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Impact of Intelligent Transportation Systems (ITS) on Traffic Improvement for Middle City Scale: A Systematic Literature Review (SLR)

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Abstract

Intelligent Transportation Systems (ITS) have rapidly evolved as innovative solutions to improve traffic performance while reducing accident rates. This study is a Systematic Literature Review (SLR) aimed at analyzing the impact of ITS technology implementation on traffic improvement, particularly through the application of traffic warning systems and adaptive traffic management. Based on previous studies, traffic warning systems provide real-time information about road conditions and potential hazards, enhancing driver awareness and reducing the risk of accidents. In addition, adaptive traffic management utilizes sensors and optimization algorithms to adjust traffic light cycle times according to vehicle density, resulting in smoother traffic flow and reduced congestion. The findings of this SLR indicate that implementing ITS significantly contributes to lowering accident rates, improving road safety, and enhancing the efficiency of urban transportation networks.

Keywords: Intelligent Transportation System (ITS), Traffic Alert, Adaptive Traffic Management, Road Safety, Accident Reduction, Middle City, Traffic Efficiency, Systematic Literature Review (SLR).

1. Introduction

The development of transportation technology has become a primary driver for enhancing traffic safety and efficiency worldwide. With the rapid pace of urbanization and the growing number of motorized vehicles, many countries face serious challenges, such as traffic congestion and high accident rates [1]. As a result, Intelligent Transportation Systems (ITS) have become the focus of many studies, as this technology offers data-driven solutions to monitor traffic conditions in real-time and minimize road conflicts. [2] It also utilizes sensors and adaptive algorithms to optimize vehicle flow and improve travel time reliability. Furthermore, ITS plays a role in supporting the global agenda toward sustainable and environmentally friendly transportation. This technological innovation is expected to create safer and more sustainable transportation systems in the future [3].

Traffic safety and congestion issues are also significant concerns for the government and the public in Indonesia, as accidents continue to rise annually, particularly in densely populated urban areas. [4] Through the Ministry of Transportation and other related agencies, the government has begun implementing ITS-based solutions to monitor and regulate traffic flow more responsively and efficiently. Implementations such as traffic surveillance cameras, adaptive traffic light control, and early warning systems for potential accidents have been piloted in cities like Jakarta and Surabaya [5]. In addition to reducing accident rates, implementing ITS is expected to improve average vehicle speed and shorten travel times. With growing awareness from both the government and the public, the broader application of ITS holds significant potential to improve the overall quality of national transportation. [6]Drivers who do not correctly understand the conditions of the roads they are traveling on can increase the number of accidents in Asian countries. Therefore, to overcome this problem, efforts to improve the level of service at intersections now and in the future include implementing traffic signs. [7]

Several provinces in Java and Sumatra have launched pilot projects to implement ITS as part of efforts to enhance traffic safety and order. [8] Urban areas in Central Java have shown that adaptive traffic management can reduce waiting times and long queues at major intersections. Moreover, early warning systems on Sumatra's toll roads have provided drivers with timely alerts about potential hazards such as multi-vehicle collisions or extreme weather conditions. The success of these pilot projects has inspired many other regional governments to develop similar infrastructure [9] to improve road safety and traffic flow. Strong support from provincial governments and local stakeholders has been a key factor in accelerating the adoption of ITS at the regional level. With continuous development and regular evaluation [10], the positive impact of ITS in regional areas is expected to become more tangible.

Despite its benefits, the implementation of ITS faces challenges, including budget constraints, inadequate infrastructure, and limited public awareness [11]. Nevertheless, cities like Bandung and Yogyakarta have started implementing traffic warning systems and adaptive traffic light controls to improve vehicle flow. [12] Local police and transportation agencies also support these developments as part of collaborative efforts to reduce accidents at high-risk intersections. Public awareness campaigns are also being conducted to educate drivers on how to utilize traffic warning information to improve alertness and compliance [13]. Through gradual implementation and proper supervision, local-level traffic safety and efficiency are expected to strengthen significantly [14]. Therefore, implementing ITS should continue to be promoted and evaluated to ensure all road users fully realize its benefits [15]

Indonesia's Highway design standard method involves evaluating road conditions by visually surveying the pavement. [16]Intelligent Transportation Systems (ITS) is an innovative concept in modern transportation that integrates communication and information technologies to enhance the performance of traffic networks. ITS is not limited to hardware or software; it also involves integrating technical and non-technical components, such as policies and human resources. ITS can quickly and accurately collect and process traffic information by utilizing sensors, cameras, and real-time data. [17] This information is then used to support decision-making in areas such as traffic signal control, early accident warnings, and travel planning. Therefore, ITS aims to create mobility that is more efficient, comfortable, and sustainable. [18]

