

Emerging Technologies for Smart Mobility: A Systematic Mapping Study

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Abstract— The study explores how artificial intelligence (AI) is integrated into smart mobility systems and how it can enhance the efficiency and safety of urban transportation. It also examines current trends, challenges, and prospects of applying AI to transform urban mobility in smart cities. Moreover, the study discusses how AI can address significant issues such as congestion, energy consumption, and public safety, as well as the challenges related to data privacy and regulatory compliance. Applying the systematic mapping method, we identify major AI applications in smart mobility and their contributions to traffic optimization, promotion of autonomous vehicles, and improvement of emergency response systems. In this context, operations research complements AI by providing advanced tools for modeling, optimization, and strategic decision-making to enhance resilience and efficiency in urban mobility systems.

Keywords: Smart mobility system, artificial intelligence, optimization, operational research, emergency technology.

I. INTRODUCTION

The advent of smart mobility systems changes urban transportation management by integrating advanced technologies such as big data analytics (BDA) and artificial intelligence (AI). AI is crucial to optimize traffic flow, enable autonomous vehicles, and improve emergency response systems[1]. With rapid urbanization and increasing traffic congestion, AI-driven solutions have become essential for designing efficient and sustainable transportation networks[2].

This study applies a systematic mapping methodology to assess AI adoption in smart mobility systems. By examining key applications, including intelligent traffic management, autonomous mobility, and real-time data processing[1, 2], the study aims to offer a comprehensive analysis of AI's impact on urban transport.

Furthermore, it explores the challenges in the sector, particularly those related to suppliers, end-user adoption, and data privacy concerns. The study also highlights the crucial role of Operational Research (OR), which provides the mathematical models and optimization techniques necessary for these AI-driven solutions. The synergy between AI's data analysis capabilities and OR's optimization methods allows for the dynamic resolution of complex urban mobility challenges[6].

II. BACKGROUND

The rapid urbanization of cities worldwide has amplified the demand for more efficient, sustainable, and intelligent mobility solutions. Smart mobility has emerged as a key component of smart cities, aiming to improve transportation systems through the integration of advanced technologies such as Artificial Intelligence (AI), Optimization algorithms, and Operational Research (OR) techniques.

AI enables machines to learn from data, predict traffic patterns, optimize routes, and support autonomous vehicle functions. Optimization techniques, on the other hand, help in resource allocation, traffic flow control, and logistics planning to minimize travel time, costs, and environmental impact. Operational Research provides mathematical and analytical models to support complex decision-making processes in transportation systems.

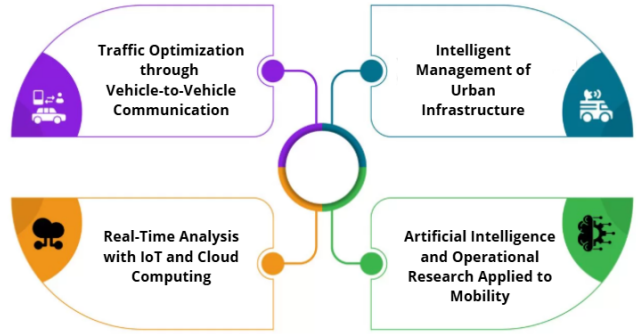


Fig. 1. Key Technologies in Smart Mobility

Together, these technologies contribute to the development of smart transportation systems, autonomous vehicles, Mobility-as-a-Service (MaaS) platforms, and emergency traffic management solutions. Various countries such as South Korea, Japan, and Singapore have already implemented such systems, setting examples for other nations to follow.

The continuous advancement in IoT, edge computing, 5G connectivity, and big data analytics has further enhanced the effectiveness and scalability of smart mobility solutions. However, despite these advancements, there remain several

challenges, including system integration, infrastructure limitations, data privacy concerns, and the need for standardized regulatory frameworks.

This section provides the necessary foundation for understanding the technical and strategic aspects of smart mobility research, paving the way for exploring its challenges, opportunities, and future directions.

III. RESEARCH METHOD

A. Goal and Main Research Questions (MQs)

The primary goal of this study is to explore and synthesize the state of the art in smart mobility research, with a particular focus on the integration of Artificial Intelligence (AI), Optimization techniques, and Operational Research (OR) methodologies. This research aims to identify current challenges, opportunities, and trends, while highlighting promising future directions for the development of sustainable and intelligent transportation systems.

