while neglecting their interdependencies and broader systemic influences (Schikofsky et al., 2020; Zhang et al., 2016) This lack of integration fails to consider the interconnections between these factors and how they work together to influence users' usage and sustainable travel behavior. Additionally, while studies acknowledge the importance of individual factors, such as psychological dimensions (Pellegrini and Tagliabue, 2024; Schoenau and Müller, 2017), and external influences, such as infrastructure design (Blitz and Lanzendorf, 2020; Schoenau and Müller, 2017), the combined effects of these elements within the broader MaaS ecosystem remain underexplored. To bridge this gap, a holistic framework is needed to capture the interdependencies between policy, technology, infrastructure, economic incentives, and user behavior, providing a more comprehensive perspective on MaaS-driven mobility transitions.

This paper aims to develop a conceptual framework that identifies and analyzes the factors within the MaaS ecosystem that encourage individuals to adopt sustainable travel behaviors. Through a systematic literature review, this study synthesizes existing research to explore the relationship between MaaS and sustainable mobility, guided by the following research questions, which are operationalized in the Methods section using the PICOS framework:

What role does MaaS play in promoting sustainable travel behaviors among users, and how do these behaviors vary across different user groups and contexts?

How do different transport modes within the MaaS ecosystem (e.g., shared cars, shared bikes, ride-hailing) contribute to sustainable travel behaviors, and what are the key themes emerging from their study in MaaS research?

What factors drive MaaS adoption, and how do these factors interact to influence sustainable travel choices?

To address these questions, **Section 2** outlines the review methodology; **Section 3** presents the research findings on MaaS adoption and sustainable travel behavior; **Section 4** develops a conceptual framework for understanding MaaS-sustainability dynamics; and **Section 5** offers conclusions and directions for future research.

2 Methods and materials

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, applying a structured and transparent framework to identify, select, and synthesize relevant literature (Page et al., 2021). The review is guided by the research questions stated in the Introduction and follows the PICOS framework to ensure alignment between study aims and eligibility criteria (Table 1). This methodology ensured a comprehensive analysis of existing research on the role of MaaS in promoting sustainable travel behavior while enhancing reproducibility, minimizing bias, and increasing the reliability of the systematic literature review process. The review employed a comprehensive search strategy across four major academic databases: ACM, IEEE Xplore, Web of Science (WoS), and Scopus to ensure disciplinary breadth. To complement peer-reviewed sources and minimize the risk of publication bias, selected gray literature was also included, such as industry reports, technical guidelines, and white papers (Godin et al., 2015; Paez, 2017). Gray literature inclusion is particularly justified in MaaS research given the rapidly evolving nature of the field, where implementation insights and policy developments often emerge through institutional reports before appearing in peer-reviewed literature (Adams et al., 2017). While gray literature may lack formal peer review processes, its inclusion provides essential insights into operational practices, policy frameworks, and emerging market conditions that are critical for understanding real-world MaaS implementation challenges and opportunities. To mitigate risks related to credibility and relevance, only gray sources from recognized institutions or established industry bodies were considered. Additionally, given the interdisciplinary scope of this topic, which spanning urban planning, sustainable development, information technology, behavioral science, and transport policy, the choice of databases was made to ensure broad and representative coverage of both technical and applied

TABLE 1 Inclusion and exclusion criteria for literature selection.

PICOS element	Inclusion criteria	Exclusion criteria
Population (*P*)	Urban transport users (individuals or groups) in metropolitan contexts, including different demographic segments.	Studies focused exclusively on rural, tourist, or non-urban contexts.
Intervention (*I*)	MaaS platforms, integrated mobility services, or individual shared mobility services (e.g., bike-sharing, car-sharing, ride-hailing) when examined in the context of multimodal urban mobility systems or sustainable transport transitions.	Studies focusing solely on private vehicle use, freight/logistics, or tourism-related mobility without any connection to shared mobility services or multimodal urban mobility systems. Studies examining purely technical infrastructure (e.g., traffic signals, road design) without user behavior or service integration components.
Comparator (*C*)	Baseline travel patterns, traditional transport modes, or pre-MaaS mobility behaviors. Studies examining different MaaS configurations or service bundles are included when they provide insights into sustainable travel behavior changes.	Studies lacking any reference point for behavioral or system change (e.g., purely descriptive studies without baseline or comparative analysis). Evaluations of transport systems completely unrelated to urban passenger mobility (e.g., freight logistics, aviation, maritime transport).
Outcomes (*O*)	Behavioral and/or environmental impacts, including modal shift, reduced car dependency, changes in emissions, congestion, or accessibility.	Studies focusing solely on technical system design, operational logistics, or economic modeling without behavioral or environmental outcomes.
Study design (*S*)	Empirical studies employing quantitative, qualitative, mixed-methods, case study, or field trial approaches.	Theoretical papers, conceptual frameworks, editorials, or literature reviews without original empirical data.

research (Ariza-Colpas et al., 2024; Valente et al., 2022; Zhu and Liu, 2020).

2.1 Search strategy

The literature search strategy was designed using comprehensive Boolean logic, targeting studies focused explicitly on how MaaS influences sustainable travel mode choices in urban contexts. The search string combined multiple synonymous and alternative terms to ensure an inclusive and extensive search across titles, abstracts, and keywords:

TITLE-ABS-KEY[("Sustainable Transport*" OR "Eco-friendly Travel" OR "Sustainable Mobility" OR "Low-carbon Transport" OR "Green Transport") AND ("Travel Behavior" OR "Travel Pattern" OR "Mobility Behavior" OR "Transport Behavior" OR "Mode Choice" OR "Modal Shift") AND ("Shared Car*" OR "Car sharing" OR "Shared Bike*" OR "Bike Sharing" OR "Shared electronic Bike*" OR "E-bike Sharing" OR "Shared Scooter*" OR "Shared Mobility" OR "MaaS" OR "Mobility-as-a-Service" or "Mobility as a Service" OR "MaaS trial*") AND ("City*" OR "Urban" OR "Metropolitan")]

The search covered peer-reviewed journal articles and conferences papers published in venues with editorial or peer-reviewed standards, as well as relevant gray literature published up to May 2025. Initially, 2,402 records were initially retrieved. Articles were first screened to remove duplicates, non-English publications, and those lacking full-text availability (e.g., abstracts-only conference proceedings), thus ensuring the comprehensiveness and quality of the analysis (Song et al., 2010). Review articles were excluded to prevent double-counting of primary data (Edinger and Cohen, 2013). This initial screening process reduced the dataset to eight hundred and fifteen papers.

Following the initial screening, a second stage was conducted to assess the relevance of the remaining articles through a review of their titles and abstracts. This step focused on determining alignment with the study's aims, particularly the relationship between MaaS, sustainable urban mobility, and travel behavior. Articles clearly unrelated to these key themes were excluded at this stage. For example, studies focused exclusively on rural or tourist contexts were excluded, as their transportation dynamics, such as lower population densities and seasonal travel patterns, which differ markedly from urban settings where MaaS is most applicable (Li and Voege, 2017; Maas, 2022; Martinčević et al., 2022; Mitropoulos et al., 2023). This stage resulted in a refined set of 197 articles for full-text review.

