






The Transformative Impact of Information and Communication Technology on Transportation Services: A Systematic Literature Review



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ABSTRACT

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Technology has significantly improved transportation services through information and communication technologies (ICT), and it has enhanced efficiency, accessibility, security, and sustainability in transportation systems. This study aims to comprehensively understand how ICT impacts the transportation system through a systematic literature review. Moreover, this study systematically reviews and synthesizes literature on the impact of Information and Communication Technologies (ICT) on various facets of transportation. It specifically investigates the transformative potential of ICT, including blockchain and IoT technologies, in replacing traditional transportation systems. This review followed the PRISMA guidelines for reporting systemic reviews and meta-analyses. The review process involves several stages, including initial search queries, screening studies, eligibility assessments, and the final selection of articles. The study used only one database, Scopus and it found 425 articles, only 10 papers matched the selection criteria. The Study findings suggest that information and communication technologies have played an important role in transportation services, like smart traffic management, real-time data analysis, and enhanced user interfaces. Despite this, data privacy, infrastructure integration, and equitable access remain challenges. This review contributes to a deeper understanding of the relationship between ICT and transportation. The findings offer valuable insights for policymakers, researchers, and practitioners striving to harness the potential of ICT for creating more efficient, sustainable, and user-centric transportation systems. Based on the study, future research should explore the integrated impact of blockchain, IoT, and AI on transportation efficiency, user acceptance, regulatory adaptations, and environmental implications.

1. INTRODUCTION

The use of information and communication technology (ICT) has had an impact, on sectors bringing about transformations in the way societies function and communicate. One area that has experienced changes due to ICT is transportation. Transportation plays a role in society connecting different places and bringing people together. As Sumalee and Ho [1] accurately stated, transportation systems act as the lifelines of both rural areas facilitating the movement of individuals and goods while driving activities. Through a network of roads railways, ports and airways transportation influences our lives by promoting social interactions and enabling the exchange of ideas and resources. It's worth noting that Chang et al. [2] emphasizes how transportation is a factor, in shaping landscapes affecting land usage patterns and contributing to the overall character of cities.

The impact of information and communication technology

(ICT) on transportation goes beyond the transportation itself. It also influences planning and land use. With the integration of technology, we are witnessing the emergence of "cities" where transportation systems and data-driven urban planning strategies are intertwined. As discussed by Klopp and Cavoli [3], the data collected through ICT tools in areas can provide insights for making decisions about infrastructure development, zoning regulations and public transportation routes. Additionally, ICT-driven transportation options like bike sharing and e-scooter services play a role in reducing traffic congestion and transforming city landscapes [4, 5]. Therefore, the collaboration between ICT and urban planning is crucial for creating more livable and sustainable cities.

Kashinath et al. [6] highlight the importance of collecting and analyzing real-time data to improve traffic flow. With the increasing number of sensors, GPS devices, and smartphones, transportation systems have become responsive [7]. This connectivity allows for the development of transportation

systems that can anticipate and alleviate congestion, ultimately reducing travel time and fuel consumption [8]. Real-time navigation applications, like Waze and Google Maps, serve as examples of how information and communication technology has empowered travellers to make informed decisions and choose the most efficient routes.

Researchers have shown interest in using information and communication technology (ICT) to enhance safety. In the study [9], they discussed the use of technologies in communication systems which enable vehicles to communicate with each other (V2V) and with infrastructure (V2I). These systems allow for the exchange of information to prevent accidents, such as alerting drivers about collisions, lane departures and other dangerous conditions in real-time. As a result, the likelihood of accidents can be reduced [10]. The potential for vehicles further enhances these safety advantages, although there are concerns about their ethical and regulatory implications [11].

Moreover, ICT directly impacts transportation systems. According to the study [11], the concept of the "economy" highlights how ICT transforms industries and creates new economic opportunities. This transformation is evident in the transportation sector as well. The emergence of ride-hailing services and shared mobility platforms has disrupted taxi industries, leading to the rise of the "economy" and innovative business models [12]. Additionally, investments in research and development driven by vehicles and related technologies are affecting the automotive sector and making a broader impact on the overall economy.

The integration of information and communication technology (ICT) has brought about an era of decision-making in transportation planning and management driven by data. The substantial volume of data generated by ICT systems, often called "data," provides insights into travel patterns, congested areas and infrastructure usage [13]. Suryani et al. [14] discuss how data analytics can assist policymakers in identifying bottlenecks, optimizing transportation routes and planning infrastructure upgrades. Furthermore, applying machine learning techniques to transportation data enables travel demand prediction, facilitating resource allocation [15]. By utilizing this data-driven approach, operational efficiency can be improved. Evidence-based policy interventions can also be guided.