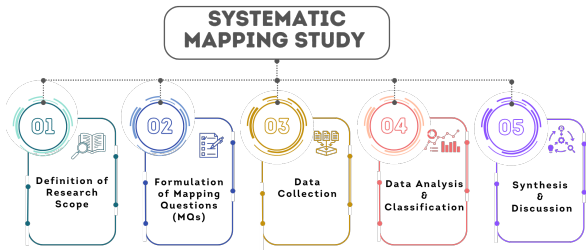


Fig. 2. Systematic Mapping Process

To achieve this objective, the following Main Research Questions (MQs) have been defined:

TABLE I
MAPPING QUESTIONS

MQ1: What type of publication is most common in smart mobility research?
MQ2: What is the annual publication trend for smart mobility studies using AI, optimization, and operational research techniques?
MQ3: How are research papers on smart mobility distributed across countries, and what factors influence this distribution?
MQ4: In which field is smart mobility most applied, and what systems are proposed?
MQ5: What are the main challenges and opportunities identified in recent smart mobility research?
MQ6: What types of research are most frequently published in this field?
MQ7: Which Q1 and Q2 journals show the greatest interest in this field?
MQ8: What are the most commonly used approaches, and why?

B. Search Strategy and Data Sources

1) *Search String:* To ensure a comprehensive coverage of the relevant literature in the domain of smart mobility and emergency technologies, we conducted automated searches primarily using the **Scopus** database and **Google Scholar**. These platforms were selected for their extensive repository of peer-reviewed scientific research and wide accessibility in the domains of engineering, AI, and transportation systems.

To construct our search string, we followed the **PICOC** (Population, Intervention, Comparison, Outcomes, Context) methodology:

- **Population:** Smart mobility systems
- **Intervention:** Artificial Intelligence (AI), Optimization, Operational Research, and Emergency Technology
- **Comparison:** Not Applicable (NA)
- **Outcomes:** Identification of trends, methods, and technologies applied in smart mobility
- **Context:** Scientific publications focused on AI-driven mobility systems, smart cities, and emergency response solutions

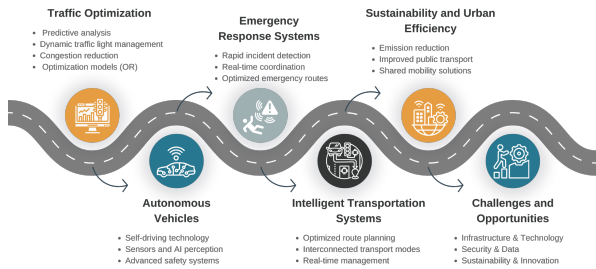


Fig. 3. Smart Mobility Trends

Based on this, we formulated the following search string:

((“smart mobility” AND (“artificial intelligence” OR “machine learning”))
OR (“smart mobility” AND “optimization”)
OR (“smart mobility” AND “operational research”)
OR (“smart mobility” AND “emergency technology”))

The query was tested iteratively across both Scopus and Google Scholar to refine keyword combinations and maximize the relevance and completeness of the results.

2) *Screening Process for Inclusion and Exclusion:* To ensure the reliability and scientific relevance of our study, a rigorous selection protocol was followed based on pre-defined **Inclusion** and **Exclusion** criteria, inspired by guidelines from existing Systematic Mapping Studies (SMS).

A total of **2025 articles** were initially retrieved. After applying the selection criteria, **90 primary studies** were retained for in-depth analysis.

a) Inclusion Criteria:

- **I1:** Articles that contribute directly to the development or analysis of **smart mobility systems** through the

use of **artificial intelligence, optimization, operational research, or emergency technology**.

