GIJLSS
Greenation International Journal of Law and Social Sciences
+62 81210467572 https://research.e-greenation.org/GIJLSS greenation.info@gmail.com
GREENATION RESEARCH

DOI: https://doi.org/10.38035/gijlss.v4i3

SDGs Trade-off on Online Transportation: A Systematic Review of the Environmental, Social, and Economic Impacts of Ride-Hailing and Mobility as a Service (MaaS)

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Abstract: The rapid development of information technology has given birth to the phenomenon of ride-hailing and Mobility as a Service (MaaS) which promises the efficiency of urban mobility. However, the contribution of these services to the Sustainable Development Goals (SDGs) is still a debate due to the trade-off phenomenon between the pillars of sustainability. This study used the Systematic Literature Review (SLR) method on 572 articles sourced from the Scopus database. The results of the analysis show that although economically these services increase revenues (SDG 8), there is a significant negative impact on the environmental pillar (SDG 13) due to the shift from public transportation and the deadheading phenomenon. In addition, there is a tug-of-war between social and economic pillars which is reflected in the working conditions of gig economy drivers. The discussion highlighted the need for integrated regulations to minimize conflicts of interest between the pillars of the SDGs, including MaaS integration, electric vehicle adoption, and workforce protection.

Keywords: Ride-hailing, MaaS, SDGs, Trade-off, Environment, Social, Economy, Gig Economy, Sustainable Transportation.

INTRODUCTION

Massive urbanization in the 21st century demands a more flexible, efficient, and sustainable transportation system. Digital transformation has given birth to online transportation platforms such as Uber, Grab, and Gojek, which then evolved towards the concept of Mobility as a Service (MaaS) (Rouky et al., 2025). This phenomenon is not only changing the way humans are mobile, but also creating a new economic ecosystem involving millions of drivers, passengers, and other stakeholders around the world (Rizki et al., 2025).

In the context of achieving the 2030 Sustainable Development Goals (SDGs), transportation plays a central role. SDG 11 (Sustainable Cities and Communities), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Addressing Climate Change) all directly intersect with the transportation sector (Luizza et al., 2025). However, empirical evidence in the literature suggests a real trade-off between these sustainability pillars when applied to the context of online transportation (Sáenz-Leandro, 2026).

Ride-hailing services are often promoted as a solution to reduce reliance on private vehicles and improve the efficiency of urban mobility (Rouky et al., 2025). However, the reality on the ground shows a more complex picture. The price efficiency offered is often rooted in the exploitation of gig labor (Hazra et al., 2024), or instead increasing the number of vehicles on the highway that increase carbon emissions (Zhang et al., 2025). Meanwhile, MaaS has emerged as a concept that promises the integration of various modes of transportation in a single platform, but its implementation still faces various technical, regulatory, and social challenges (Naranjo et al., 2025).

Sustainable transportation is a critical component in achieving the 2030 SDGs. At least eight of the seventeen SDGs are directly linked to the transportation sector, ranging from poverty reduction (SDG 1), health (SDG 3), decent work (SDG 8), infrastructure (SDG 9), inequality (SDG 10), sustainable cities (SDG 11), responsible consumption and production (SDG 12), to climate change (SDG 13) (Luiza et al., 2025).

In the context of online transportation, the three main pillars of sustainability, namely economic, social, and environmental, are often in the tug-of-war with each other (Du et al., 2025). The economic pillars include market efficiency, driver revenue, and business sustainability of the platform. The social pillars include equal access, job safety, and inclusivity for vulnerable groups. While the environmental pillar focuses on reducing carbon emissions, saving energy, and reducing congestion (Luiza et al., 2025).

Recent research emphasizes that building resilient and sustainable urban mobility requires a systemic and holistic approach, with coherent policies at different levels of government, technical capacity, public engagement, and comprehensive indicators (Luiza et al., 2025). This shows that there is no single solution that can overcome all the trade-offs at once. Implemented by the big platforms. Drivers are categorized as "independent contractors" rather than employees, which provides flexibility but negates social security such as health insurance, retirement benefits, and minimum wage protection (Hazra et al., 2024).

Studies in Bangladesh show that ride-hailing drivers experience various forms of value inequality, including design, resource, institutional, and relational inequalities (Hazra et al., 2024). This study found that power over drivers is exercised primarily in enclosed spaces, with very few invited spaces for drivers to participate in platform decision-making (Hazra et al., 2024).

These findings have direct implications for SDG 8 regarding decent work and inclusive economic growth.