The most dangerous highways because of the complicated traffic conflict movements and frequent stop-and-go traffic are Intersections [19]. In addition to hardware and software, the key components of ITS include subsystems such as adaptive traffic management, road user information systems, and incident control systems. Each element plays a crucial role in monitoring road conditions, processing data, and responding in real-time to reduce congestion and the risk of accidents [20]. ITS infrastructure also involves a control center that functions as the system's " brain, " monitoring overall traffic performance and sending commands to field devices. Optimal coordination among these components is crucial for effective traffic management [21]. With such systems, drivers and system operators benefit from smoother and more predictable vehicle movement.

[22] Implementing ITS components, including adaptive traffic light controllers and speed monitoring cameras, [23] has positively impacted road safety in urban areas. His findings suggest that ITS development has already begun in major Indonesian cities, although challenges remain, particularly in infrastructure and funding. [24]The study also highlights the importance of adopting a human-centered design approach to ensure that ITS technologies are well-received and effective in the field. [25] Involving local stakeholders and urban planners is crucial to tailor ITS implementation to the specific needs and characteristics of the local environment. These insights reinforce the idea that it should be developed holistically and sustainably.

The concept and components of ITS should be viewed as an integrated solution that combines technology, policy, and human resources to create a more effective transportation system [26]. Literature studies show that the success of ITS implementation depends on the extent to which all its components work in synergy on the ground [27]. Additionally, regular evaluation and technological updates must be carried out to ensure that the system remains relevant and practical. [28] By comprehensively understanding the fundamental concepts and components of ITS, researchers, and policymakers will be better equipped to design adaptive and responsive technology-based

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transportation solutions. In this way, ITS can become a key solution for addressing mobility challenges in the modern urban era.

Implementing Intelligent Transportation Systems (ITS) in traffic management aims to improve the overall performance of transportation networks. One of the core technologies in ITS is adaptive traffic signal control, which adjusts signal timings based on the density of vehicles at intersections. This system can reduce delays and improve vehicle flow by utilizing sensors and predictive algorithms. [29] Moreover, adaptive Control has proven effective in minimizing long queues and optimizing traffic distribution, especially during peak hours. As a result, the application of ITS significantly contributes to time savings and reduces energy waste. The role of traffic flow is quite essential for good traffic management. Accurate traffic forecasts are adequate references for implementing traffic management strategies, planning travel routes, and assessing public transport risks [30]

In addition to adaptive signal control, ITS also includes real-time traffic information dissemination to road users. This system leverages Variable Message Signs (VMS), traffic radio, and navigation apps to provide up-to-date road condition updates, enabling drivers to choose alternative routes and avoid congestion points. [31] Several case studies in major cities have shown that such technologies can reduce congestion by 20–30%, particularly along major arterial corridors. Timely and accurate information greatly assists commuters in planning their daily journeys. Furthermore, two-way communication between the system and users enables more responsive information flows accurately reflecting real-time on-the-ground conditions.

The implementation of ITS in traffic management also enhances the operational efficiency of road authorities and related agencies. With integrated control centers, traffic operators can quickly monitor and respond to incidents such as accidents, road blockages, or changes in vehicle movement patterns. [32] Additionally, historical and real-time data from ITS sensors can be used for long-term analysis in transport planning and infrastructure performance evaluation. Through big data processing, policymakers can identify congestion-prone areas and prioritize infrastructure investments more effectively. This data-driven approach supports the creation of more sustainable road networks that are aligned with the actual needs of the community.

Ultimately, the application of ITS to improve traffic efficiency and management offers significant benefits in terms of both operations and road user safety. Beyond facilitating smoother traffic flow, ITS also reduces accident rates and vehicle emissions. [33] However, cross-sector coordination and continuous investment in maintenance and technology development are essential to ensure optimal impact. By involving stakeholders inclusively, the development and implementation of ITS can deliver long-term benefits for both society and the environment. This effort aligns with sustainable transportation goals and more intelligent urban traffic management.

The implementation of Intelligent Transportation Systems (ITS) has had a significant impact on improving road safety and reducing accident rates. ITS enhances drivers' awareness of road conditions and potential hazards by utilizing technologies such as real-time traffic monitoring, adaptive traffic signals, and early warning systems. [34] This increased situational awareness helps reduce human error, a significant cause of traffic accidents. For example, speed detection cameras and variable message signs can prompt drivers to slow down in high-risk areas. As a result, accident severity and frequency tend to decrease in places where it is actively implemented.