- **I2:** Studies proposing models, frameworks, or architectures based on AI or OR techniques for traffic management, emergency response, or decision-making systems in urban mobility contexts.
- **I3:** Research papers addressing one or more of the Mapping Questions (MQ1–MQ8), particularly those analyzing trends in publication type, geographical distribution, applied fields, research approaches, or journal impact.
- **I4:** Publications focusing on the application of intelligent systems in **smart cities**, including intelligent transport systems (ITS), autonomous vehicles, or mobility innovations in healthcare, logistics, and public safety.

b) Exclusion Criteria:

- **E1:** Papers written in a language other than English.
- **E2:** Editorials, short communications, opinion letters, or non-peer-reviewed documents lacking scientific rigor.
- **E3:** Studies published before the year 2000 or after 2024, outside the defined time frame of technological relevance.
- **E4:** Articles not available in full-text, limiting reproducibility or verification of content.
- **E5:** Papers addressing only minor or isolated technical improvements without significant impact on AI, optimization, or operational research within smart mobility systems.
- **E6:** Research limited solely to economic, legal, or policy aspects without proposing or evaluating technological solutions or models.
- **E7:** Studies where smart mobility, artificial intelligence, or emergency technology is mentioned superficially or not as a primary focus of investigation.

By applying these criteria, our **Systematic Mapping Study (SMS)** focuses on high-impact and relevant studies. This method allows us to provide a structured and holistic view of how AI, optimization, and emergency innovations are shaping smart mobility systems in urban environments.

C. Data Extraction Strategy

Achieving a balance between comprehensive research coverage and a manageable number of studies is essential for the success of any Systematic Mapping Study (SMS) [24]. To achieve this, we followed the methodological guidelines proposed by Kitchenham et al. [26] and Petersen et al. [27], ensuring a structured, transparent, and reproducible approach.

2) Screening Process for Inclusion and Exclusion:

To ensure the reliability and scientific relevance of our study, a rigorous selection protocol was followed based on pre-defined **Inclusion** and **Exclusion** criteria, inspired by guidelines from existing Systematic Mapping Studies (SMS).

A total of **2025 articles** were initially retrieved from our combined search in Scopus and Google Scholar, using the search string defined earlier. After applying our inclusion and exclusion criteria, **90 primary studies** were retained for in-depth analysis.

The selection process was carried out in multiple filtering stages as follows:

- **Duplicate Removal:** Articles retrieved from both databases were compared, and duplicate entries were eliminated.
- **Article Type Screening:** We retained only peer-reviewed journal articles, conference papers, and book chapters. Editorials, short notes, and opinion pieces were excluded.
- **Citation-Based Filtering:** To ensure academic significance, studies with fewer than 10 citations (when available) were excluded, unless they presented novel or highly relevant contributions.
- **Title & Abstract Screening:** Articles that did not explicitly mention smart mobility, AI, optimization, operational research, or emergency technology were excluded during preliminary screening.
- **Full-Text Review:** When ambiguity remained, a full-text evaluation was performed to confirm whether the article aligned with our Mapping Questions (MQ1–MQ8).

A study was included if it satisfied all inclusion criteria, and excluded if it met any exclusion criteria. This systematic filtering ensured that only high-quality and relevant literature contributed to our analysis.

By following this rigorous data extraction strategy, inspired by established SMS protocols [24], [26], [27], we ensured that our study accurately captures the most impactful and scientifically relevant contributions at the intersection of smart mobility, artificial intelligence, optimization, and emergency technologies.

D. Research Facets

To systematically classify the selected studies, we grouped publications into four research facets:

- 1) **Application Domain Facet:** This facet categorizes studies based on the application domains of smart mobility. The analyzed articles focus on applications such as urban traffic management, Intelligent Transportation Systems (ITS), autonomous vehicles, smart parking solutions, and urban logistics optimization. Advanced technologies in mobility are applied chiefly within these outlined use cases.
- 2) **Research Area Facet:** This facet identifies the main technological and methodological research areas. To achieve the objectives of these studies, the authors emphasized applying artificial intelligence (AI) as well as machine learning (ML), deep learning (DL), and deep reinforcement learning (DRL). They also pointed out IoT's essential role for data gathering, next-generation telecommunication systems like 5G for real-time data transfer, and emerging information technology frameworks. Other equally important fields comprise computer vision and hybrid predictive models.
- 3) **Research Type Facet:** Building upon evidence from earlier systematic reviews, we've adopted a more



Fig. 4. Filtering steps

pragmatic approach to how papers are organized. In essence capturing the diverse approaches that had been implemented, most analyzed publications qualify as Synthesis Papers which concentrate on providing a comprehensive comprehensive overview of cutting-edge research known as state-of-the-art research which is predominately.