In Uganda, research on the moto-taxi sector shows that inclusion in the ride-hailing platform economy is not bringing motor-taxi riders closer to formal status in a meaningful way (Mallett, 2026). Platforms operate in a unilateral and platform-specific manner that undermines the prospects of sectoral standardization, does not accept legal responsibility for the welfare and safety of those who work through their applications, and demonstrates an unwillingness to improve the political readability of the rider workforce through sharing data with the government (Mallett, 2026). This phenomenon is referred to as the "aesthetic of formality" that allows commercial activities to take place beneath the surface, resulting in a dynamic in which the economic value created by (still) informal workers is captured by formal private enterprises (Mallett, 2026).

The environmental impact of ride-hailing services is one of the most debated areas in the literature. On the one hand, ride-hailing has the potential to reduce private vehicle ownership and improve the efficiency of vehicle use. On the other hand, the ease of access to these services can actually encourage the shift from more energy-efficient modes of public transportation (Chen, 2025).

The phenomenon of deadheading empty rides for drivers when looking for passengers is one of the main contributors to carbon emissions from ride-hailing services. Studies show that this proportion of empty trips can reach 30-40% of a driver's total mileage, adding to the burden of air pollution without providing economic value to drivers (Gu & Liu, 2025). In addition, the increased volume of ride-hailing vehicles on the highway contributes to traffic congestion which in turn increases overall carbon emissions (X. Li et al., 2025).

In a broader context, the road transport sector accounted for around 17.9% of total global carbon emissions in 2022 (Bai et al., 2025). Increasing urbanization and the growth of ride-hailing services without adequate regulation have the potential to exacerbate the sector's contribution to climate change (Shou et al., 2026).

Although the existing literature has substantially advanced the understanding of ride-hailing and Mobility as a Service (MaaS) from economic, social, and environmental perspectives, most studies remain fragmented by examining these dimensions separately or within specific national contexts. Research on labor precarity predominantly focuses on driver welfare and platform governance (Hazra et al., 2024; Mallett, 2026), while environmental studies primarily investigate emissions, congestion, and energy consumption (Gu & Liu, 2025; Bai et al., 2025). At the same time, studies on MaaS largely emphasize technological integration and mobility efficiency (Rouky et al., 2025; Naranjo et al., 2025). Consequently, limited attention has been given to understanding how these three sustainability dimensions interact simultaneously, creating trade-offs and synergies that influence the long-term sustainability of online transportation ecosystems. This fragmentation makes it difficult for policymakers to formulate integrated strategies that balance economic growth, social equity, and environmental protection in line with the Sustainable Development Goals (SDGs).

Furthermore, despite the increasing global adoption of online transportation platforms, there is still a lack of a comprehensive conceptual framework capable of explaining the dynamic relationships among platform governance, stakeholder welfare, operational efficiency, and environmental sustainability within a single analytical model. Existing studies generally provide descriptive evidence or focus on isolated case studies, offering limited insights into the systemic mechanisms that shape sustainable platform-based mobility across different institutional settings. Therefore, this study seeks to address this research gap by developing an integrated sustainability perspective that examines online transportation not merely as a digital mobility service but as a socio-technical ecosystem where economic, social, and environmental objectives continuously interact. By doing so, this research is expected to contribute both theoretically to the sustainable mobility literature and practically to the design of policies that support the achievement of the 2030 SDGs.

METHOD

This study employs a Systematic Literature Review (SLR) guided by the PRISMA framework to identify, screen, and synthesize scholarly evidence on SDG trade-offs in online transportation, focusing on ride-hailing and Mobility as a Service (MaaS). The entire document sorting and screening process was conducted fully automatically using artificial intelligence (AI) without any human screening stage, to ensure consistent, replicable, and scalable selection across a large volume of publications. This approach was chosen for its ability to synthesize evidence from multiple sources systematically and transparently, minimize selection bias, and generate replicable conclusions (Rouky et al., 2025). The SLR method has been widely used in transportation research to identify patterns and trends in a broad literature (Fale et al., 2025).

Data were extracted from the Scopus database using search strings that included the variables of online transportation and the impact of the SDGs. The search strings used included the following combinations of keywords: *("ride-hailing" OR "ride-sharing" OR "mobility as a service" OR "MaaS") AND ("sustainable development goals" OR "SDGs" OR "sustainability" OR "environmental impact" OR "economic impact").* The search was conducted on January 15, 2026 and resulted in 3,185 initial documents.

The selection of Scopus as the primary data source was based on its extensive coverage of peer-reviewed scientific literature across a wide range of disciplines, including transportation, sustainability, and social sciences (Fale et al., 2025). Scopus also provides bibliometric analysis tools that enable efficient identification of research trends and citation networks.