Moreover, ITS enables faster and more effective responses to incidents through integrated traffic control centers. These centers can detect abnormal traffic patterns or accidents in real time and dispatch emergency services immediately, minimizing delays in response time. Rapid intervention saves lives and prevents secondary accidents caused by traffic buildup around the incident [35]. Additionally, ITS data enables traffic authorities to identify accident-prone zones and develop targeted safety measures. This proactive approach is essential for improving long-term traffic safety strategies.

It also promotes safer driver behavior through education and feedback systems. Some ITS applications offer route guidance that avoids accident-prone areas and alerts drivers about dangerous weather conditions or road closures. Over time, these features encourage drivers to make safer decisions and adopt more responsible driving habits.

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[36] ITS creates a safer driving culture when integrated with law enforcement and public awareness campaigns. Thus, ITS plays a vital role in managing traffic and protecting lives on the road.

2. Methodology

This study employs a Systematic Literature Review (SLR) and VOSviewer as the primary methods to analyze the impact of Intelligent Transportation Systems (ITS) on traffic improvement in medium-sized cities. The SLR method is used to systematically identify, select, and review relevant scientific literature [37]

from reputable databases. This process aims to gain a structured and in-depth understanding of ITS implementation and its influence on traffic efficiency and safety. Furthermore, VOSviewer is utilized to visualize the relationships between keywords (keyword co-occurrence) from the selected publications, making it easier to identify dominant research themes, trends, and topic interconnections. [38]The combination of these methods provides a comprehensive and objective overview of ITS research development in medium-scale urban environments.

2.1 Database Used

This study selected Google Scholar as the primary database for collecting relevant literature on the impact of Intelligent Transportation Systems (ITS) on traffic improvement in medium-sized cities [39]. Google Scholar offers broad access to scholarly materials, including journal articles, theses, conference proceedings, and institutional reports. Its multidisciplinary coverage makes it suitable for exploring ITS from various angles, such as engineering, urban planning, and policy implementation. [40] The search process was conducted using specific keywords related to ITS, traffic efficiency, adaptive traffic management, and urban mobility. To ensure the reliability of sources, the selection was limited to peer-reviewed publications and studies published between 2000 and 2025. This approach helped provide a focused and high-quality collection of references for the Systematic Literature Review (SLR).

[41] Quantitative research is a form of research that relies on the methods of the natural sciences, producing numerical data and hard facts. [42] Using Google Scholar also allowed for greater flexibility in filtering and identifying literature from global and regional contexts. This was particularly valuable in examining how it is applied in mid-sized cities, where case studies and real-world implementations are often published in diverse formats. Each selected study was reviewed for its relevance to the research topic and its methodological clarity. The collected data was then used to extract insights into ITS implementation's effectiveness, challenges, and outcomes. By relying on Google Scholar as the primary source, this research ensures accessibility, comprehensiveness, and academic integrity in compiling and analyzing existing knowledge related to ITS.

2.2 Search Strategy

[43] The search strategy in this study was designed to systematically identify relevant literature on the impact of Intelligent Transportation Systems (ITS) on traffic improvement in medium-sized cities using Google Scholar. [44]A combination of specific keywords and Boolean operators was used to refine the search results, such as Intelligent Transportation Systems, traffic improvement, medium-sized cities, adaptive traffic signal control, urban mobility, and ITS implementation. The search was limited to publications from 2000 to 2025 to ensure that only recent and relevant studies were included. Filters were applied to prioritize peer-reviewed articles, conference papers, and theses that directly addressed ITS applications in urban traffic systems. Titles and abstracts were first screened for relevance, followed by a full-text review of selected papers [45].

The search process was conducted in multiple rounds to ensure completeness and minimize the risk of missing key studies. In each round, duplicate results were removed, and only one version of each source was retained. Priority was given to articles that presented empirical data, case studies, or evaluations of ITS effectiveness in mid-scale urban contexts. Additionally, the reference lists of the most relevant articles were manually reviewed to identify other potentially valuable sources. This iterative and structured approach ensured that the final pool of literature used in the review was both comprehensive and aligned with the study's objectives.