V. COMPARATIVE ANALYSIS

Overview of Selected Primary Studies

MQ1:What type of publication is most common in smart mobility research?

After selecting and analyzing the identified papers, the five main types of publications in our dataset were journal articles, review papers, Conference Paper, Book, Book Chapter and other minor categories.

Key Findings: Peer-reviewed journals remain the most preferred type of publication since they receive the highest share of original research articles and conceptual advancements (34.6%).

The importance of literature reviews, systematic mapping studies, and critical analysis is prominent given their focused attention on evaluating and synthesizing existing literature with a 30.8% contribution towards review and survey papers in the context of smart mobility and AI optimization.

In this rapidly changing area of study, scientific conferences continue to be an essential venue for presenting new work and its results; hence the representation of conference papers at 23.1% of the dataset.

Research on this subject published in edited academic volumes appears to be very limited owing to book chapters and books as a whole only comprising 11.5% of the total.

This classification marks a notable finding regarding publication channels preferred within smart mobility research, as it highlights the extensive role provided by reviews alongside journal articles while also acknowledging conferences as additional important contributors to knowledge dissemination.

TABLE II

DISTRIBUTION OF SELECTED PAPERS PER DOCUMENT TYPE.

Publication Type	Count	Percentage
Journal Article	9	34.6%
Review / Survey Paper	8	30.8%
Conference Paper	6	23.1%
Book	2	7.7%
Book Chapter	1	3.8%
Total	26	100%

MQ2: What is the annual publication trend for smart mobility studies using AI, optimization, and operational research techniques?

Figure 5 illustrates The evolution of smart mobility systems integrated with AI, optimization, and operational research is illustrated in Figure 6. Our analysis reveals that research interest began to increase significantly around the year 2020, likely due to the rise of AI technologies, IoT solutions, and 5G networks.

This trend reflects the growing need for real-time data processing, intelligent traffic management, and sustainable urban development. The continuous increase in publications suggests that smart mobility remains a dynamic and rapidly evolving research field, particularly with advancements in AI-based modeling and optimization techniques.

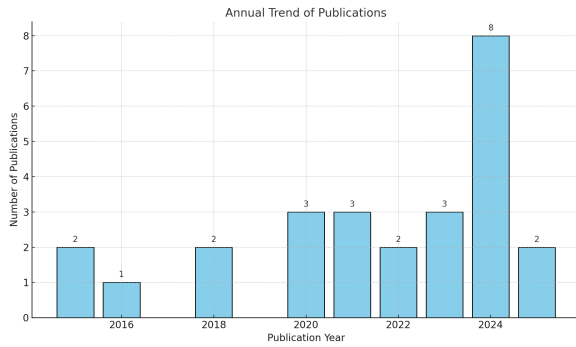


Fig. 5. Annual publication trend for smart mobility studies using AI, optimization, and operational research.

MQ3: How are research papers on smart mobility distributed across countries, and what factors influence this distribution?

As shown in Figure 2, the different countries are marked depending on the concentration of scholarly articles published on the topic of smart mobility and its related concepts. From the documents provided to us, we can conclude that this research is done internationally by multiple institutions as they all share their works. The geographical distribution owes greatly to the innovations brought about in AI, IoT, 5G technologies, along with some major research hubs and good international partnerships existing within these areas

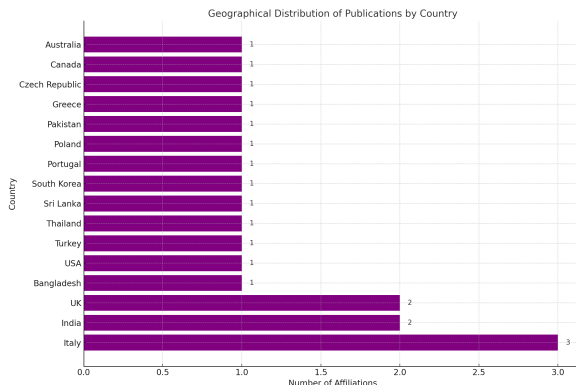


Fig. 6. Geographical Distribution of Publications by Country

MQ4: In which field is smart mobility most applied, and what systems are proposed?