Sumalee and Ho [1] highlight the importance of transportation systems as lifelines for rural areas. Comparing this finding with the work of the study [2], which emphasizes transportation's role in shaping landscapes, we can conclude that transportation facilitates movement and contributes to the character of cities through its influence on land usage patterns. Additionally, we can analyze how advancements in ICT have led to innovations like bike sharing and e-scooter services, which, as noted by the study [4, 5], reduce traffic congestion and transform urban landscapes. By comparing these findings, we can emphasize the role of ICT in reshaping urban transportation dynamics.

It is crucial to examine the intricate relationship between Information and Communication Technology (ICT) and transportation, as the nature of mobility is constantly developing in the era of digitalization. The ongoing progress of technology has significantly transformed both urban and rural areas. However, there needs to be more comprehensive knowledge regarding the overall effects of integrating information and communication technology (ICT) into transportation networks. This encompasses various economic,

social, cultural, ethical, and environmental dimensions. This systematic literature review aims to present a comprehensive analysis of the academic discourse around the influence of information and communication technology (ICT) on transportation. This study will examine the various dimensions of change that ICT has introduced, including efficiency, sustainability, safety, and user experience enhancements. To achieve this objective, the following research questions were identified:

1. How has the integration of ICT into transportation systems influenced the efficiency and sustainability of urban and rural mobility?

2. What ethical and regulatory challenges have arisen with the increased use of ICT in transportation, and how can these concerns be effectively addressed?

3. How have advancements in data analytics and machine learning techniques transformed decision-making in transportation planning and management, and what are the implications for shaping future transportation systems and policies in the digital age?

2. MATERIALS AND METHOD

Our research involved a comprehensive review of information and communication technology (ICT) within the transportation domain, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The primary aim was to analyze and curate scholarly articles from 2015 to 2023, focusing on ICT's impact on transportation services. This nearly eight-year timeframe was chosen deliberately to ensure a thorough compilation of insights into ICT's role in transportation.

Part of the larger Sphere project, which emphasizes evidence-based practices, our study dedicated substantial efforts to establishing a robust evidence base. We included articles published before 2023 to ensure a comprehensive search and inclusion of pertinent literature.

Our search strategy, conducted exclusively on Scopus for journal articles and conference proceedings, employed specific keywords ("ICT" OR "IT") AND ("Transportations" or "Transports") following a qualitative analysis of relevant terms. The review examined the title and abstract of 425 articles, followed by a detailed assessment of the full text.

Following PRISMA guidelines, our study delineated four stages in the search and findings: preliminary screening, study screening, identification of eligible studies, and final inclusion. Initial screening involved developing search queries and identifying relevant articles from various databases. Subsequent phases removed duplicates and ineligible papers based on predetermined criteria, resulting in a refined list of articles for detailed review, as depicted in Figure 1.

Our systematic review, following PRISMA protocols, rigorously examined and synthesized scholarly literature to offer a comprehensive understanding of ICT's impact on transportation services.

In this study, we implemented a five-phase process outlined in Table 1, which details our inclusion and exclusion criteria. Phase I involved a systematic literature search for relevant articles on ICT in transportation from 2015 to 2023. In Phase II, we conducted full-text screening, excluding 191 duplicates. Phase III eliminated 88 articles due to unrelated issues. Phase IV reported 77 articles as needing to be retrieved. In the final Phase V, 70 articles were manually assessed, and only 10 were

included, aligning with our research objectives to select

documents contributing significantly to ICT in transportation.