The final stage involved a detailed, full-text review using predefined inclusion and exclusion criteria (Table 1), which were developed to ensure alignment with the research objectives and support a consistent and transparent evaluation process. This review was independently conducted by two authors, with disagreements resolved through discussion to enhance reliability and minimize selection bias. Additionally, backward and forward citation tracing methods were utilized to identify relevant studies potentially missed through database queries (Hirt et al., 2021). Following this comprehensive screening process, eighty five studies were included in the final synthesis: sixty four from full-text review and twenty one additional records (twelve from citation tracing, nine gray literature sources). The PRISMA flow diagram (Figure 1) provides a visual summary of the review process and exclusion rationale at each stage. A complete summary of all included studies is provided in Supplementary Table S1.

2.2 Data extraction and synthesis

To facilitate a consistent and rigorous synthesis process, two authors independently extracted key information from each included study using a standardized data extraction template. After initial extraction, the results were then cross-checked and consolidated into a shared spreadsheet following discussion and consensus. The recorded variables included the article title, authorship, year of publication, publisher, country or region studied, research methodology, participant demographic

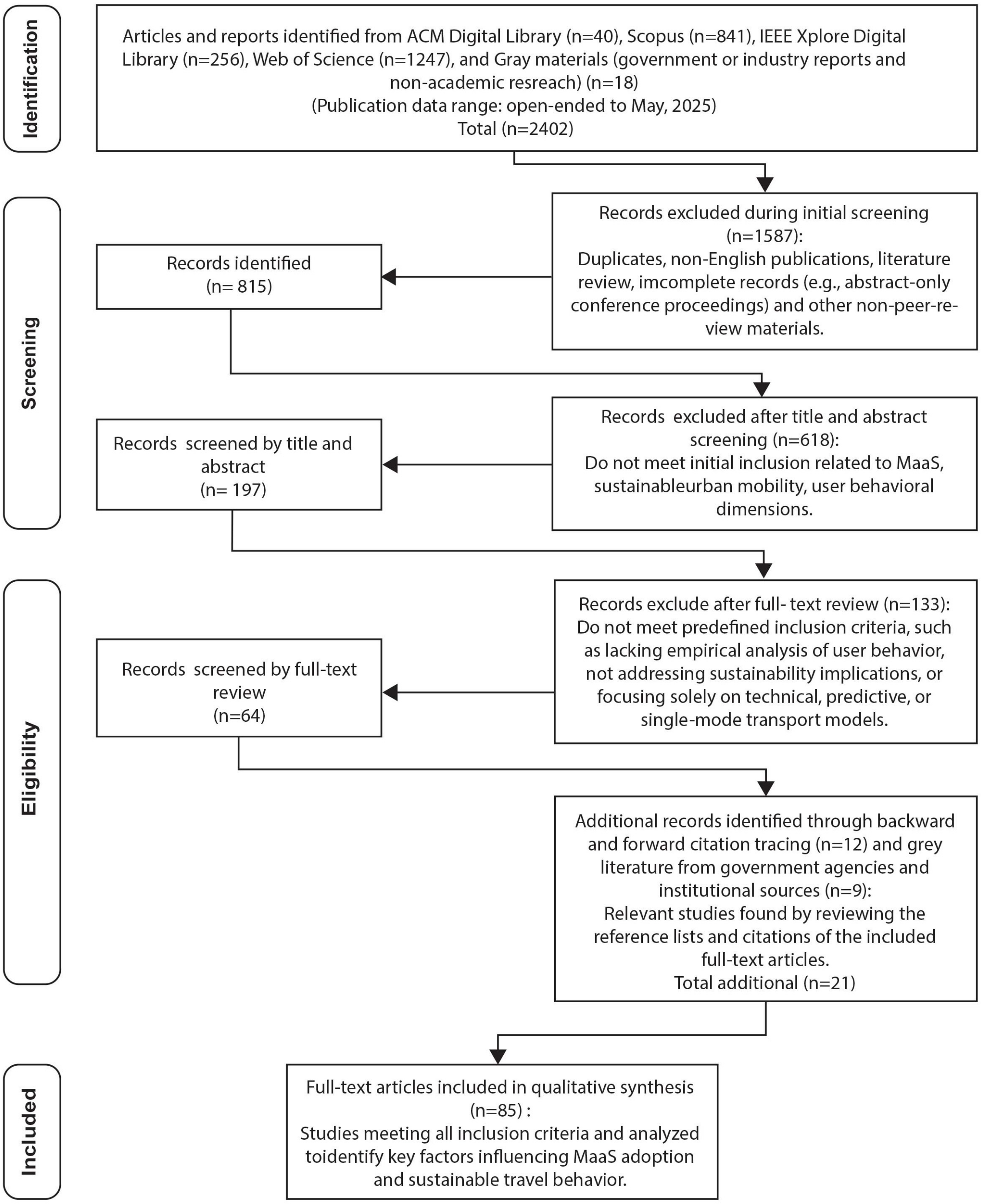

FIGURE 1
Procedure for systematic literature search.

characteristics, relevant MaaS modes, and key findings. This process helped reduce the risk of omission and improved the transparency and reliability of the review.

Dues to the diversity of methodological approaches and research contexts among the included studies, such as surveys, interviews, and case studies, a quantitative meta-analysis was not feasible. Instead, a mixed-methods synthesis was employed, integrating descriptive analysis to map research characteristics and systematic analysis organized around the three guiding research questions to examine MaaS adoption and sustainable travel behavior patterns. This synthesis approach included systematic comparison across studies to examine variations in findings, assess evidence quality across different contexts, and identify areas where evidence converges or diverges in relation to each research question. Data extraction and coding were conducted using NVivo software, which enabled the systematic categorization of findings according to the research question framework: (1) user group differences in MaaS adoption and sustainable behavior, (2) transport mode contributions to sustainable travel behaviors, and (3) adoption factors and their interactions. This iterative coding process organized findings into research question-focused categories. Coding was performed by one author and verified by the second, with iterative discussions to resolve discrepancies, and cross-checking with the raw data to ensure rigor and comprehensiveness of the analysis (Houghton et al., 2017).

3 Findings

This section presents an integrated assessment of the MaaS and sustainable mobility literature, addressing the research questions through systematic synthesis of existing evidence. The analysis identifies patterns in findings, acknowledges methodological variations, and synthesizes mixed evidence to provide a comprehensive understanding of MaaS impacts on sustainable travel behaviors.

The findings are organized into three complementary analytical dimensions: First, bibliometric analysis maps the research landscape, identifying concentration areas and research gaps; Second, methodological assessment examines the range of research approaches employed, noting variations in study design and their implications for findings; Third, thematic synthesis ievidence across multiple studies to identify key factors influencing MaaS adoption and behavioral change toward sustainable mobility.

3.1 Temporal and network analysis of MaaS research development

Academic research on MaaS has gradually evolved from early conceptual discussions to a more practice-oriented and interdisciplinary field. As shown in Figure 2, the period from 2015 to 2017 saw limited publication activity, and with a primary focus on technical and conceptual work within Transportation Engineering and Information Technology. These initial contributions laid theoretical foundations but remained largely untested in practical contexts. After 2018, publication volume increased notably, accompanied by a broadening of disciplinary engagement. In particular, contributions from Psychology, Behavioral Sciences, and Urban Planning became more prominent. This shift reflects growing academic interest in understanding how MaaS functions in real-world settings—emphasizing user behavior, governance, and policy integration, in addition to technical feasibility. Research during this period increasingly examined implementation processes and challenges, reflecting a shift toward more empirical and applied investigations. By 2022, studies grounded in behavioral and psychological approaches accounted for a significant portion of the literature, highlighting the field's growing interest in connecting system design with user engagement and policy support.

