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A Bibliometric Analysis of Public Transportation Management-Based Sustainable Development

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Abstract
Sustainable transport is one way to address the challenges associated with urbanization and support environmentally friendly, inclusive, and innovative city development. Trend analysis, evolution of themes and research opportunities in the field of public transport management with sustainable development perspective: A bibliometric study the research data was collected in the Scopus database by requesting publications using keywords, "transportation management," "sustainable development," "urban transportation," and "public transportation systems," which included 153 publications from 2000 to 2025 (as of May 24, 2025). Collaborations between countries, authors, and research clusters were visualized using VOSviewer software. Results indicate that publications on sustainable public transportation management are scarce, with a notable lack of international collaboration, and are mainly dominated by China, India, and Australia. Five major clusters were identified, namely sustainable development in conjunction with urban transport, traffic congestion and mode of transport, urban transport and public transit systems, urban planning and transportation plans, as well as sustainable transport utilizing renewable energy sources. Such a changing focus points to a growing body of work addressing the enabling of governance and policy arrangements of the clean energy transition. The complexity of management constructs remains entangled with the integration of energy policy and sustainability into transport management. While previous bibliometric studies primarily focused on the technical and service aspects of the literature, this study shifts the emphasis to the management and policy of clean energy. This emphasizes the need to streamline and integrate the low-carbon public transport systems. In this context, these findings provide a starting point for advocating collaborative studies across borders and the use of collaborative transport systems for evidence-based advocacy and policy development.
Keywords: Bibliometric Studies; Sustainable Development; Sustainable Transport; Public Transport; Transport Management.

INTRODUCTION

A transportation system is a system that enables transfer from one location to another (Cappelli, 2018; Nawangsari & Ismaili, 2022). In This Age, The Construction of new growth centers increases the need for new transport systems, as they serve a crucial function in promoting community integration and life (Thaller et al., 2021; Budiman et al., 2022; Romadhona et al., 2024). As argued by Miller et al. (2013), the economic, social, and environmental benefits of public transport, as well as their contribution to the interconnectedness of different parts of the country, make their inclusion within a nation's infrastructure a necessary component of sustainable development. Nevertheless, the increase in automobile ownership has led to numerous socio-economic problems and environmental issues, particularly the aggravation of traffic congestion, an increase in

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public health threats, and pollution on the streets (Novita, 2022; Primastuti & Puspitasari, 2022; Astuti et al., 2024; Sofaniadi et al., 2022). These problems are further compounded by the inefficient public transportation systems available, particularly in efforts to decarbonize the transportation sector. Sustainable transport system management requires the strategic use of available resources while promoting economically viable alternatives.

Global carbon emissions and fossil fuel consumption are significantly affected by the transportation sector. According to the International Energy Agency (2020), transportation and fuel production account for 24% of carbon emissions. The World Health Organization (2019) estimated that 4.2 million deaths occur each year due to global ambient air pollution, a significant portion of which is attributed to pollution caused by vehicles. Additionally, the United Nations (2023) states that urban areas, which comprise only 3% of the Earth's surface, house over half of the world's population, utilize 70% of global energy, and account for 75% of global carbon emissions. This is a result of urbanization (Ruggieri et al., 2021). An increase in urban population leads to a higher demand for all types of vehicles (Breyer et al., 2019), resulting in increased energy consumption and CO2 emissions (Mohsin et al., 2019). The International Energy Agency (2021) estimated the world's transportation sector was responsible for approximately 8.5 gigatons of CO2 emissions in 2019 and over seven gigatons in 2020. This necessitates the evaluation of potential alternative approaches to optimize energy use, diversify fuel sources, and reduce CO2 emissions (Haase et al., 2022).