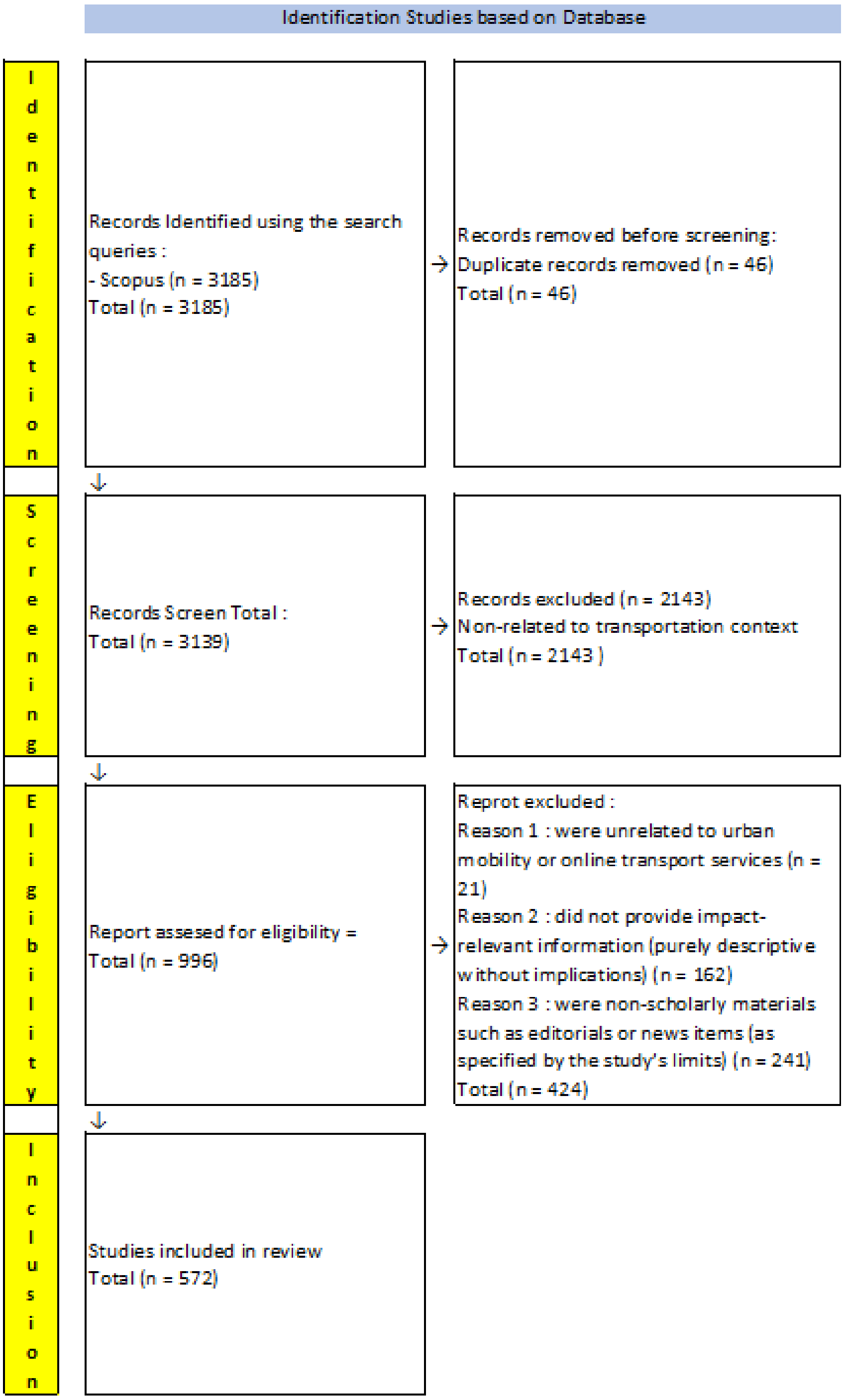

Figure 1. flowchart of study selection process.

Document selection was implemented in two automated stages:

1. AI-based title, abstract screening.
   An AI model assessed each record based on the title and abstract and assigned one of three statuses: Include / Exclude / Uncertain. Decisions followed a standardized instruction template (prompt) encoding the inclusion and exclusion criteria. To improve consistency and traceability, the AI also produced a brief rationale and categorical labels (ride-hailing / MaaS / both; impact dimension: environmental / social / economic).
2. AI-based full-text screening.
   For records labeled Include or Uncertain, the AI performed a second-pass assessment using the full text (or available sections such as Introduction, Methods, Results, Discussion). Records were retained if the AI identified explicit evidence of relevant impacts or SDG trade-offs. Each decision included a justification supported by textual evidence excerpts to reduce the risk of misclassification.