At the same time, this evolving focus raises important questions about how well current research aligns with MaaS's sustainability goals. Although MaaS is frequently positioned as a strategy to promote sustainable mobility, Figure 2 shows comparatively limited engagement from disciplines such as Sustainable Development and Environmental Studies during the same period that practical implementations expanded globally. While research into user behavior and system operations has gained prominence, there appears to be less systematic attention to evaluating whether MaaS delivers on its environmental and equity-related promises. This trend invites further reflection on research priorities and whether sufficient evidence is being generated to support sustainability-oriented decision-making.

Co-citation network analysis further examines the intellectual foundations of MaaS sustainability research. As visualized in Figure 3, three primary research clusters have emerged: a core transportation research cluster centered around Transportation Research journals (Parts A, C, and D), a sustainability-focused cluster including environmental and energy journals, and a behavioral sciences cluster encompassing psychology and urban planning perspectives. These clusters demonstrate the field's interdisciplinary nature but also suggest limited intellectual integration across disciplinary boundaries.

Transportation Research journals occupy central positions, reflecting their role as primary venues for MaaS empirical studies and methodological approaches. In contrast, journals with a focus on sustainability are included in the network but tend to be positioned at the margins, particularly when compared to the dense connections among transportation-focused publications. This distribution suggests that, although sustainability is often cited as a guiding objective of MaaS, environmental evaluation has not yet become a central concern within the core empirical literature, which remains more strongly oriented toward technical, policy, and behavioral aspects of implementation.

While the presence of multiple clusters reflects the field's interdisciplinary scope, the network also points to limited cross-referencing between domains whose integration is critical to advancing MaaS as a sustainable solution. Connections between behavioral science and sustainability journals remain relatively weak, despite the clear relevance of both perspectives to understanding how MaaS can support environmental goals through changes in individual travel behavior. Likewise, journals focused on urban planning and information technology are positioned at the margins of the network, suggesting that important spatial and digital aspects of MaaS have not been fully integrated into the core research dialogue. Policy journals tend to draw more heavily on technical transportation studies than on environmental or social science literature, which may limit the development of more holistic or innovative policy approaches. Overall, while the field has attracted contributions from multiple disciplines, closer intellectual exchange is still needed to address the complex challenges of implementing MaaS as a truly sustainable mobility solution.

3.2 Evaluating research methods in MaaS studies

This section provides a critical evaluation of methodological approaches across the 85 reviewed studies, examining how different research designs affect findings reliability and contribute

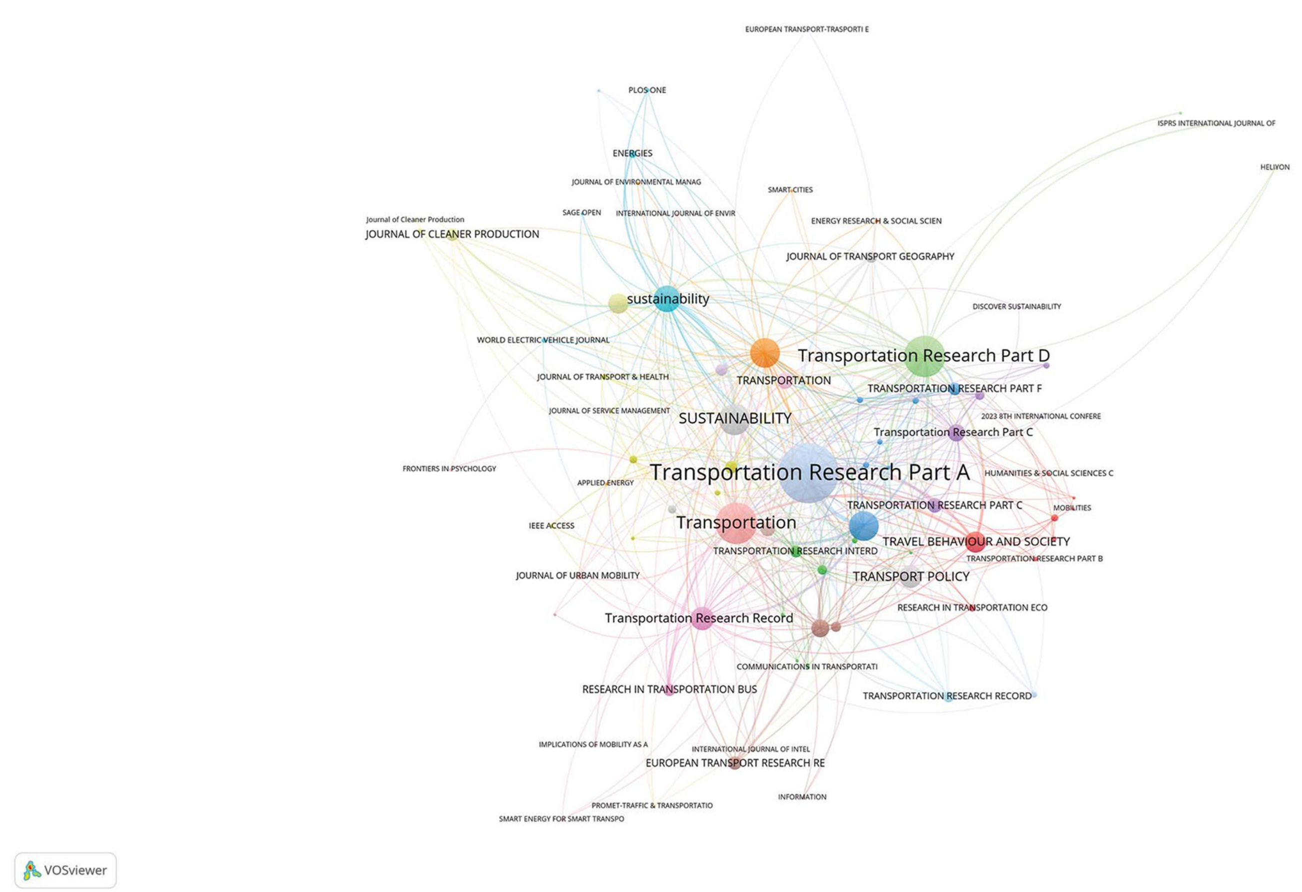

FIGURE 2
Temporal distribution of MaaS and sustainable travel behavior research by disciplinary field.

to inconsistent results in the literature. Survey-based approaches dominate the MaaS literature, with quantitative cross-sectional studies representing the largest category ($n = 49$), complemented by stated choice experiments ($n = 5$) that explore hypothetical adoption scenarios. These studies typically apply statistical techniques such as structural equation modeling, logistic regression, and factor analysis, often drawing on the Theory of Planned Behavior and the Technology Acceptance Model. While these approaches provide rigorous evidence on attitudes, preferences, and adoption intentions, their reliance on cross-sectional designs and self-reported data means that they primarily capture perceptions and short-term intentions rather than sustained behavioral change. Empirical findings from the reviewed studies show that environmental attitudes often fail to translate into sustained behavior change, with convenience being a stronger motivator than environmental concerns (Acheampong et al., 2021). However, the predominant use of cross-sectional designs limits our confidence in understanding these relationships over time. Longitudinal field experiments ($n = 8$) address this limitation by tracking actual travel behavior over time through multi-source data, thereby moving beyond one-time assessments or self-reported intentions. Sochor et al. (2016) UbiGo trial in Sweden illustrates this approach through mixed-method design combining questionnaires, interviews, travel diaries, and usage data to reveal both behavioral changes and underlying user motivations. Similarly, Hensher et al. (2021) Sydney MaaS field trial demonstrates how integrating multiple data sources with joint discrete-continuous modeling can examine the relationship between subscription bundle choices and travel behavior patterns.