1. Application Domains of Smart Mobility:

Smart mobility, often regarded as Intelligent Transport Systems (ITS), remains one of the key areas artificial intelligence (AI) is deployed in smart cities. The mobility industry accounts for a significant share of AI adoption – only trailing healthcare – with a predicted influence of 19%. The provision and facilitation of mobility services, along with modernization of transportation infrastructures systems, are critical areas where AI can revolutionize cities and enable environmentally friendly transitions.

2. Proposed Systems:

The systems presented in the reviewed literature leverage a variety of technologies, including artificial intelligence (AI), machine learning (ML), deep learning (DL), and the Internet of Things (IoT). The main systems discussed include:

- **Intelligent Transportation Systems (ITS):** These systems integrate advanced sensors, control systems, and information and communication technologies (ICT) to collect large volumes of data and manage traffic efficiently.
- **Physical Internet (PI) System:** This logistics concept includes “PI-movers” (connected and autonomous vehicles – CAVs, and unmanned aerial vehicles – UAVs), “PI-containers,” and “PI-hubs” (such as warehouses and retail stores) to enable real-time decision-making and the efficient orchestration of logistics systems.
- **AI-Based Systems:** AI is utilized to address complex transportation challenges. Deep learning and intelligent vision techniques are frequently applied within these systems.
- **IoT-Based Systems:** The IoT is a foundational component of smart cities. When integrated with AI, it enables the development of systems that enhance sustainability, improve citizen comfort, and increase productivity.
- **Energy Management Systems:** An example includes energy management systems for commercial buildings, which are part of the broader smart city infrastructure.
- **Communication Technologies:** Emerging technologies such as 5G, Beyond 5G (B5G), and millimeter-wave (mmWave) communications are highlighted as key enablers for AI applications in smart cities.

MQ5: What are the main challenges and opportunities identified in recent smart mobility research?

Recent research on smart mobility highlights a dynamic landscape, rich in innovation but also marked by significant technical, social, and organizational challenges. Based on the reviewed literature, the main challenges and opportunities can be grouped into the following categories:

Challenges:

- **Data-Related Limitations**
- Inadequate data quality, heterogeneity, and privacy concerns hinder the performance of AI and optimization models.
- Real-time data collection and integration from IoT sensors, vehicles, and users remain complex and costly.
- **Technological Constraints**
- Edge computing, despite its promise, faces difficulties with processing power, synchronization, and system orchestration.
- AI models (especially deep learning) require high computational resources, which are not always feasible in real-time urban environments.
- **Infrastructure and Deployment**
- Many smart mobility technologies (e.g., connected autonomous vehicles, drone-based transport, MaaS platforms) lack supportive infrastructure in developing con-

texts.

- The transition to intelligent transport systems requires large-scale investment and strong public-private coordination.
- Social and Ethical Concerns
- Public trust in AI-powered mobility solutions is limited, especially regarding autonomous decision-making and data surveillance.
- Lack of user-centered design risks excluding vulnerable populations and diminishing overall adoption.
- Policy and Standardization
- Regulatory uncertainty, fragmented governance, and lack of standardized frameworks delay the deployment of smart solutions.
- Cybersecurity and legal liability in autonomous systems are still underdeveloped.

Opportunities:

- AI and Big Data for Urban Optimization
- AI enables predictive traffic management, congestion avoidance, and smart emergency routing, as seen in studies using machine learning and Dijkstra-based models.
- Reinforcement learning and swarm intelligence offer new ways to optimize transport flows and delivery systems.
- Operational Research for Sustainability
- Vehicle Routing Problems (VRP), scheduling, and multi-objective optimization help reduce energy consumption, emissions, and costs.
- Integration with electric vehicle (EV) planning, drone logistics, and predictive maintenance supports sustainability goals.
- Edge Computing and 5G Integration
- The confluence of AI and edge computing enables ultra-low latency, making real-time applications (e.g., smart ambulances, connected AVs) feasible.
- 5G networks enhance communication among vehicles, infrastructure, and city services.
- Cross-Domain Synergies
- Emerging smart mobility solutions intersect with healthcare, education, industry, and public safety, creating multidisciplinary research and deployment opportunities.
- Drone delivery for medical emergencies and AR/VR-based simulation for autonomous vehicle training are promising directions.
- Policy Innovation and Smart Ecosystems
- Countries like South Korea, Singapore, and Japan showcase the impact of strong national strategies and data-driven governance in smart mobility success.
- Frameworks like SCOPE and MBSE demonstrate how structured design can support scalable, low-cost educational and experimental platforms.