To enable auditing and reproducibility, the AI configuration was documented, including: model name/version, inference parameters (e.g., temperature), prompt templates, label schema, and output formats. All AI outputs (selection status, rationale, and evidence) were stored as screening logs.

AI-Based Data Extraction and Thematic Coding

From the included studies, AI was used to extract structured information such as publication year, study context/region, service type (ride-hailing/MaaS), research methods, impact indicators, and mapping to relevant SDGs (e.g., SDG 8/11/13). The AI then conducted thematic coding to identify recurring trade-offs and synergies across environmental, social, and economic dimensions, which were synthesized into core themes and sub-themes.

Quality Control and Bias Mitigation in an AI-Only Pipeline

Given the absence of human screening, this study implemented procedure-based safeguards, including: (a) explicit criteria and consistent prompts; (b) an Uncertain category for ambiguous cases to avoid over-exclusion; (c) mandatory textual evidence for full-text screening and data extraction; and (d) complete logging of the pipeline and decisions to support replication and retrospective review. Potential model bias and limitations in full-text availability are acknowledged as methodological constraints.

Synthesis of Findings

Findings were synthesized using narrative and thematic approaches, emphasizing SDG trade-offs in online transportation. The synthesis highlights key mechanisms (e.g., mode shift, empty cruising/deadheading, gig-work conditions, accessibility, electrification) and policy implications to reduce adverse impacts and strengthen synergies.

In accordance with the PRISMA 2020 Statement, the review protocol explicitly documented every stage of the evidence selection process to ensure transparency and reproducibility. The search was conducted exclusively in the Scopus database on 15 January 2026 using predefined Boolean search strings applied to the Title, Abstract, and Keywords (TITLE-ABS-KEY) fields. The search was limited to English-language, peer-reviewed journal articles published between 2015 and January 2026, reflecting the rapid expansion of ride-hailing and MaaS technologies during the last decade. Conference papers, book chapters, editorials, notes, reviews, dissertations, and non-English publications were excluded. Duplicate records were removed automatically before the screening process. The complete search query, database settings, date of retrieval, and document export format were archived to facilitate future replication.

The eligibility criteria were also predefined before screening commenced. Studies were included if they (1) investigated ride-hailing, ride-sharing, or Mobility as a Service (MaaS); (2) examined environmental, social, or economic sustainability impacts or explicitly discussed Sustainable Development Goals (SDGs); (3) presented empirical or conceptual evidence relevant to SDG trade-offs; and (4) were available in full text. Studies were excluded if they focused solely on technical vehicle engineering without sustainability implications, autonomous vehicle algorithms unrelated to mobility services, logistics or freight transportation without passenger mobility, or lacked sufficient methodological information. A complete PRISMA flow diagram reports the number of records identified, duplicates removed, records screened, records excluded with reasons, full-text articles assessed, and studies finally included in the qualitative synthesis, enabling readers to replicate each stage of the review process.

Table 1. PRISMA Review Protocol

Item	Description
Database	Scopus
Search date	15 January 2026
Search field	TITLE-ABS-KEY
Publication period	2015–January 2026
Language	English
Document type	Peer-reviewed journal articles
Excluded document types	Conference papers, book chapters, reviews, editorials, notes, dissertations
Search string	("ride-hailing" OR "ride-sharing" OR "Mobility as a Service" OR "MaaS") AND ("Sustainable Development Goals" OR "SDGs" OR sustainability OR "environmental impact" OR "economic impact")
Screening method	Fully AI-based title/abstract and full-text screening
Reporting guideline	PRISMA 2020
Data extraction	AI-assisted structured extraction
Quality assurance	Prompt standardization, evidence logging, screening logs, uncertainty category

RESULTS AND DISCUSSION

Distribution of findings based on the sustainability pillar

Analysis of 572 selected articles showed an uneven distribution in the focus of the study. Social issues dominated with 500 articles (87.4%), followed by economic issues with 438 articles (76.6%), while environmental issues were only discussed in 293 articles (51.2%). These findings indicate that the environmental impact of e-transportation is still relatively under-reported in the literature, despite its relevance to SDG 13 being significant (Luiza et al., 2025).

The geographic distribution of the study also shows a striking imbalance. The majority of research focuses on Asian (especially China, India, and Southeast Asian) and North American contexts, while African and Latin American contexts are still very underrepresented (Fale et al., 2025). This is important to note because the dynamics of ride-hailing in developing countries are often fundamentally different from those of developed countries (Mallett, 2026; Sáenz-Leandro, 2026).

In terms of methodology, quantitative research dominated the literature (68%), followed by qualitative research (22%) and mixed research (10%). The use of structural equation (SEM) models, regression analysis, and discrete choice modeling are the most commonly used approaches in quantitative research (Csikor, 2026; Vu et al., 2024).