Mixed-methods studies (n=6) further strengthen the evidence base by triangulating quantitative behavioral data with qualitative insights. For example, Henderson et al. (2022) combined secondary car club membership data with semi-structured interviews to understand behavior change, while Hartl et al. (2018) integrated a cross-sectional survey, an experimental design, and exploratory interviews. These designs provide detailed causal accounts of how adoption connects to everyday travel choices and allow for more accurate calibration of models that might otherwise overstate adoption effects. Similarly, qualitative studies ($n = 5$) using interviews and focus groups provide deep contextual insights understanding of how travelers interpret MaaS and adapt it within their daily mobility routines. Policy and guidance documents ($n = 8$) complement empirical research by synthesizing implementation experiences across diverse contexts, helping identify institutional and infrastructural factors that enable or constrain MaaS success. These analyses prove particularly valuable given MaaS's dependence on complex stakeholder coordination and regulatory frameworks that vary significantly across different

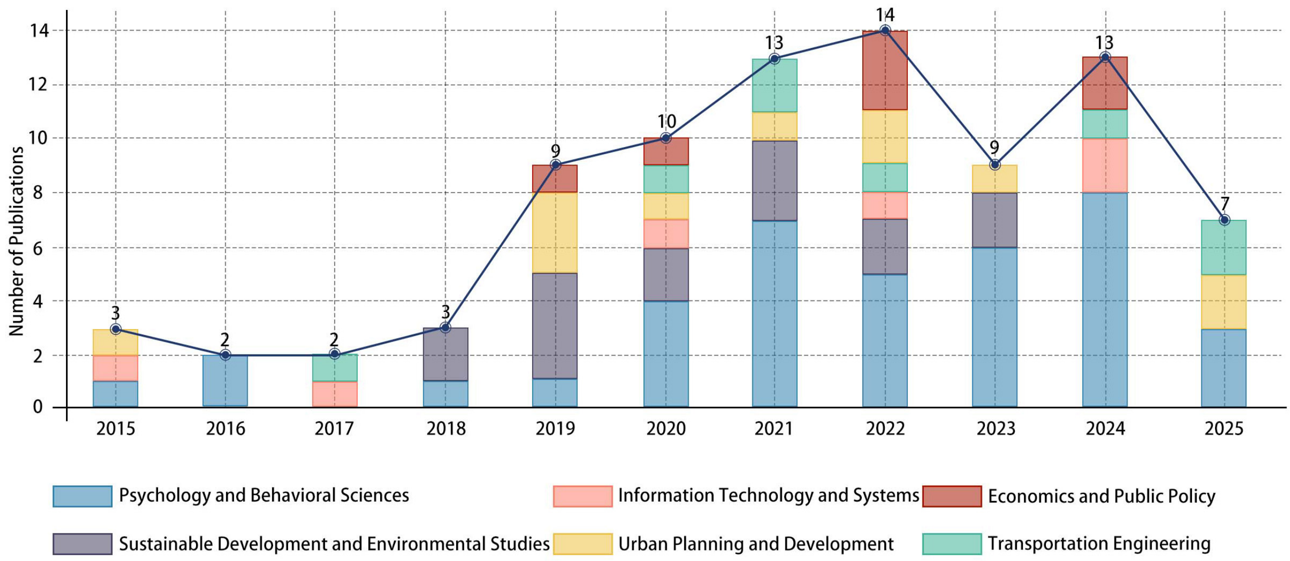

FIGURE 3
Co-citation network of key journals in MaaS and sustainable mobility research.

urban contexts. Table 2 presents the methodological diversity in studies investigating the impact of MaaS on sustainable travel behavior, highlighting the growing development of approaches over the past decade. However, the field would benefit from more longitudinal studies and real-world behavioral tracking to better understand how initial adoption translates into sustained travel behavior change.

3.3 Analyzing MaaS adoption and sustainable travel behavior

The results of the eighty five review studies revolve around three guiding research questions, examining how MaaS adoption relates to sustainable travel outcomes across diverse user groups, transport modes, and and contextual conditions. Across these dimensions, the review draws on convergent and divergent evidence, highlighting the consistency and variability of results across different contexts, study designs, or user characteristics. The analysis begins with demographic influences on adoption and sustainability, highlighting contrasting patterns across age, gender, and income groups that challenge common assumptions about technology-led sustainable mobility. It then examines how different transport modes within MaaS systems can both advance and undermine environmental goals. Finally, the synthesis identifies service design, cost, and policy incentives as the most consistently reported drivers of MaaS adoption, while also noting differences in how these drivers operate across settings and interact to shape both uptake and sustainability outcomes.

3.3.1 User group differences in MaaS adoption and sustainable behavior

Multiple studies indicate that adults under 35 adopt MaaS and other digital mobility platforms at significantly higher rates than older cohorts (Abouelela et al., 2024; Aguilera-García et al., 2022; Alyavina et al., 2024; Farahmand et al., 2021; Feneri et al., 2022; Ho, 2022; Lavieri et al., 2017; Tran et al., 2019). This tendency is often attributed to greater familiarity with digital technologies, stronger adaptability to new mobility options, and heightened environmental awareness (Eccarius and Lu, 2020; Lopez-Carreiro et al., 2020; Suchanek and Szmelter-Jarosz, 2019). However, several studies caution that the motivations driving younger users' adoption may not align with sustainability objectives. While this group is more receptive to app-based and integrated transport solutions, adoption is frequently motivated by convenience, technological appeal, and perceived usefulness rather than environmental concerns (Suárez et al., 2025; Tran et al., 2019; Zhang and Li, 2020). Such convenience-oriented usage may increase overall mobility consumption, potentially offsetting the environmental benefits of MaaS. Older adults generally show lower rates of MaaS adoption compared with younger cohorts, and when they do adopt, their usage patterns often differ substantially. They are more likely to maintain existing travel habits and rely on private vehicles, deriving comparatively less utility from shared mobility services (Haustein and Kroesen, 2022; Matyas and Kamargianni, 2019). While this lower uptake is linked to digital literacy barriers and preference for familiar transport options (Suchanek et al., 2021), some studies suggest that older respondents may report interest in shared mobility due to perceived social expectations rather than actual experience (Zawieska et al., 2025). Research indicates that as digital platforms become more widespread and car-sharing services gain visibility, adoption among older users may gradually increase, particularly as technological familiarity improves within this group (Aguilera-García et al., 2022). However, a longitudinal evidence shows that older participants were more likely to revert to car-dependent travel patterns when faced with service limitations, indicating challenges for sustained sustainable usage (Haustein and Kroesen, 2022).

TABLE 2 Methodological framework analysis of reviewed literature.