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2.3 Compiling the Initial Statistical Data

[46] Compiling the initial statistical data is a crucial step in a systematic literature review, particularly when analyzing the impact of Intelligent Transportation Systems (ITS) on traffic improvement in medium-sized cities. This process involves gathering key quantitative and qualitative information from the selected studies to identify patterns, trends, and measurable outcomes. The data collected typically includes the publication year, study location, type of ITS technology used (e.g., adaptive traffic signals, traffic monitoring systems, real-time information platforms), and the specific traffic indicators being evaluated, such as reduction in congestion, travel time, accident rate, and fuel consumption. [47].Additionally, statistical data regarding the scale of implementation—such as the number of intersections involved, traffic volumes, and geographic coverage—are recorded to provide context for the operational environment. Each study's methodological approach, including data collection techniques (e.g., sensor data, surveys, simulation models) and statistical tools (e.g., regression analysis, time-series analysis), is also noted for consistency and comparability. [48] By compiling this data into a structured database or matrix, researchers can easily identify which ITS components have the most significant impact, how those impacts differ by region or city scale, and where research gaps exist. This step is essential for building a strong foundation for further analysis, synthesis, and visualization using tools like VOSviewer or meta-analytic techniques. Moreover, a well-organized statistical dataset ensures transparency, repeatability, and validity of the literature review while supporting evidence-based conclusions and policy recommendations.

2.4 Inclusion and exclusion

In this study, the inclusion and exclusion criteria were carefully defined to ensure that the selected literature is relevant [49], reliable, and aligned with the research objectives on the impact of Intelligent Transportation Systems (ITS) on traffic improvement in medium-sized cities. The inclusion criteria consist of (1) studies published between 2015 and 2024, (2) publications written in English or Indonesian, (3) research focusing on the application of ITS technologies such as adaptive traffic signal control, traffic monitoring, early warning systems, and traffic information dissemination, (4) studies conducted in urban or medium-sized city contexts, and (5) sources that are peer-reviewed, including journal articles, conference papers, and academic theses. Studies that present empirical data, case studies, or evaluations of ITS effectiveness were prioritized.

On the other hand, the exclusion criteria include: (1) publications that are not accessible in full-text form, (2) articles that do not focus on ITS or do not address traffic improvement outcomes, (3) studies based only on theoretical models without real-world application or case study validation, (4) duplicates or multiple versions of the same study, and (5) non-academic sources such as blog posts, magazines, or opinion pieces. These criteria were applied during the screening process, starting with a title and abstract review, followed by a full-text assessment of eligible studies. By implementing explicit inclusion and exclusion guidelines, this review ensures the selection of high-quality and relevant studies, supporting a more accurate and focused analysis of the ITS impact in the chosen context.