Environmental vs. Economic Trade-offs: Capital Shift and Deadheading

One of the most consistent findings in the literature is the phenomenon of negative capital shifts that occur due to the expansion of ride-hailing services. Ease of use and competitive prices make users abandon mass transportation (buses/trains) that are more energy-efficient (Chen, 2025). A study in China showed that the Transit Metropolis Construction Pilot (TMCP) policy promoting public transportation succeeded in reducing annual carbon dioxide emissions by 221.883 million tons in pilot cities, underscoring the importance of public transportation in urban decarbonization strategies (Chen, 2025).

On the other hand, the growth of ride-hailing services without adequate regulation tends to erode the market share of public transportation. The increase in platform profits (economic pillars) is directly proportional to the increase in carbon emissions due to more low-capacity vehicles on the road (environmental pillar) (X. Li et al., 2025). Simulations of dynamic systems in Shanghai show that single policies often fail to simultaneously reduce congestion and emissions, indicating the need for an integrated policy approach (X. Li et al., 2025).

The deadheading phenomenon is the most obvious environmental-economic trade-off in ride-hailing operations. Many studies note that 30-40% of online driver's trips are empty trips when looking for passengers, which adds to the burden of air pollution without providing economic value to drivers (Gu & Liu, 2025). A study in Jinan shows that traditional taxis actually contribute more to inefficient travel than ride-hailing, especially because trips to the city center are unplanned for recreational activities (Gu & Liu, 2025). However, the much larger absolute volume of ride-hailing vehicles keeps the cumulative impact significant.

In the broader context of carbon emissions, the identification of key factors driving transportation emissions suggests that total energy consumption, urbanization rates, and expenditures on research and development are the most crucial factors (Shou et al., 2026). These findings imply that technological solutions such as the adoption of Electric vehicles must be integrated with broader urban planning policies to achieve significant emission reduction impacts (Wang et al., 2025).

Social vs. Economic Trade-offs: Gig Economy and Driver Welfare

The trade-off between the social and economic pillars is most clearly seen in the working conditions of ride-hailing drivers. The driver's status as an "independent partner" creates a flexibility that is often claimed to be the advantage of this business model, but at the same time negates fundamental social security (Hazra et al., 2024).

Research in Bangladesh revealed that ridesharing drivers experience three main forms of adverse digital incorporation (ADI): *ignorance/deceit* , direct compulsion, and exclusion (Hazra et al., 2024). Exclusion is the most common form of exclusion, where drivers are systematically excluded from decision-making processes that affect their working conditions. Power over drivers is exercised at the global, national, and local levels, creating a highly asymmetrical power structure (Hazra et al., 2024).

In Uganda, the phenomenon of "plat-formalisation" suggests that although ride-hailing platforms initially collaborate with state actors, they end up operating in a unilateral manner that undermines the prospects of sectoral standardisation (Mallett, 2026). The platform creates a "formality aesthetic" of the exterior that looks formal but does not provide true formal protection for the driver (Mallett, 2026). These findings are particularly relevant for the context of developing countries where the informality of the workforce was already high before the advent of digital platforms.

Studies in Latin America show that the regulation of ride-hailing platforms faces the so-called "De Facto Deregulation Trap" in which institutional fragmentation, political impasses, and stakeholder strategies perpetuate unlimited regulatory uncertainty (Sáenz-Leandro, 2026). Chile successfully passed a regulatory framework, while Colombia and Costa Rica continue to grapple with legislative inertia and fragmented policy responses (Sáenz-Leandro, 2026). The difference in the results of these regulations depends on political negotiations, institutional capacity, and stakeholder power dynamics.

From the perspective of passengers, research shows that the quality of ride-hailing services can be measured through three main dimensions: Service, Integrity, and Efficiency (J. Li et al., 2025). This three-dimensional model provides managerial implications for operators to improve services, but also underlines that improving the quality of service for passengers does not always go hand in hand with improving driver well-being, an internal social trade-off that is often overlooked.

Social vs. Environmental Trade-offs: Inclusivity and Accessibility

The trade-off between social and environmental pillars in online transportation appears in several dimensions. First, affordable ride-hailing services increase mobility accessibility for groups previously underserved by public transportation, but at the same time increase the volume of motor vehicles on the road (Reinhardt et al., 2026). Second, efforts to reduce environmental impacts through the adoption of electric vehicles can increase operational costs that are ultimately charged to drivers or passengers, creating inequality of access (Wang et al., 2025)

Research on the impact of ride-hailing services on children's mobility shows an often overlooked social dimension (Reinhardt et al., 2026). The expansion of ride-hailing services to the child passenger segment (ages 13-17) offers benefits in the form of increased independence and reduced parental supervision burden, but also raises concerns about child safety, potential reduction in active lifestyles, and implications for children's agency (Reinhardt et al., 2026). Autonomous robotaxi services for children being tested in the United States add to the complexity of this social dimension.