Building a sustainable multimodal transport system is a crucial initiative for inclusive and environmentally friendly development (Nawangsari & Ismaili, 2022). Here, the value and role of transport management systems as a “process of planning, organizing, implementing and controlling the transport system's…efficiency, effectiveness and continuity” (Fistung, 2024) is of great significance. Unsustainable transport system management induces social and environmental inequities, primarily through the CO_2 emissions, noise, and congestion generated, as well as inequitable access to transport services (Azodi, 2013; Dimić et al., 2016). The overall systemic re-organization, strategies, policies, and plans, integrated, synergized, or crafted together, are designed to improve and sustainably manage the movement of goods and people transport systems. This is an expression of the SDGs, specifically goal 11; “make cities and human settlements inclusive, safe, resilient and sustainable” through “access to safe, affordable, accessible and sustainable transport systems,” and goal 13; the reduction of climate change through transport innovation and policies that reduce carbon emissions. Hence, the Governance of sustainable transport systems for low emissions is a “global commitment” that escalates to the SDGs' “evident goal” of resilient, climate-resilient urban settlements.

Integrating renewable energy into public transit systems is crucial for minimizing the emissions that contribute to climate change (Dunlap, 2023). Several alternatives to fossil fuels are being utilized in mass transportation, including solar-powered electricity,

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hydrogen, and biofuels (Kumar & Sharma, 2024). Operational efficiencies are gained, in addition to reducing emissions, with clean energy-powered electric buses (Larsson et al., 2015; Ramírez-Márquez & Sánchez-Ramírez, 2020). Nevertheless, the technology's deployment is hindered by inadequate charging facilities, the condition of the electric supply grid, and the need for costly preliminary investments, which calls for inventive incentives and financing assistance (Soy & Nayak, 2025). Weak inter-agency coordination and oversight mechanisms, from a policy viewpoint, are fundamental barriers to the enactment of the energy transition roadmap (Ramkumar et al., 2025). Long-term environmental sustainability relies heavily on cross-border energy cooperation, innovative policy-making, and sustained investments in low-carbon transport technologies (John et al., 2025).

Most of the past literature examines the technical aspects, such as fleet efficiency, infrastructure design, and green vehicles, as well as the service aspects of user satisfaction and comfort. However, there is a gap in the literature from a management perspective and the integration of clean energy within the Governance of public transport. Most literature focuses on the operational aspects of efficiency or the user's behavior. This study aims to fill this gap by examining the scientific evolution of management within the field of public transport in relation to sustainable development and the extent to which the research discourse incorporates the integration of sustainable energy.

Analyzing research trends and gaps for innovative and evidence-based initiatives in transportation policy can be accomplished by employing bibliometric analysis. This technique is an extension of the quantitative approach to measuring, analyzing, and mapping a given territory's scientific output and publications (Van & Waltman, 2010; Mukhlisa & Hasan, 2024). As a bibliometric analysis is based on developing a sound theoretical underpinning to address a gap, in this case, it enables the tracing of the interrelationships between themes, scholars, and works of literature, which clarifies the flow of science and the shape of the science of sustainable transport. Consequently, while bibliometrics is descriptive, it can underpin the identification of theoretical gaps and research trends, as well as the consolidation of initiatives on research into the interplay between public transport systems and the green energy transition, thereby reversing the descriptive flow of science on sustainable transport.

This study aims to map the scientific development and understand the trajectory of research on the management of public transport systems, grounded in sustainable development, using a bibliometric analysis approach. In this regard, this study attempts to respond to the following questions:

1. What are the global research development trends and trajectories about sustainable development public transport management?
2. What are the more dominant and interconnected themes in the body of scholarly work?

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3. What future research gaps can be determined to consolidate public transport management and sustainable energy further?

This work aims to support researchers and scholars in developing pertinent, innovative, and advocacy-driven research that facilitates the achievement of a sustainable transportation system.

METHOD

Research data were collated from the Scopus database, accessed through the Scopus website (www.scopus.com). Scopus was selected for the research due to its standing as one of the largest academic databases. It provides bibliographic data, including titles, abstracts, and author keywords, which help clarify the intricacies and diverse components of scientific systems.

Data were acquired using the keywords “transportation management”, “sustainable development”, “urban transport”, “sustainable transportation”, and “public transport systems.” The period from 2000 to 2025 (as of May 24, 2025) was selected for searching titles, abstracts, and keywords. The first search yielded 162 documents, which were then refined to 153 English-language publications, including relevant journal articles and conference papers. The relevance selection process was manually conducted by reading titles and abstracts to ensure alignment with the study, which focused on transportation management with an emphasis on sustainable development.