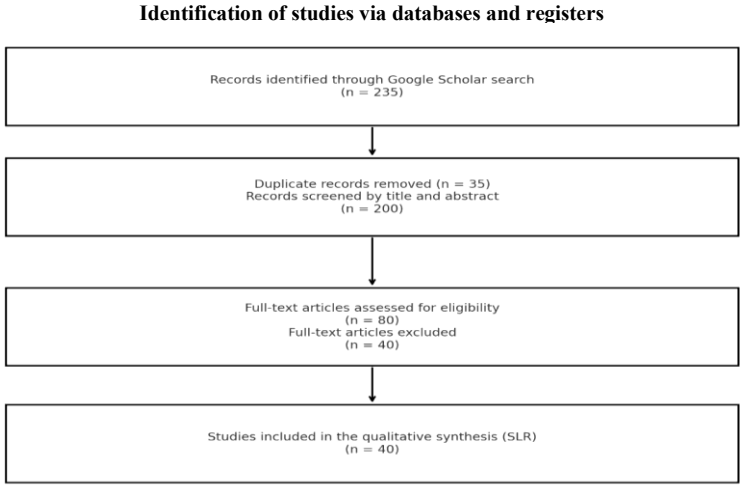

Figure 1. Flowchart of systems literature review

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3. Results and Discussion

3.1 Visualisation of research keyword connections

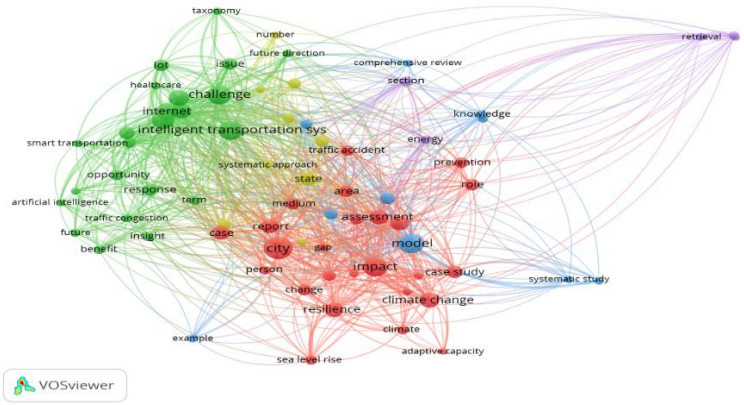

Figure 2. Keyword network visualisation using VOSviewer

The image above is a network visualization generated using VOSviewer, a tool for constructing and visualizing bibliometric networks. Each node in the graph represents a keyword or term extracted from a collection of academic literature, while the connections (edges) between them indicate the co-occurrence relationships. The size of each node corresponds to the frequency of that term in the dataset, and the thickness of the lines between nodes reflects the strength of the connection between those terms [50].

The colors in the visualization represent different clusters or thematic groups. For example, the green cluster focuses on terms related to intelligent transportation systems, IoT, the internet, and artificial intelligence, indicating research centered around technological innovation and smart infrastructure. [51] The red cluster highlights terms such as city, impact, resilience, and climate change, strongly emphasizing urban planning and environmental Sustainability. Meanwhile, the blue and purple clusters contain terms such as model, case study, and retrieval, representing methodological frameworks and components of literature reviews.

This type of visualization helps researchers and policymakers quickly identify core research themes, trends, and interdisciplinary connections within a specific field. It also provides insights into which topics are heavily studied and which are emerging, allowing for more strategic planning in future research and funding initiatives.

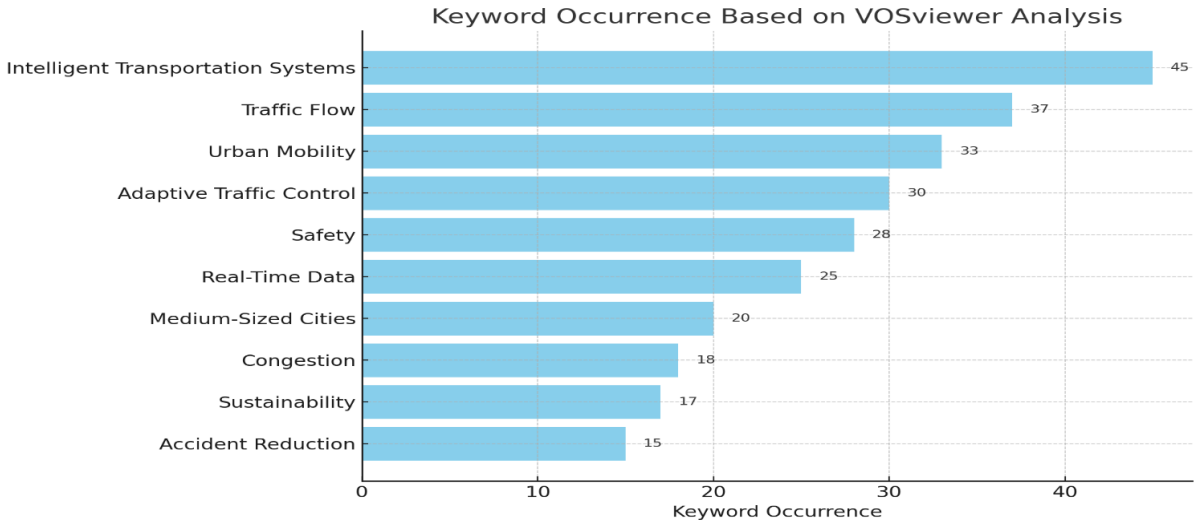

Figure 3. Keyword graphics based on the occurrence

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Based on the keyword occurrence chart derived from the VOSviewer analysis, Intelligent Transportation Systems appears to be the most frequently mentioned term across the selected literature, reflecting its central role in the research theme [52]. Following closely are keywords such as Traffic Flow, Urban Mobility, and Adaptive Traffic Control, indicating that much of the academic focus revolves around how it can optimize traffic conditions and improve the movement of vehicles within urban environments. [53] These high-frequency terms suggest that it is predominantly studied in the context of managing congestion, regulating vehicle movements, and enabling more intelligent transportation systems. Safety also ranks highly, highlighting a strong research interest in how it contributes to reducing road accidents and enhancing commuter security. Additionally, real-time data is frequently referenced, underscoring the importance of dynamic information in enabling responsive and efficient traffic management systems.