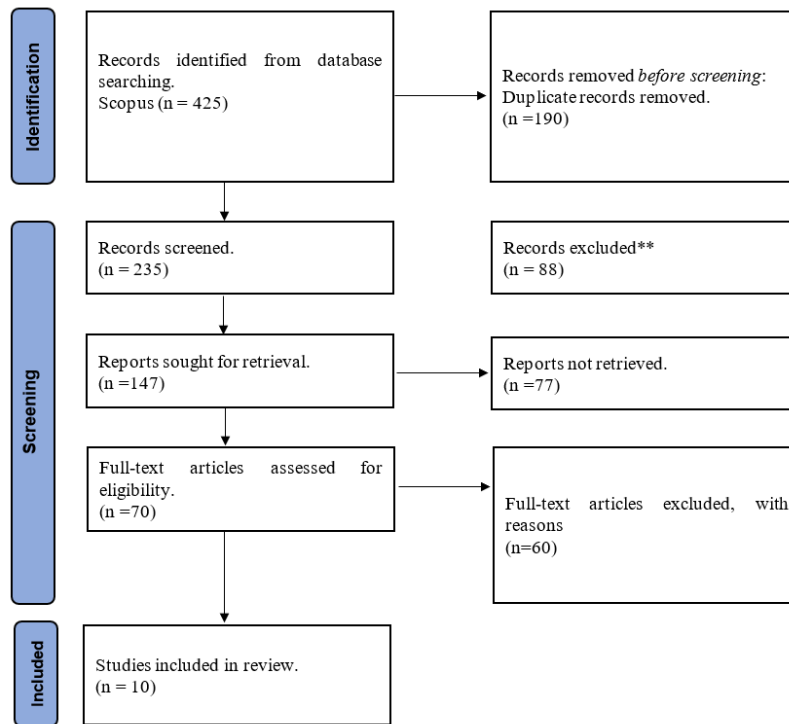


Figure 1. Selection process

Table 1. Inclusion and exclusion criteria

Inclusion	Exclusion
Publications that focus on ICT in Transportation (2015 to 2023)	ICT not related to Transportation
Peer-reviewed journal articles in English language	Had a non-English manuscript
Related to the research questions	Not related to the research questions
Publications with adequate explanations for research findings	

3. RESULTS AND DISCUSSION

The aims, results, conclusions, and methods used in previous studies are depicted in Table 2.

The impact of information and communication technology (ICT), on transportation goes beyond the infrastructure. It also affects how people choose to travel and the demand for modes of transportation. When we talk about "adaptation", we refer to how individuals change their travel decisions when they have ICT-enabled options [16]. For example, the rise of ride-hailing services has introduced solutions for the last mile of a journey, which in turn influences the use of transportation. Shao et al. [17] highlight how these services can help connect areas with transit stations, potentially reducing reliance on cars. However, it is important to note that these adaptations are complex and can have negative consequences. This emphasizes the need for analysis considering all aspects involved.

The use of information and communication technology (ICT) in transportation has also led to advancements in sustainability. According to studies [18, 19], shared mobility platforms and ride-sharing services play a role in reducing the number of vehicles on the road, which ultimately results in carbon emissions. Additionally, ICT enabled grids facilitate the adoption of vehicles by providing charging infrastructure and managing demand [20]. This does not reduce our

dependence, on fuels but also helps decrease air pollution in urban areas.

The rapid progress of information and communication technology (ICT), in transportation has brought about policy challenges that require consideration. The rise of ride-hailing platforms and autonomous vehicles has sparked discussions about frameworks [21, 22]. Policymakers need to address concerns regarding insurance, liability, data sharing and safety standards. Moreover, as ICT enabled transportation services expand, ensuring competition with modes of transport becomes crucial [23]. Striking a balance between fostering innovation and safeguarding consumer interests continues to challenge authorities.

The selected reviewed articles emphasized the advantages of Information and Communication Technology (ICT) to transportation systems. One significant benefit is the improvement of efficiency, through the analysis of real-time data and intelligent systems. By utilizing ICT-driven data sources like sensors and GPS devices, traffic flow can be optimized, and congestion can be predicted, resulting in reduced travel times and fuel consumption [16, 19]. Moreover, the integration of ICT has led to the development of Mobility as a Service (MaaS) platforms that provide travellers with access to various transportation modes, thereby promoting efficient multi-modal journeys [20]. These platforms need to simplify travel. It also helps reduce traffic congestion and

contributes to a more sustainable urban mobility landscape.

Furthermore, the impact of information and communication technology (ICT) reaches safety improvements in transportation systems. With the help of ICT, vehicles can communicate in time with infrastructure, exchanging information that aids in accident prevention through collision warnings and hazard notifications. The introduction of vehicles further strengthens safety measures by eliminating

human error, which is a major cause of road accidents [10]. Moreover, ICT has played a role in promoting sustainability by enabling platforms for shared mobility ride-sharing services and the adoption of vehicles. These advancements align with objectives by reducing emissions and congestion, paving the way for environmentally friendly transportation systems.