Methodological approach		Data collection methods	Data analysis technique	Theoretical framework	No. of article
Quantitative methods	Quantitative cross-sectional studies	Secondary data	Structural Equation Modeling (SEM); Logistic Regression Models; Factor Analysis (EFA, CFA); Statistical hypothesis testing; Descriptive statistics	Theory of Planned Behavior (TPB) / Extended TPB Model; Unified Theory of Acceptance and Use of Technology (UTAUT2); Technology Acceptance Model (TAM); Random Utility Theory; Random Utility Theory	1
		Survey			47
		Modeling			1
	Stated choice/preference experiments	Survey	Mixed logit models; error components logit; discrete choice models		4
		Experiment			1
	Longitudinal survey	Survey	Longitudinal panel data analysis		1
Experimental methods	Field experiments	Mixed methods	Discrete choice models; Joint discrete-continuous models; Mixed effects regression; Descriptive statistics; Mixed quantitative-qualitative analysis	Theory of Planned Behavior (TPB); perceived behavioral control (PBC); Economic Theory; Nudge theory	4
		Secondary data +survey			2
		Secondary data			2
	Quasi-experimental studies	Secondary data	Difference-in-differences regression; Statistical hypothesis testing; Multiple Linear Regression; Descriptive statistics		1
		Survey			2
Qualitative methods		Semi-structured Interviews	Thematic analysis; Content analysis; Deductive and inductive coding	Social Practice Theory (SPT); Extended Theory of Planned Behavior (TPB); Stage Model of Self-Regulated Behavioral Change (SSBC); User-Centric Model	3
		Focus Groups			2
Mixed methods		Survey + interviews	Descriptive analysis + qualitative coding; Thematic analysis + statistical analysis; MANOVA + template analysis; AHP + KPI analysis	Practice Theory (SPT); Extended Theory of Planned Behavior (TPB)	2
		Secondary data+interview			2
		Quantitative + experimental + qualitative			1
		Case study + evaluation framework			1
Policy and guidance documents		Secondary data synthesis	Synthesis of case studies and best practices	N/A	8

Women often place greater emphasis on environmental considerations and personal security in their travel choices, and are more willing to shift from private vehicles to shared mobility when these services provide reliable and accessible alternatives (Gkartzonikas et al., 2025; González-Sánchez et al., 2024; Kawgan-Kagan, 2015; Mostofi, 2022; Suchanek and Szmelter-Jarosz, 2019). Women's environmental orientation often includes moral and ethical dimensions, with studies showing stronger responses to social norms promoting sustainable travel and to moral motives for adopting low-impact mobility options that fit within their existing travel habits (Steffen et al., 2024). This value-driven orientation is reflected in their stronger preference for consistency between attitudes and behavior: they are less likely to adopt transport modes that conflict with their environmental or ethical preferences, but show greater commitment once they choose a mode that aligns with their values (Haustein and Kroesen, 2022). In contrast, men are more likely to prioritize technological features and convenience over environmental considerations in mobility choices (Abouelela et al., 2024; Suárez et al., 2025). However, safety concerns significantly limit women's adoption, as they are more sensitive to perceived risks in transport environments (Berg et al., 2019; González-Sánchez et al., 2024). When women perceive MaaS services as unsafe or unreliable, their environmental preferences may not translate into sustainable mobility choices, and their moral motivations often weaken when encountering practical barriers such as cost, time, or convenience constraints (Alyavina et al., 2020; Chou et al., 2024; Ramos and Bergstad, 2021).

Income effects reveal patterns where both higher- and lower-income users achieve unsustainable outcomes through different pathways. Lower-income individuals adopt MaaS primarily as a cost-saving alternative to car ownership, while higher-income users are less inclined to replace private vehicles and often avoid shared mobility even when available (Farahmand et al., 2021; Lavieri et al., 2017). When higher-income users do adopt MaaS, their greater economic flexibility tends to lead to increased overall travel rather than shifts toward sustainable transport choices (Farahmand et al., 2021; Sener et al., 2023). Conversely, lower-income users in developing contexts adopt shared mobility services, but economic constraints drive them toward informal options like shared motorcycle taxis that displace sustainable public transport and increase emissions (Suatmadi et al., 2019). These patterns suggest that current MaaS systems may reproduce existing inequalities, enabling overuse among higher-income users while steering lower-income users toward unsustainable informal options. The reliance on digital payment systems and app-based access further marginalizes economically disadvantaged groups (Abouelela et al., 2024), creating a two-tiered mobility landscape that undermines both equity and environmental goals. Employment status adds complexity, as individuals with limited or uncertain income are less inclined to choose MaaS options due to upfront subscription costs and perceived inflexibility (Feneri et al., 2022), while both working and retired individuals often retain private transport preferences despite MaaS availability due to predictability and convenience requirements (Ali et al., 2025; Haustein and Kroesen, 2022; Tran et al., 2019).

3.3.2 Transport mode contributions within MaaS ecosystems to sustainable travel behaviors

The sustainability impact of including various transport modes in MaaS ecosystems demonstrates significant variation, with research showing that while public transport integration consistently delivers environmental benefits, other modes often produce conflicting results, including potential increases in carbon emissions. This analysis examines how research attention is distributed across transport mode categories (Table 3) and evaluates their respective environmental impacts while exploring the reasons for these varying outcomes across different contexts.

Public transport integration represents the foundation of successful MaaS ecosystems, receiving the highest research attention (40.7% of studies for PT integration, 19.7% for comprehensive MaaS platforms) and demonstrating the most reliable sustainability outcomes. Well-connected public transport networks enhanced by decentralized mobility hubs consistently improve accessibility across diverse demographic groups, including underserved communities (Cantelmo et al., 2022; Czarnetzki and Siek, 2023; Hjorteset and Böcker, 2020). The integration of shared mobility services with public transport and active travel modes creates synergistic effects that reduce private car use, ease congestion, and lower emissions (Abbasi et al., 2022; Campbell and Brakewood, 2017; Hou et al., 2025; Lavieri et al., 2017; Nikitas, 2018; Suárez et al., 2025; UITP, 2020). Bike-sharing, in particular, can serve as a first-mile/last-mile solution, extending the reach of public transport and improving convenience while reducing car dependence for short trips (Sochor et al., 2015). Demand-responsive transport solutions further enhance this integration by addressing spatial equity through dynamic local service provision and improved connectivity (Gkartzonikas et al., 2025; SCADask, 2024). The system's flexibility during off-peak hours broadens MaaS appeal by accommodating diverse user needs (Interreg Central Europe, 2022).

Building on this foundation, comprehensive MaaS platforms that integrate multiple transport modes demonstrate how strategic bundle design can amplify sustainability benefits. The UbiGo MaaS bundle from Gothenburg exemplifies successful platform development through seamless integration across car-sharing, public transit, and cycling options that reduced private car dependency (Sochor et al., 2015). Similarly, the Sydney MaaS trial showed that multimodal subscription bundles influenced travel behavior, with bundle adoption associated with statistically significant changes in monthly car use compared to pay-as-you-go options (Hensher et al., 2021; Ho, 2022). However, these trials show that bundle composition critically influences the overall sustainability impact, as users may substitute between modes within bundles, with the risk of drawing users toward less sustainable shared modes if not carefully designed. Preference studies indicate, for example, that making flexible options like taxis more affordable can draw users away from public transport (Liu et al., 2023), while user preferences for flexibility in uncertain situations may favor less sustainable options (Jang et al., 2021). Wang et al. (2024) found that bundles targeting car users achieve meaningful emissions reductions when bundle composition prioritizes public and active transport modes as core components. These findings indicate that while public transport integration provides the foundation for sustainable MaaS, comprehensive platforms must strategically organize mode combinations to reinforce rather than undermine this foundation. Evidence suggests that car users tend to favor car-sharing rather than public transport within MaaS platforms, indicating that fundamental car-based travel preferences may persist despite platform adoption (Farahmand et al., 2021). This pattern makes meaningful emission reductions difficult as voluntary transitions back to sustainable modes prove challenging once car-centered mobility patterns are established (Alyavina et al., 2024; Haustein and Kroesen, 2022).