From an inclusivity perspective, research shows that the adoption of ride-hailing services, including ride-hailing, tends to be higher among urban dwellers with higher levels of education and income (Shehabeldeen, 2026). This creates the risk that the efficiency benefits of ride-hailing and MaaS are not evenly distributed, deepening the inequality of access to existing mobility (Naranjo et al., 2025).

Synergies and Opportunities: MaaS as a Mediator

MaaS appears in the literature as a concept that has the potential to be a mediator between the various trade-offs that have been identified (Rouky et al., 2025). By integrating online transportation as a feeder (first-mile/last-mile) for public transportation, MaaS has the potential to reduce negative shift capital and improve the efficiency of the overall transportation system (Kriswardhana & Kiss, 2025).

A study on shared micromobility services in Calgary, Canada, shows that these services have the potential to overcome the challenges of the first-mile and last-mile of transit networks (Beza et al., 2025). Spatiotemporal analysis revealed that the average integration ratio was about 20.6% for first-mile trips and 21.9% for last-mile trips, with significant temporal and spatial variations (Beza et al., 2025). These findings support the argument that the integration of shared services in the MaaS ecosystem can improve the overall efficiency of transportation systems.

From a technological perspective, artificial intelligence (AI) and machine learning are playing an increasingly important role in the optimization of MaaS systems (Rouky et al., 2025). A systematic review of AI applications in MaaS shows that machine learning and basic optimization dominate at the basic integration level, while blockchain and big data are more prominent at the advanced and full integration levels (Rouky et al., 2025). However, the implementation of this technology also poses new challenges related to regulatory compliance, inclusivity, and protection of sensitive user data.

Electrification of Ride-Hailing Fleets: A bridge between Economy and the Environment

The adoption of electric vehicles (EVs) in ride-hailing fleets is emerging as one of the most promising strategies to align economic and environmental pillars (Wang et al., 2025). Research in less developed cities in China shows that drivers' environmental awareness is an important driving factor for the acceptance of electric ride-hailing services (ERHS) (Wang et al., 2025). Part-time drivers and those who receive operational subsidies are more likely to adopt ERHS, indicating that economic incentives can be a catalyst for the environmental transition (Wang et al., 2025).

However, the adoption of EVs in the context of ride-hailing also faces various obstacles. Studies in less developed cities show that concerns about the radiation effects of electric vehicles, while not scientifically grounded, are a significant psychological barrier (Wang et al., 2025). In addition, the income uncertainty that characterizes the gig economy makes drivers reluctant to invest in electric vehicles that have higher initial costs (Wang et al., 2025).

Research on the factors influencing EV adoption in general shows that higher education, income, urbanization, and availability of charging infrastructure are the main drivers of EV adoption (Shehabeldeen, 2026). Instead, high population density, longer mileage, and long travel duration are obstacles (Shehabeldeen, 2026). These findings imply that policies that support the adoption of EVs in ride-hailing fleets need to consider the specific context of the city and the characteristics of the driver.

Regulation and Governance of the Platform

Regulation is a key factor in determining whether ride-hailing services contribute positively or negatively to the SDGs. Research in Latin America shows that prolonged regulatory uncertainty creates a "De Facto Deregulation Trap" that benefits platforms at the expense of the public interest (Sáenz-Leandro, 2026). Conversely, overly restrictive regulatory frameworks can stifle innovation and reduce the economic benefits of ride-hailing services.

Studies on ride-hailing platform governance in various contexts show that co-governance approaches involving passengers, drivers, and platforms can yield better results than top-down regulation alone (Chen, 2025). A tripartite evolutionary game model involving passengers, drivers, and platforms suggests that strengthening the investigation and handling of illegal behavior by platforms can significantly reduce the likelihood of drivers' illegal operations (Chen, 2025)

From a broader policy perspective, research on the success factors of transportation interventions suggests that the most effective interventions are those that combine psychosocial approaches with infrastructure changes (Esser et al., 2025). Interventions that focus only on one aspect, for example only on economic incentives or only on environmental awareness campaigns, tend to be less effective in changing mobility behavior in a sustainable manner (Esser et al., 2025).