Smart mobility research presents a landscape of high potential supported by AI, optimization, and operational research. However, the real-world deployment of these tech-

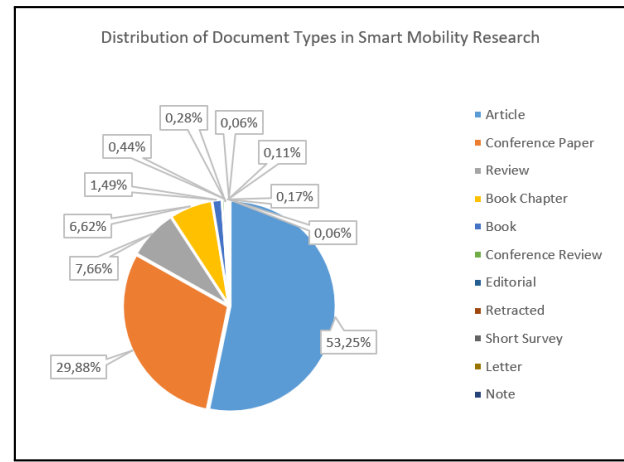


Fig. 7. Distribution of Document Types in Smart Mobility Research

nologies is constrained by data, infrastructure, ethical concerns, and governance gaps. Addressing these will require interdisciplinary collaboration, investment in digital infrastructure, and citizen-centered innovation to ensure long-term success and sustainability.

MQ6: What types of research are most frequently published in this field?

Out of the 2025 documents retrieved and screened, the most common publication types were **journal articles** (966, 47.7%), followed by **conference papers** (542, 26.8%) and **review articles** (139, 6.9%). Book chapters accounted for 120 studies (5.9%), while other formats such as books, conference reviews, editorials, and short surveys represented less than 2% each.

This distribution highlights the field's strong academic foundation in peer-reviewed articles, while also reflecting the dynamic and evolving nature of smart mobility technologies through conference contributions and review papers.

TABLE III
TYPES OF RESEARCH DOCUMENTS IN SMART MOBILITY

Document Type	Count	Percentage
Article	1212	59.88%
Conference Paper	681	33.61%
Review	175	8.64%
Book Chapter	151	7.45%
Book	33	1.63%
Conference Review	10	0.49%
Editorial	6	0.30%
Retracted	4	0.20%
Short Survey	3	0.15%
Letter	1	0.05%
Note	1	0.05%
Data Paper	0	0.00%
Total	2025	100%

MQ7: Which Q1 and Q2 journals show the greatest interest in this field?

Our analysis of the 2025 selected articles revealed that several high-impact **Q1** and **Q2** journals are prominently involved in publishing research related to smart mobility systems. Based on Scopus-indexed source data, the following

journals stand out for their consistent and substantial contributions:

Q1 Journals:

- **IEEE Access** (196 articles): Covers multidisciplinary research, especially in smart mobility, AI, and communication systems.
- **Sensors** (93 articles): Focuses on sensor technologies and AI integration in intelligent transport.
- **IEEE Transactions on Intelligent Transportation Systems** (77 articles): A leading source in autonomous mobility and traffic optimization.
- **Sustainable Cities and Society** (42 articles): Well-cited for its sustainability-oriented urban mobility research.
- **Journal of Cleaner Production** (37 articles): Publishes work on sustainable transport and green technologies.
- **IEEE Internet of Things Journal** (50 articles): Includes studies on IoT-driven smart urban mobility systems.