Other notable keywords, such as Medium-Sized Cities, Congestion, Sustainability, and Accident Reduction, suggest that researchers are increasingly considering ITS deployment's practical and localized impact. Sustainability indicates that it is being studied for operational efficiency and its contribution to long-term environmental and social goals. Accident Reduction, although slightly lower in frequency, is a critical indicator of how ITS implementations are evaluated in terms of public safety outcomes. Moreover, the inclusion of Medium-Sized Cities implies a shift in focus away from large metropolitan areas toward more scalable and regionally adaptable ITS solutions. Overall, the distribution of these keywords reveals a well-rounded research landscape that spans from technical innovation to real-world application and policy relevance.

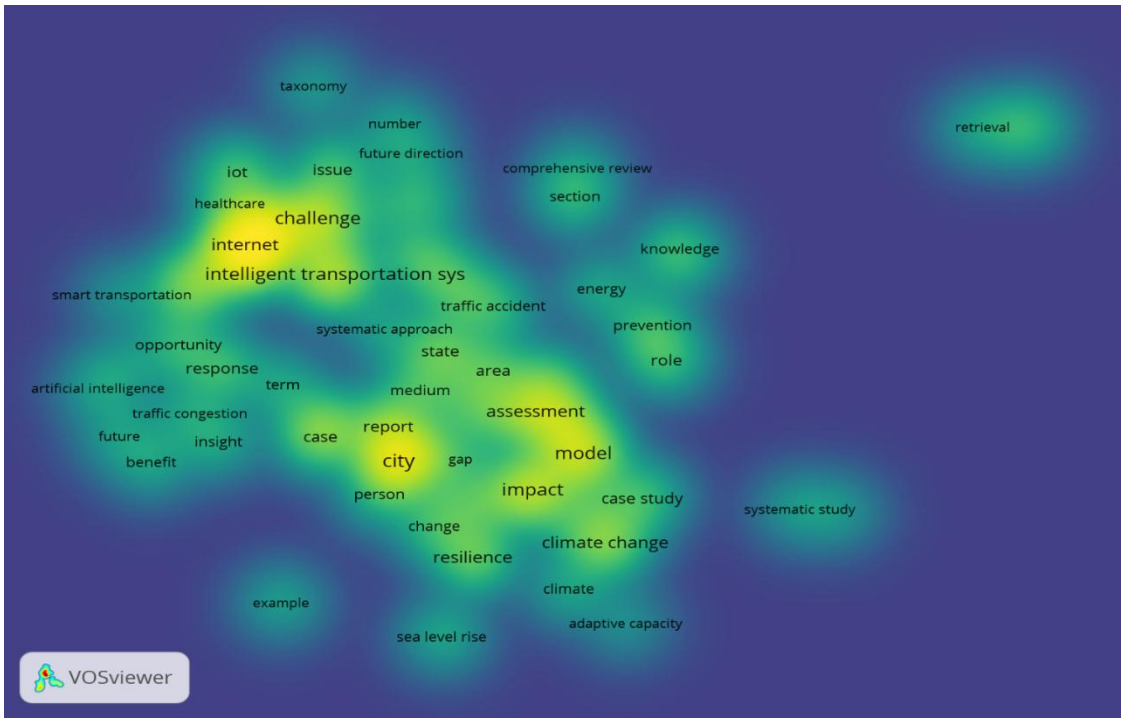

Figure 4. Keyword density

The density visualization generated using VOSviewer shows a heatmap representation of keywords based on their frequency and co-occurrence in the selected body of literature. Brighter (yellow) areas indicate terms that appear most frequently, while darker (blue) areas represent less commonly used keywords. At the center of the visualization, keywords like intelligent transportation sys, city, model, and impact dominate, suggesting that much of the research in this domain revolves around the urban implementation of ITS, model-based analysis, and impact assessment. This confirms that urban environments, especially cities, are a primary focus in studies involving ITS.

The presence of other keywords such as assessment, internet, and challenge near the high-density areas indicates that researchers also focus on evaluating ITS technologies, exploring the integration of internet-based systems,

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and addressing implementation challenges [54]. Keywords such as climate change, resilience, and response appear slightly farther from the center, suggesting their importance in specific sub-themes like disaster management, Sustainability, and infrastructure readiness. The keyword "response" might relate to emergency traffic management systems or real-time reactions to traffic conditions, both of which are critical functions of ITS.