Table 2. Content review of the selected article

Author	Aim	Method	Result	Recommendation
[24]	To find capabilities in road freight movement that are made possible by technology and figure out their readiness level (RL).	Multi-method (SLR and Secondary data)	The findings reveal 32 technology-enabled capabilities in road freight transportation systems, grouped into six categories.	In the future, surveys or case studies on the role of these technology-enabled capabilities in road freight transportation that are backed by a desktop or mobile application could be done as part of the research.
[25]	To develop a classification system for shared mobility based on 1) how digital technology and transport work together and 2) the more significant idea of the sharing economy.	Review	The suggested taxonomy helps people from the public, private, and academic sectors agree on the solutions included in the term "shared mobility." This takes away one of the first barriers to using the term.	By using the real-world features of shared mobility solutions, the taxonomy can keep up with the fast-paced changes in this area without significant changes. This could make the taxonomy a basic piece in the future study of shared mobility.
[26]	To figure out what gets in the way of ITS being used in cities from the point of view of people in charge of planning urban transport who work for the local governments of some Polish cities.	Survey	The results show the main groups and subcategories of problems with implementing ITS. There are economic, social, organizational, technological, and legal barriers that have been found.	The fact that there are many different ways to look at the benefits of urban transport and ITS, as well as the fact that they are changing quickly, gives scientists a solid direction for more research.
[27]	To learn more about the connections between ICT and travel by doing a thorough literature study.	Review	The results of this study were used to make a mental model, which had three different layers and showed how they worked together.	ICT can have a direct effect on many aspects of life quality. But they were not taken into account for this work. In the future, studies can look into these things.
[28]	To examine into how people use physical travel (like walking, biking, and bike-sharing) and public transit (like buses and trains) together, taking into account personal and situational factors.	Survey	The model shows that physical and social environments that work well together, as well as spatial skills and a willingness to learn, are important for multimodality.	It would be interesting to find out how ready people are to replace car trips with "greener" options, so that the adoption and cessation stages of change can be looked at together.
[29]	To give an overview of the different ways that collaborative drones and the Internet of Things (IoT) could be used and how they could make smart towns even smarter.	Survey	The study found that ML could be used between the IoT framework and drones to keep the network safe from cyberattacks.	To find better ways to protect the networks where drones and IoT devices work together, more study is needed.
[30]	To determine how drivers feel about their own driving skills after an experiment where they were watched and given comments on how they did.	Case Study	Results show that most drivers thought the information in the feedback reports was important, especially the information about how much fuel they used and how pushy they were.	Future studies could look at how much drivers know about driving activities, eco-driving techniques, and the factors that go into them.
[31]	To establish how using smart gadgets affects the way people feel about public transport in general.	Questionnaire	The findings indicate that a new generation of "equipped travellers" has developed expectations about their trips on public transport that may be hard for service providers to meet right now.	For future studies, it should be a goal to get data from more representative groups than were used in this one. This will make the results more reliable in the real world.
[32]	To explain how the 4PL method can be used to reengineer a traffic handling process.	Case Study	The outcomes of the study show that using a 4PL method makes it easier to improve the transportation process.	ICT prototypes must be implemented for use by the actors involved.
[33]	To examine how low-cost planes in Europe set their prices and what effect the Internet has on this.	Secondary Data	The study stated that the amount of competitors, how the demand changes, and the costs are the most important factors for understanding pricing strategies.	The addition of new factors can be seen as a step forward in the study of the low-cost airline market segment.

However, integrating ICT into transportation systems has some downsides, as mentioned in the reviewed articles. One significant concern revolves around equity and accessibility. While ICT-powered services offer convenience to those with access, they could unintentionally exclude individuals needing more literacy or technology resources. Additionally, privacy and security challenges are associated with collecting and using data in ICT powered transportation systems. The extensive use of sensors and tracking technologies raises questions about data ownership, consent, and potential surveillance.

In our analysis of the impact of information and communication technology (ICT) on transportation, we observe a convergence of findings among the studies. Specifically, adopting ICT-driven transportation solutions, such as ride-hailing services and shared mobility platforms, consistently leads to positive outcomes related to efficiency, sustainability, and safety. These findings suggest a promising trend in which ICT enhances various facets of the transportation landscape. However, it is crucial to acknowledge the nuances in the data. While the general trend is positive, some studies emphasize ICT adaptation's complexities and potential negative consequences. These complexities indicate that the effects of ICT on transportation are multifaceted and context-dependent.

4. CONCLUSIONS

This study has provided a comprehensive overview of how information and communication technology (ICT) has significantly improved transportation services. This study analyzes a diverse range of literature to elucidate how ICT has revolutionized and enhanced the transportation landscape. From the 425 articles identified in the Scopus database, only 10 were included in the review due to our stringent selection criteria. By systematically analyzing a wide range of literature, it has become evident that ICT integration has led to intelligent transportation systems, data-driven decision-making, and enhanced connectivity. These advancements have redefined travel experiences and operational efficiency. However, the evolution requires a balanced approach to address security concerns, data management, and equitable access. Moving forward, this review offers valuable insights for policymakers, researchers, and industry leaders to harness ICT's potential effectively, driving sustainable, safe, and transformative transportation solutions.

The current research on ICT's impact on transportation has limitations. One notable limitation is the need for more comprehensive knowledge regarding the long-term environmental impact of ICT-driven transportation. Future research should focus on assessing the sustainability of these advancements over time and their potential ecological effects. Additionally, there is a need for a more in-depth exploration of ethical and regulatory challenges, particularly in areas related to data privacy, ownership, consent, and potential surveillance. Future studies should delve deeper into these aspects to provide a more comprehensive understanding of the implications of ICT in transportation. The most important questions that future research should address are the long-term sustainability, equity, and privacy aspects of ICT-driven transportation.

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