Q2 Journals:

- **Applied Sciences (Switzerland)** (92 articles): Broadly covers technological advancements in mobility.
- **Smart Cities** (51 articles): Focused on intelligent city systems including transport and emergency services.
- **Electronics (Switzerland)** (58 articles): Publishes research on embedded systems and electronics in transport.
- **IEEE Transactions on Intelligent Vehicles** (52 articles): Features studies on autonomous and cooperative vehicular networks.
- **Journal of Intelligent and Fuzzy Systems** (15 articles): Hosts AI-driven traffic control and mobility optimization work.
- **Transportation Research Part D: Transport and Environment** (28 articles): Focuses on environmental impacts of transportation systems.

These journals demonstrate strong editorial interest and ongoing contributions to the evolving intersection of *smart mobility, artificial intelligence, and emergency technologies*.

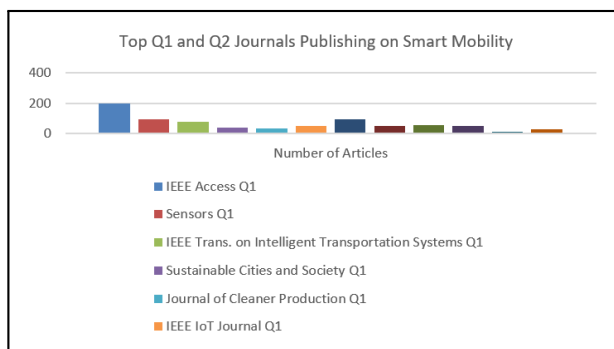


Fig. 8. Top Q1/Q2 Journals in Smart Mobility Research

MQ8: What are the most commonly used approaches, and why?

Smart mobility systems use a variety of technologies and methods to tackle the challenges brought on by urban growth.

Their goal is to make cities more efficient, sustainable, and comfortable for everyone. Based on the reviewed articles, the most common approaches and their justifications are as follows:

1. Artificial Intelligence (AI) and Machine Learning (ML)

AI and ML are pivotal technologies in smart mobility. They are applied across transportation, environmental management, and urban governance.

Why they are used:

- To solve complex problems and optimize processes in transportation and logistics.
- For predictive analysis in sectors like finance and job markets.
- To automate operations in supply chains and customer support.
- To enhance decision-making through data-driven insights.
- To improve transportation systems including autonomous vehicles, traffic control, and smart parking.
- To process large datasets in real time, especially from sensors and IoT, enabling responsive mobility services.

2. Internet of Things (IoT)

IoT is a foundational technology in smart cities, enabling interconnected devices to operate in coordination.

Why it is used:

- To collect real-time data from traffic sensors, environmental monitors, and vehicles.
- To support automation of urban mobility with minimal human intervention.
- To interconnect systems and technologies for seamless operation.
- To foster sustainable and comfortable urban lifestyles.

3. Wireless Communication Technologies (e.g., 5G, B5G, mmWave)

Advanced wireless networks are essential for reliable, high-speed communication within smart mobility systems.

Why they are used:

- To enable real-time information exchange between vehicles, infrastructure, and users.
- To ensure robust network performance for handling complex mobility environments.

4. Unmanned Aerial Vehicles (UAVs / Drones)

Drones are increasingly integrated into smart mobility strategies for their flexibility and efficiency.

Why they are used:

- To monitor traffic dynamically and assist in emergency response.
- To enhance urban logistics and reduce surface traffic congestion through aerial deliveries.

5. Blockchain Technology

Blockchain provides a decentralized, secure platform for communication and data exchange in smart mobility.

Why it is used:

- To create secure and transparent V2X (Vehicle-to-Everything) communication channels while protecting user privacy.
- To ensure data integrity and trustworthiness for autonomous systems and digital mobility transactions.

IV. CONCLUSION

Smart Mobility Systems are revolutionizing transportation management by leveraging AI, optimization, and operational research to provide effective solutions tailored to modern needs, particularly in emergency technology. However, challenges remain and require continuous advancements. Future priorities include strengthening research on AI and optimization algorithms to enhance real-time traffic management and improve traffic flow. Additionally, developing sustainable and inclusive mobility solutions is essential for building smart cities that are accessible to all. Finally, improving the cybersecurity of these systems remains a priority to ensure their reliability, prevent cyberattacks, and encourage widespread adoption.

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