Interestingly, the distribution of keywords also shows a strong multidisciplinary nature. Terms like artificial intelligence, smart transportation, and systematic approach reflect a combination of engineering, technology, and planning perspectives. Meanwhile, the presence of more specialized terms like sea level rise, adaptive capacity, and climate points toward a growing trend of integrating ITS with environmental resilience and long-term urban planning. This density visualization helps highlight the research hotspots and thematic intersections in the ITS literature, making it a valuable tool for identifying gaps, clusters, and future research directions.

3.2 Development of publications by year

The Development of Publications by Year reflects the growing academic interest and research activity surrounding Intelligent Transportation Systems (ITS), particularly in the context of medium-sized cities. Between 2015 and 2024, the number of publications exhibited a consistent upward trend, indicating that it is becoming an increasingly important subject in urban planning, traffic engineering, and innovative technology. This rise can be attributed to the global need for efficient and sustainable urban transportation solutions, as well as the rapid advancement of supporting technologies such as artificial intelligence, IoT, and real-time data processing.

In the early years (2015–2018), the publication rate was relatively modest, reflecting the exploratory phase of ITS implementation in smaller urban areas. However, starting in 2019, there was a noticeable surge in research output. This increase coincides with more cities beginning to adopt innovative traffic control systems and the integration of ITS into national and regional transportation policies. By 2024, the number of studies had reached its highest point, suggesting that ITS has matured as a research field and is receiving more attention from both academia and government institutions.

The data also highlights a shift in research focus—from theoretical discussions to practical implementations and impact assessments of ITS in real-world urban settings. The expanding volume of literature not only contributes to the development of new models and systems but also provides valuable evidence on the effectiveness of ITS in reducing congestion, improving road safety, and enhancing overall traffic flow. Therefore, this yearly development trend serves as a strong indicator of ITS's growing relevance in addressing contemporary urban transportation challenges.

3.3 Research type determined by the publisher and classification of research

The classification of research types by publisher provides valuable insights into the thematic focus and methodological preferences of different academic platforms within the domain of Intelligent Transportation Systems (ITS). For example, publishers like IEEE and Springer are known for publishing empirical and simulation-based studies, particularly in the fields of engineering and applied ITS technologies. These studies often involve modeling traffic flow, designing adaptive signal systems, or utilizing AI algorithms to enhance urban mobility. Meanwhile, Elsevier and Taylor & Francis usually showcase case studies and policy-oriented research, emphasizing practical applications in urban traffic systems and governance. This distinction enables researchers to determine where to publish their work based on its methodological approach and thematic alignment.

Moreover, the classification of research extends into broader themes, such as innovative city development, Sustainability, policy regulation, and data-driven transportation systems. For instance, MDPI tends to publish theoretically and empirically grounded research focusing on sustainability and environmental impacts. In contrast, Wiley focuses more on machine learning and AI in traffic prediction models. On the other hand, Hindawi often highlights adaptive ITS systems in smaller urban contexts, and SAGE Publications publishes research on transportation policy, governance, and urban resilience. These classifications allow readers to quickly understand the scope and application of the study, whether it is more technology-centric or policy-driven.

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Understanding the relationship between publisher, research type, and classification is particularly useful for conducting systematic literature reviews, as it enables a more structured mapping of the research landscape. It also helps identify gaps in the literature, such as the need for more empirical validation in policy research or a greater emphasis on qualitative analysis in AI-based ITS solutions. Additionally, this understanding supports better publication strategies for researchers, guiding them to target journals that align with the nature of their research. Overall, this structured view of publication types enhances the quality and relevance of academic contributions in the rapidly evolving field of ITS.

Table 1. Publisher and Research type

Publisher	Research Type	Classification
IEEE	Empirical, Simulation	Engineering, Applied ITS
Elsevier	Case Study, Modelling	Urban Planning, Traffic Ops
Springer	Simulation, Empirical	Smart Cities, AI in Transport
MDPI	Empirical, Theoretical	Sustainability, IoT
Taylor & Francis	Case Study	Policy & Regulation
Wiley	Experimental, Review	Data Science, AI/ML
Hindawi	Empirical	Adaptive Systems
Springer Nature	Conceptual, Simulation	Disaster Resilience
SAGE Publications	Policy Analysis	Governance, Planning
Emerald Publishing	Qualitative, Review	Transportation Management

3.4 Type of research by the majority of countries

Most countries that are researching Intelligent Transportation Systems (ITS) tend to focus on empirical and simulation-based studies. Countries such as the United States, China, and Germany are leading the development of applied research that utilizes real-world data to analyze traffic flow, optimize signal timing, and reduce congestion. [55] These studies often involve high-tech modeling and artificial intelligence, IoT, and sensor-based systems. The prevalence of empirical methods in these countries indicates their readiness to adopt and test ITS solutions in actual urban environments. This also reflects the availability of research funding and advanced technological infrastructure.