Additionally, although active mobility sharing services receive significant research attention (28.7% of studies) and theoretically represent the most environmentally beneficial MaaS components due to their zero-emission nature, empirical evidence reveals a troubling pattern of modal substitution that undermines their sustainability promise. Multiple studies demonstrate that bike-sharing and e-scooter sharing services frequently replace already-sustainable modes like walking, cycling, or public transport rather than displacing private car use (Eccarius and Lu, 2020; Farahmand et al., 2021; Kopplin et al., 2021; Roig-Costa et al., 2025; Suchanek et al., 2021). This substitution effect raises concerns about the net benefit of these services and, in some cases, suggests they may inadvertently increase ecological impact. Nevertheless, bike-sharing programs retain strategic value in low-cycling contexts by enhancing access and normalizing cycling behavior, particularly among users without bike ownership (Nikitas, 2018).

Shared motorized services are promoted for their potential to reduce vehicle ownership and emissions through pooling mechanisms (Gkartzonikas et al., 2025; Si et al., 2024). Evidence supports this potential, showing that car-sharing can encourage individuals to give up private vehicles while increasing use of public transport, cycling, and walking, particularly when electric vehicle stations are strategically located in residential areas to promote shorter trips (Abbasi et al., 2022). However, if they divert users from public transport or fail to attract ride-pooling participants due to social preferences for solo travel, the sustainability benefits diminish (Mitropoulos et al., 2024; Reck et al., 2021). Economic factors also limit uptake, with stronger appeal for longer commutes where cost savings are greater, but reduced attractiveness for short urban trips (Simancas et al., 2024). On-demand ride services show more consistently negative sustainability effects. Studies find they rarely replace private car use, instead drawing passengers from

TABLE 3 Distribution of transport modes in reviewed MaaS studies.

Transport mode category	Definition	Example services	Sustainability impact mechanism	No. of studies	% of total studies
Public transport integration	MaaS services that enhance or complement public transport	PT + bike sharing integration, PT + car sharing, demand-responsive transit feeders	Strengthens public transport attractiveness and accessibility	35	40.7%
MaaS bundle platforms	Integrated mobility services combining multiple sustainable modes	MaaS bundles (Public transport + bike sharing + car sharing + taxi)	Reduces private car dependency through convenient multimodal alternatives	17	19.7%
Active mobility sharing	Human-powered or low-energy shared mobility	Bike sharing, e-bike sharing, e-scooter sharing	Replaces motorized trips with zero/low emission alternatives	24	27.9%
Shared motorized services	Pooled or shared car-based services that reduce vehicle ownership	Car sharing (station-based, free-floating), carpooling, ride-pooling	Reduces total vehicle fleet through shared usage and pooling	10	11.6%
On-demand ride services	Individual ride-hailing without mandatory	Uber, Lyft (individual rides), taxi-hailing apps	Potentially unsustainable - may increase total vehicle travel and reduce PT/active mode use (if additional travel)	12	14.0%

Studies may examine multiple service categories, so percentages may sum to more than 100%.

public transport and active modes, which increases vehicle mileage, congestion, and emissions (Gomez et al., 2021; Hasselwander et al., 2022). This shift is particularly marked among younger users, who may see ride-hailing as offering similar autonomy and convenience to car ownership, reinforcing car-oriented norms and potentially encouraging future vehicle acquisition (Acheampong et al., 2023). Without strong policy integration or pooling incentives, these services risk exacerbating car dependence rather than reducing it.

3.3.3 MaaS adoption factors and their interactions

User-oriented service features that successfully drive MaaS adoption may simultaneously undermine sustainability objectives through design choices that prioritize convenience over environmental outcomes. Technological advancements such as streamlined interfaces, user-friendly digital interface, one-click booking, and integrated payment systems successfully enhance user accessibility and drive adoption (Ali et al., 2025; Jang et al., 2021; Mavlutova et al., 2021; Storme et al., 2020; Tran et al., 2019), with services like UbiGo exemplifying this approach through one-stop smartphone access for activating tickets, making bookings, and checking balances (Sochor et al., 2015, 2016). While these convenience features successfully attract users, they may inadvertently undermine environmental objectives by making less sustainable options more attractive within MaaS platforms. Studies show that convenience-oriented MaaS offerings can unintentionally draw users away from sustainable modes (Jang et al., 2021; Liu et al., 2023), while infrastructure investments may encourage car-oriented travel patterns when platform design prioritizes providing full transport option ranges without giving preference to lower-emission modes (Lavieri et al., 2017; Roig-Costa et al., 2025). Technological reliance creates additional complications, as concerns about enabling technology reliability—such as mobile device battery life or internet coverage—can make transport users less likely to give up car ownership despite convenience benefits (Alyavina et al., 2024). Empirical evidence demonstrates that although positive environmental attitudes are frequently associated with higher willingness to adopt shared mobility options (Mouratidis, 2022; Suárez et al., 2025; Tran et al., 2019), actual travel decisions within MaaS platforms are often shaped more strongly by perceptions of convenience, perceived usefulness, and ease of use than by sustainability values (Alyavina et al., 2020; Hjorteset and Böcker, 2020; Shao and Liang, 2019; Wali and Khattak, 2022).

Service quality and personalization further shape adoption patterns, but their sustainability impacts remain uncertain. Deficiencies in infrastructure, limited data interoperability, and weak integration with public transport systems consistently undermine user trust and satisfaction (Ali et al., 2025; Hasselwander et al., 2022; Hou et al., 2025; International Transport Forum (ITF), 2021; Roig-Costa et al., 2025), indicating that reliable service delivery is essential for sustained platform use. Customization addresses this challenge by meeting diverse user needs through locally adapted service bundles and personalized information that improve perceived functional value, especially when services align with specific mobility challenges or expectations (Ali et al., 2025; Hartl et al., 2018; Poslad et al., 2015; Strömberg et al., 2018). Research shows that MaaS bundles become more attractive for adoption when they include a wider range of transport modes (Ceccato et al., 2023; Militão et al., 2025). Personalization features such as CO_2 reduction tracking, tailored subscription plans, and feedback tools can further strengthen user engagement can reinforce sustainability goals (ERTICO - ITS Europe, 2019; Urban Mobility Partnership, 2023). These effects are amplified when supported by well-connected mobility hubs and integrated transport systems, which improve accessibility and make public transport more appealing through features like transfer-free trips (Cantelmo et al., 2022; Feneri et al., 2022; Hjorteset and Böcker, 2020).