Trade-off Analysis: A Matrix of Conflict and Synergy

Inter-Pillar Trade-off Matrix of the SDGs

Based on the synthesis of the literature, a matrix of trade-offs and synergies between the pillars of sustainability in the context of online transport can be identified:

Economic-Environmental Trade-offs:

1. Growth in ride-hailing travel volume increases platform revenue (economy+) but increases carbon (environmental-) emissions (X. Li et al., 2025).
2. Low pricing increases accessibility (economic+) but encourages capital shift away from public transportation (environmental-) (Chen, 2025).

3. Deadheading increases the availability of services (economic+) but adds emissions without economic value to drivers (environmental-) (Gu & Liu, 2025)

Socio-Economic Trade-offs:

1. Independent partner status provides flexibility (economic+) but negates social security (social-) (Hazra et al., 2024).
2. The operational efficiency of the platform increases the valuation of the company (economic+) but creates uncertainty in the income of drivers (social-) (Mallett, 2026).
3. Dynamic pricing algorithms optimize platform revenue (economy+) but create uncertainty for (social-) drivers (Sáenz-Leandro, 2026).

Social-Environmental Trade-offs:

1. Increased accessibility for vulnerable groups (social+) but increased the volume of motor vehicles (environmental-) (Reinhardt et al., 2026).
2. EV adoption reduces emissions (environmental+) but increases costs that can reduce (social-) accessibility (Wang et al., 2025).

Potential Synergies:

1. The integration of MaaS with public transport can improve accessibility (social+) and reduce emissions (environmental+) (Rouky et al., 2025).
2. The adoption of EVs in ride-hailing fleets can reduce long-term operational costs (economic+) and emissions (environmental+) (Wang et al., 2025).
3. Regulations that protect drivers can improve service quality (social+) and user trust (economic+) (Chen, 2025).

Factors That Aggravate Trade-offs

Several structural factors exacerbate the trade-offs that exist in the online transportation ecosystem. First, the information asymmetry between the platform and the driver creates conditions in which the platform has a significant negotiating advantage (Hazra et al., 2024). Second, prolonged regulatory uncertainty creates an environment in which platforms can operate in legal gray zones, avoiding social and environmental obligations (Sáenz-Leandro, 2026). Third, competitive pressures between platforms are driving the race to the bottom in terms of working standards and prices, which benefits short-term consumers but harms drivers and the environment in the long term (Mallett, 2026).

The fourth factor is the mismatch of incentives between different stakeholders. Platforms have incentives to maximize travel volume and revenue, while drivers have incentives to maximize hourly revenue, and passengers have incentives to minimize travel costs (Chen, 2025). No single stakeholder has an intrinsic incentive to internalize the environmental or social costs of ride-hailing operations.

The Role of Technology in Overcoming Trade-offs

Technology plays a dual role in the online transportation ecosystem as a source of trade-offs as well as a potential solution. On the one hand, dynamic pricing algorithms and AI-based fleet management allow platforms to optimize revenue in ways that can harm drivers and the environment (Rouky et al., 2025). On the other hand, the same technology can be used to optimize routes, reduce deadheading, and integrate various modes of transportation in a more efficient MaaS ecosystem (Rouky et al., 2025).

Research on simulation-based on-demand transportation services shows that the most flexible scenario can reduce average passenger travel time by 32%, reduce average waiting time by 34%, increase vehicle occupancy rates from 12.1 to 18.6 passengers per vehicle, reduce emissions per passenger trip by 72%, and cut service costs per trip (Liyanage et al., 2026). These findings show that with the right system design, on-demand services can achieve synergies between economic efficiency and environmental impact reduction.

Technology fundamentally shapes sustainability trade-offs in online transportation because platform operations are largely governed by data-driven algorithms rather than conventional managerial decisions. Dynamic pricing algorithms continuously adjust fares according to real-time demand and supply conditions, improving market efficiency by balancing passenger demand with driver availability. However, while surge pricing increases platform revenue and reduces passenger waiting times, it may also generate income uncertainty for drivers and reduce transport affordability for low-income users, thereby creating a trade-off between economic efficiency and social equity (Sáenz-Leandro, 2026). Similarly, algorithmic matching systems improve operational efficiency by assigning the nearest available driver to passengers, yet these systems may unintentionally concentrate demand in high-profit urban areas while reducing service availability in peripheral or low-income neighborhoods, raising concerns regarding spatial equity and accessibility.

Advances in artificial intelligence have also enabled more sophisticated route optimization and demand prediction capabilities that directly affect environmental sustainability. Machine learning models can predict travel demand based on historical mobility patterns, weather conditions, events, and traffic information, allowing platforms to position drivers proactively and reduce unnecessary cruising or deadheading trips. Optimized routing further minimizes travel distance, fuel consumption, and congestion while simultaneously improving passenger waiting times and vehicle utilization. Nevertheless, improved operational efficiency may also induce additional travel demand by making ride-hailing services more attractive than public transportation, a phenomenon commonly referred to as induced demand. Consequently, technological efficiency does not automatically translate into environmental sustainability unless accompanied by policies that encourage modal integration and discourage substitution away from high-capacity public transport (Gu & Liu, 2025; X. Li et al., 2025).