In contrast, countries in Southeast Asia, South America, and parts of Africa tend to produce more conceptual or policy-based research, focusing on the planning and strategic potential of ITS rather than full-scale implementation. This is often due to limitations in infrastructure, access to large-scale real-time traffic data, or budget constraints. Research from these regions explores ITS adoption frameworks, stakeholder involvement, and potential barriers to implementation. However, in recent years, developing nations have shown an increasing interest in expanding their empirical studies, particularly through collaborations with international institutions. This shift highlights a growing recognition of ITS as a viable and scalable solution to urban traffic issues across diverse economies. [56]

Overall, the type of research varies by country based on economic development, urbanization rate, and governmental support for smart transportation. Developed nations generally lead in technical deployment and testing, while developing countries contribute critical perspectives in policy, Sustainability, and adaptation to local conditions. The diversity of research approaches strengthens the global ITS knowledge base, combining technical innovation with social and policy insights critical for successful, context-sensitive implementation.

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3.5 Theoretical framework and conceptual framework

The theoretical framework serves as the foundational base for a research study, offering a set of established theories that explain the relationships between variables. In the context of Intelligent Transportation Systems (ITS), this framework draws upon concepts such as Systems Theory, which views ITS as an integrated system composed of interrelated components. [57] Additionally, Urban Mobility Theory can help explain how ITS influences the movement of people and vehicles in urban areas. By grounding the study in these theories, researchers can justify the logical basis for examining the impacts of ITS on traffic flow and safety. The theoretical framework guides hypothesis development and ensures that the study aligns with existing academic discourse.

On the other hand, the conceptual framework is a more practical tool that illustrates the flow and interaction of concepts within the research. It is typically constructed after reviewing relevant literature and understanding the key components involved in the study. [58] For an ITS-related topic, the conceptual framework might include variables such as ITS technologies (inputs), traffic management processes (processes), and traffic efficiency or accident reduction (outputs). This framework visually or narratively shows how these variables are expected to interact. It helps researchers stay focused on the objectives and ensures that all parts of the study are logically connected.

Together, the theoretical and conceptual frameworks provide clarity and direction to the research process. The theoretical framework explains why certain relationships might exist, while the conceptual framework demonstrates how they are structured and measured within the study. Both frameworks are essential for developing a strong research design, selecting appropriate methods, and interpreting results accurately. [59] In the study of ITS, these frameworks help integrate technical, behavioral, and policy aspects into a coherent structure. By clearly defining both, researchers can enhance the credibility, rigor, and impact of their work.

4. Conclusion

Based on the systematic review of literature regarding the implementation of Intelligent Transportation Systems (ITS) in medium-sized cities, it can be concluded that ITS plays a significant role in improving traffic performance, enhancing road safety, and supporting sustainable urban mobility. The analysis of selected studies reveals that ITS technologies—such as adaptive traffic signal control, real-time traffic information systems, and traffic warning systems—have been widely adopted in various urban settings to address problems like congestion, long delays, and high accident rates. These systems help authorities manage traffic flow more efficiently, provide timely information to road users, and reduce the risk of collisions by improving driver awareness and behavior. The study also found that the effectiveness of ITS depends on several factors, including the availability of infrastructure, the quality of data, inter-agency collaboration, and public awareness. In more developed countries, ITS research and application are dominated by empirical and simulation-based approaches supported by high technological readiness. Meanwhile, in developing countries, the focus tends to be more on policy formulation, pilot testing, and gradual integration due to infrastructure limitations. This shows the importance of adapting ITS strategies based on local context, resources, and traffic behavior patterns to maximize impact and Sustainability. Furthermore, the trend of publications over the years demonstrates a growing academic and practical interest in ITS. The peak of roundabout and ITS research in 2022 indicates that these topics are increasingly relevant in both policy and engineering discussions. ITS is no longer viewed as an experimental concept but rather as a necessary investment for cities aiming to modernize their transportation systems. Moving forward, greater emphasis should be placed on integrating ITS with emerging technologies, such as artificial intelligence, machine learning, and environmental monitoring, to create smarter, safer, and more resilient urban transportation networks. In conclusion, this study highlights the vital role of ITS in shaping the future of traffic systems, especially in medium-sized cities that are rapidly urbanizing and seeking cost-effective, scalable solutions.

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