Economic considerations are among the strongest drivers of MaaS adoption, particularly when the costs of platform use are perceived as favorable compared with the high expenses of private car ownership. By avoiding expenditures on fuel, maintenance, insurance, and parking, MaaS can offer an attractive alternative for households seeking more affordable mobility solutions (Aboutorabi Kashani et al., 2023; Strömberg et al., 2018; United Nations, 2020; Wali et al., 2023). Empirical evidence indicates that competitively priced plans, multimodal bundles, and incentives such as monthly mobility budgets or loyalty rewards increase both initial uptake and continued use, while price increases—such as higher hourly rates for car sharing—reduce the likelihood of adoption (del Carmen Rey-Merchan et al., 2022; Charoniti et al., 2021; Farahmand et al., 2021; Hensher et al., 2021; Matyas and Kamargianni, 2019; Storme et al., 2020). Pricing structures can also influence the environmental implications of MaaS adoption, as lower costs for bike-sharing that substitute for car trips (Bartling, 2023), subscription bundles that enhance the financial attractiveness of public transport (Militão et al., 2025), higher parking fees that discourage car commuting (Farahmand et al., 2021), and targeted subsidies for low-emission modes (Mavlutova et al., 2021; Simancas et al., 2024; Urban Mobility Partnership, 2023) have been associated with reduced private vehicle use. These effects are not uniform across service types, with competitively priced car-sharing frequently linked to lower car ownership (Clewlow, 2016; Hjorteset and Böcker, 2020; Vejchodská et al., 2024; Vélez and Plepys, 2021), whereas ride-hailing services may foster aspirations for car ownership among convenience-oriented users (Acheampong et al., 2023; Czarnetzki and Siek, 2023; Acheampong and Siiba, 2020). However, favorable pricing can also encourage greater use of car-based modes when bundled allowances make them more accessible, which means cost savings do not always translate into sustainability gains (Reck et al., 2021). Moreover, the long-term contribution of economic drivers to both adoption and sustainability is limited by high operating costs and infrastructure demands, so financial accessibility must be paired with service designs that direct cost advantages toward low-emission, sustainable mobility behaviors (Abouelela et al., 2024).

Ho (2022) argues that for MaaS to succeed, it should be considered more as a policy tool than merely a smart application offering multimodal journey planning and payment facilitation. This perspective highlights the necessity for regulatory frameworks that integrate emerging mobility services with public transportation while ensuring equitable market conditions (Gomez et al., 2021; Julsrud and Farstad, 2020; Maa and Alliance, 2024). However, policymakers face significant challenges in aligning commercial interests with environmental goals, particularly addressing the risk of unintended shifts from public transport to less sustainable modes within MaaS packages (Ceccato et al., 2023; The Institution of Engineering and Technology, 2020). This challenge is compounded by user behavior complexity, as effective policy design requires understanding different user groups, their travel preferences, and interdependencies between mobility services to create multimodal networks that reinforce rather than compete with sustainable transport options (Abbasi et al., 2022; Campbell and Brakewood, 2017). Implementation strategies require coordinated governance approaches addressing both adoption barriers and sustainability alignment. Targeted policy interventions such as fare incentives, restrictions on private vehicle use, and infrastructure planning for multimodal hubs can strengthen MaaS's role in promoting low-carbon travel (Curtale and Liao, 2023; Hou et al., 2025; Liu et al., 2023). Public-private partnerships support this process by facilitating cooperative platforms, joint investment, and common data standards, while regulatory sandboxes create controlled environments to trial and refine new models (Cantelmo et al., 2022; Maa and Alliance, 2024). However, the effectiveness of these coordinated approaches varies significantly across different institutional contexts. Coordinated policy alignment across transport, environmental, and urban planning domains, supported by digital governance and open data protocols, enhances integration and reduces reliance on private cars (Derikx and van Lierop, 2021; Hartl et al., 2018; Zhou et al., 2024). Early stakeholder engagement involving operators, public authorities, technology providers, and user groups helps identify risks, build trust, and co-develop governance solutions tailored to local contexts (Alyavina et al., 2020; Interreg Central Europe, 2022). These strategies prove particularly critical in regions with limited institutional capacity, where addressing legal, technological, and financial barriers is essential for creating equitable and scalable MaaS ecosystems (Hasselwander et al., 2022).

4 Discussion

4.1 Overview of findings

This systematic review of eighty five studies provides a comprehensive examination of MaaS research development and its relationship with sustainable travel behaviors. The temporal analysis reveals that MaaS research has evolved from early technical and conceptual work toward more practice-oriented investigations, with increasing contributions from psychology and behavioral sciences after 2018. However, co-citation network analysis indicates limited integration between sustainability-focused journals and the core transportation research literature, suggesting that environmental evaluation has not become central to empirical. Methodologically, the field remains dominated by quantitative, survey-based research that offers valuable evidence on adoption intentions, but the predominance of cross-sectional designs over longitudinal approaches limits insight into how these intentions translate into long-term behavioral change. Findings on MaaS adoption and sustainable travel behavior indicate that platform uptake is largely driven by convenience and technological appeal, with environmental motivations playing a secondary role for most users. The sustainability contribution of specific modes varies: public transport integration generally supports positive environmental outcomes, active mobility services can displace other sustainable options, and ride-hailing often diverts users from public transport. Adoption factors reveal complex interactions between convenience features, economic incentives, and policy frameworks that drive platform uptake but may work against sustainability objectives. While MaaS platforms successfully engage users through these combined approaches, sustained engagement does not guarantee more sustainable travel choices.

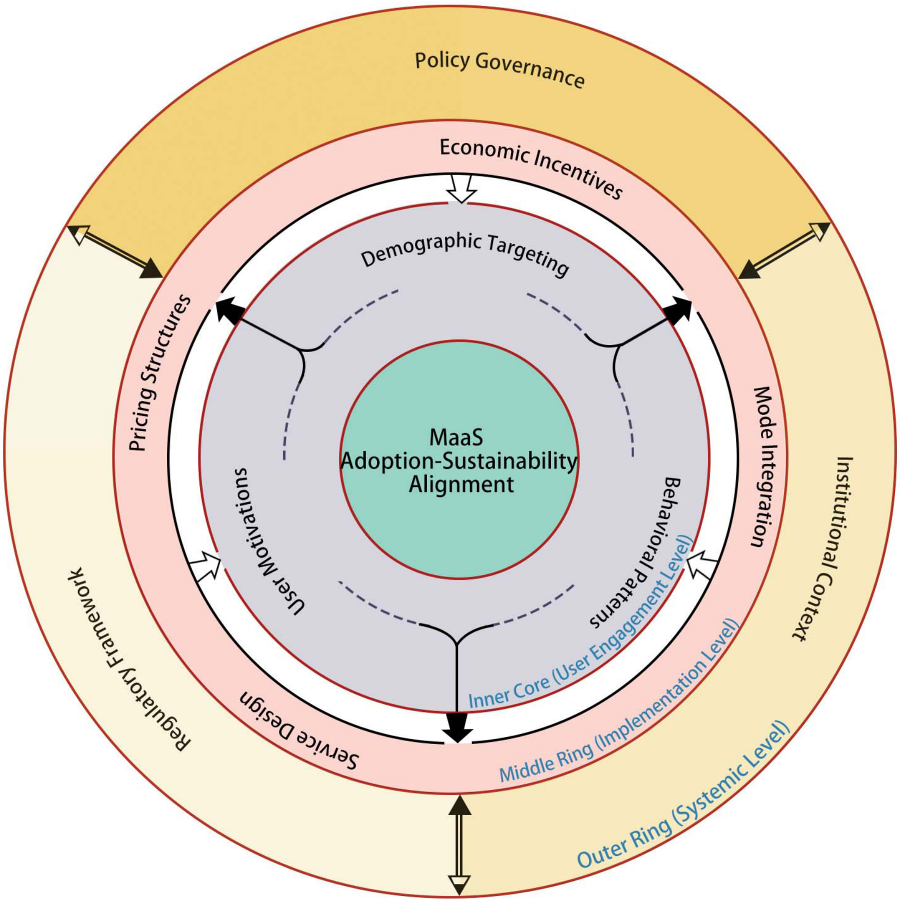

FIGURE 4
Integrated framework of factors influencing MaaS adoption and behavioral change.