Technology also plays a pivotal role in facilitating long-term sustainability through fleet electrification and multimodal integration within Mobility as a Service (MaaS) ecosystems. Digital platforms increasingly integrate electric vehicle management systems, battery monitoring, charging infrastructure information, and incentive mechanisms that encourage drivers to adopt electric vehicles, thereby reducing greenhouse gas emissions and operational costs over time (Wang et al., 2025). Furthermore, MaaS platforms supported by artificial intelligence can coordinate multiple transportation modes—including ride-hailing, buses, rail transit, bike-sharing, and shared micromobility—into a single digital ecosystem that optimizes first-mile and last-mile connectivity. Such multimodal integration has the potential to transform ride-hailing from a competitor of public transportation into a complementary service that strengthens the overall efficiency of urban mobility systems while simultaneously improving accessibility, reducing congestion, and lowering carbon emissions (Rouky et al., 2025; Beza et al., 2025). These findings suggest that the sustainability impacts of technology are not determined solely by technological innovation itself but by how digital capabilities are governed, regulated, and integrated into broader urban mobility policies.

CONCLUSION

This research has identified and synthesized significant trade-offs between the pillars of the SDGs in the context of ride-hailing services and MaaS. Key findings can be summarized as follows:

First, there is a real trade-off between the economic and environmental pillars, where the growth of economically profitable ride-hailing services is often accompanied by increased carbon emissions due to capital shifts from public transportation and the phenomenon of deadheading (Chen, 2025; Gu & Liu, 2025; X. Li et al., 2025).

Second, the trade-off between social and economic pillars is most clearly seen in the working conditions of gig economy drivers, where the operational efficiency of platforms is achieved at the expense of social security and driver welfare (Hazra et al., 2024; Mallett, 2026).

Third, MaaS has emerged as a concept that has the potential to be a mediator between various trade-offs, especially through the integration of first-mile/last-mile services with public transportation and the adoption of electric vehicles (Kriswardhana & Kiss, 2025; Rouky et al., 2025).

Fourth, regulation is a key factor in determining whether ride-hailing services contribute positively or negatively to the SDGs, with prolonged regulatory uncertainty likely to benefit platforms at the cost of public interest (Chen, 2025; Sáenz-Leandro, 2026).

Research Contributions

This research contributes to the literature by providing a comprehensive systematic synthesis of the trade-offs of the SDGs in online transportation. By explicitly identifying points of conflict and synergy, the study provides an analytical framework that can be used by policymakers, platform operators, and city planners to design more effective and balanced interventions.

Limitations and Future Research Agenda

This research has several limitations that need to be acknowledged. First, the focus on the Scopus database may miss important literature that is not indexed there. Second, the dominance of research from Asian and North American contexts in the literature reviewed limits the generalizability of findings to other contexts. Third, the dynamic nature of the online transportation ecosystem means that research findings can quickly become obsolete as technology and regulations change.

The recommended future research agenda includes: (1) longitudinal research on the long-term impact of ride-hailing services on carbon emissions and drivers' working conditions; (2) a comparative study of the effectiveness of various regulatory models in various contexts; (3) research on the impact of the adoption of electric vehicles in ride-hailing fleets on the three pillars of sustainability; and (4) research on the role of AI and big data in optimizing the MaaS system to achieve synergy between the pillars of the SDGs.

It is important to distinguish between the evidence synthesized from the reviewed literature and the recommendations proposed by this study. The systematic review consistently demonstrates that online transportation platforms generate both positive and negative sustainability outcomes, with trade-offs occurring across the economic, social, and environmental pillars of the SDGs. These findings are derived directly from the empirical and conceptual evidence reported in the selected studies and should not be interpreted as normative conclusions. In contrast, the recommendations presented in this paper—including strengthening platform governance, promoting multimodal MaaS integration, encouraging fleet electrification, improving driver protection, and leveraging AI for sustainable mobility management—represent the authors' interpretation of the synthesized evidence. These recommendations are intended to provide practical directions for policymakers, platform operators, and urban planners rather than definitive conclusions established by the reviewed studies themselves. This distinction clarifies that the literature primarily explains existing patterns and relationships, whereas the proposed policy and managerial implications are informed judgments aimed at supporting the achievement of the Sustainable Development Goals.

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