4.2 A conceptual framework for understanding MaaS adoption-sustainability dynamics

This section presents a conceptual framework (Figure 4) examining how multiple factors interact to influence MaaS adoption and its capacity to support sustainable travel behavior. The analysis reveals that adoption and sustainability are shaped by different processes and do not necessarily occur together, with their relationship shaped by complex interactions within broader social, technical, and institutional environments. MaaS platforms can improve accessibility and reduce private car dependence, but they also carry forward features of existing transport systems that can limit broader change. Current implementation approaches that prioritize convenience, technological appeal, and market expansion over environmental effectiveness create situations where successful user acquisition may not translate into sustainable travel behaviors. Understanding this dynamic requires examining how demographic characteristics, service design choices, economic incentives, and policy frameworks function as interconnected elements that can either reinforce existing mobility patterns or facilitate transitions toward sustainable behaviors, depending on how their interactions are coordinated within specific contexts. The framework developed here provides a systematic approach for analyzing these interdependencies and identifying pathways for aligning MaaS development with sustainability objectives.

At the systemic level, governance emerges not merely as external regulation but as a component that determines the operational framework within which MaaS platforms function. As explored by Marsden and Reardon (2017), governance is integrated within and responsive to evolving transportation system requirements, yet evidence indicates that current governance approaches often conceptualize MaaS as a technological rather than socio-political phenomenon. Policy decisions guided by regulatory structures, public-private partnerships, and funding mechanisms significantly influence enabling conditions for MaaS systems, establishing how infrastructure, pricing models, service delivery, and user participation correspond with sustainability objectives. However, effective governance needs to recognize that MaaS platforms are active participants in the development of mobile culture, rather than passive service providers, with the ability to perpetuate or change existing unsustainable patterns of travel behavior. The variation in policy effectiveness across institutional contexts demonstrates that successful governance necessitates intervention addressing cultural and economic transformation rather than relying solely on regulatory management.

At the implementation level, service design and economic incentives act as the primary mechanisms through which governance objectives are translated into user decision-making. Their influence extends beyond providing functional choices, as they structure how different modes are perceived in terms of convenience, value, and social appropriateness. Pricing strategies, interface layouts, and default journey suggestions not only determine the relative attractiveness of available modes but also convey implicit priorities regarding which options should be used. When these mechanisms are explicitly aligned with sustainability goals—for example, by designing pay-as-you-go (PAYG) options or monthly bundles that make shared mobility options financially attractive relative to private car use—they can encourage behavioral patterns consistent with environmental objectives (Hensher et al., 2021). In contrast, when design and incentive structures treat all modes as equally desirable, decisions are more likely to be shaped by established habits and short-term convenience, which often favor less sustainable options. This presents that effective implementation requires the deliberate integration of service design and pricing structures with policy aims, ensuring that sustainable modes are positioned as the most accessible and attractive options within the platform environment.

At the user engagement level, the interaction between demographic characteristics and platform implementation influences which sustainability outcomes MaaS can realistically achieve. Targeting strategies and design choices act as a selection process, shaping both the types of users who adopt the platform and the travel behaviors that become dominant. Platforms designed for broad market appeal, with a focus on convenience, wide service coverage, and technological features, often attract users motivated by personal efficiency and flexibility rather than environmental goals. This can result in travel patterns that diverge from sustainability objectives, reinforcing the behaviors MaaS seeks to change. Evidence indicates that engaging users whose values and practices already align with sustainable mobility can produce stronger and more durable environmental outcomes, as voluntary shifts away from car-centered habits prove difficult to achieve (Haustein and Kroesen, 2022). This approach involves emphasizing reliability, safety, and low environmental impact in platform features, structuring services so that public transport forms the core offer while limiting high-emission modes, and using targeted incentives to make sustainable choices the most attractive. While such an approach may initially lead to a smaller but more committed user base, it can establish behavioral norms that, once embedded, provide a foundation for gradually engaging wider audiences without eroding environmental benefits.

5 Conclusion

This systematic review examined how MaaS influences sustainable urban travel behavior and the factors shaping its adoption. The synthesis shows that MaaS has developed from an early technical concept into a socio-technical system in which the features that attract users, such as convenience, technological sophistication, and broad service coverage, do not always align with environmental objectives. While economic incentives and policy frameworks are key drivers of adoption, they often encourage convenience-based choices rather than directing users toward sustainable options. MaaS platforms tend to operate within existing mobility cultures, with users bringing established travel habits that can persist unless platform design actively promotes alternatives. Without targeted strategies to position sustainable modes as the most practical and attractive options, car-oriented patterns are likely to be maintained. The conceptual framework developed in this review highlights that environmental benefits depend on coordinated action between user engagement strategies, service and pricing design, and supportive policy measures, challenging the assumption that adoption alone will lead to sustainable outcomes.

The findings suggest a need to shift MaaS development priorities from rapid market expansion toward approaches that align platform growth with environmental goals. Cities seeking to operationalize this shift should focus on three key areas: first, pricing strategies that incorporate financial incentives for sustainable modes, as demonstrated by subscription bundle approaches that influenced car use behavior (Feneri et al., 2022; Hensher et al., 2021); second, platform designs that prioritize sustainable options as default choices while restricting car-based services to essential use cases; and third, governance frameworks that establish clear sustainability performance requirements for public-private partnerships. Strategic mobility hub placement that enhances accessibility to shared services and public transport, following evidence from successful decentralized implementations (Czarnetzki and Siek, 2023), can improve the convenience required for sustainable mode adoption.

A limitation of this review is that, although it draws on both peer-reviewed studies and selected gray literature, the synthesis reflects the author's interpretations, and unconscious bias may have influenced the categorization and weighting of evidence. Nevertheless, the results offer practical insights for policymakers, MaaS providers, and researchers seeking to design systems that are technologically robust, socially inclusive, and environmentally effective. While this review includes valuable field trial evidence, such as the Sydney MaaS trail using objective behavioral tracking methods through GPS monitoring, app analytics, and subscription patterns, combined with multiple analytical approaches applied to these data (Hensher et al., 2021; Ho, 2022; Militão et al., 2025), future research should expand these methodological approaches through comparative longitudinal studies across diverse institutional and cultural contexts. Such studies are needed to understand how different governance models, service design choices, and user-targeting strategies influence sustained travel behavior change, and to clarify which MaaS design features can be transferred across regions versus those requiring local adaptation. Additionally, research should investigate optimal bundle design strategies that minimize modal displacement toward less sustainable options while maintaining commercial viability, including dynamic pricing mechanisms and strategic access limitations for high-emission modes. Finally, greater attention should be given to user segmentation and targeting strategies, identifying demographic and behavioral profiles most likely to sustain long-term shifts toward sustainable mobility and thereby enabling more effective deployment of MaaS initiatives.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

CA: Methodology, Data curation, Validation, Investigation, Writing – review & editing, Conceptualization, Supervision, Resources, Formal analysis, Writing – original draft, Software, Visualization, Project administration, Funding acquisition. JS: Writing – review & editing, Writing – original draft, Investigation, Validation, Formal analysis, Data curation.

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Supplementary material

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