The bibliometric data collected included the number of publications per year, journal name, authors, affiliations, and study subjects. Initial analysis was conducted using Microsoft Excel and the Scopus Result Analyzer. Next, bibliometric network mapping and visualization were performed using the latest version of VOSviewer. VOSviewer produces three main visualization types: network, overlay, and density visualization, which are used to explore research trends, theme evolution, and opportunities for topic novelty in the field of sustainable development-based public transportation management.

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Stage 1. Academic Database Search

- Determining keywords
- Entering a combination of search term queries based on the article title, abstract, and keywords
- Scopus database
- Publication type (article and conference paper)
- Language: English
- Timeframe: 2000-2025 (as of May 24, 2025)

Stage 2. Data Extraction and Initial Analysis

- N = 153 selected documents
- Data downloaded in CSV format
- Initial analysis using Microsoft Excel and the Scopus result analyzer
- Bibliometric analysis

Stage 3. Analysis of Results

- Using VOSviewer software
- Visualization (Network, Overlay, & Density visualization)
- Bibliometric analysis of the results and trends of sustainable development-based transportation management

RESULTS AND DISCUSSION

1. Annual Outputs

The data used in this study were sourced from Scopus with the keywords "transportation management", "sustainable development", "urban transport", "sustainable transportation", and "public transport systems". A total of 162 relevant literature, consisting of scientific articles and conference papers, from 2000 to 2025 (as of May 24, 2025).. After filtering for English, the results obtained were 153. The data were then directly analyzed using Vosviewer, which was subsequently analyzed bibliometrically. After that, I will identify deeper trends in this study. The following graphic illustrates publication trends from year to year.

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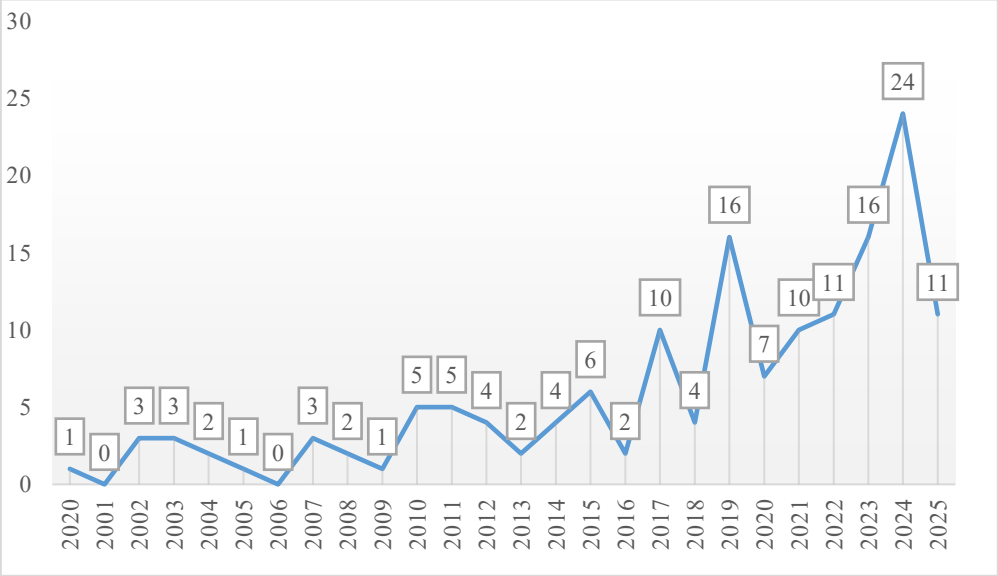

Fig 1.
Publication Trends from 2000 to 2025 (May 24, 2025)
Source: Analysis Results, 2025

Fig.1 shows the development of publications from 2020 to 2025 (as of May 24, 2025), with a focus on public transport management based on sustainable development. Over the 26 years, with a total of 153 documents, the average number of publications per year was only around 6-7 documents. During the period 2000-2010, only 21 documents were published, with no publications in 2001 and 2006, indicating low initial interest. From 2011 to 2017, the number of publications began to increase, with 33 documents, although the number continued to fluctuate. A significant increase occurred from 2018 to 2024, with a total of 84 documents, peaking at 24 documents in 2024. By May 24, 2025, there were already 11 documents, indicating potential for further growth.

This means that the topic of public transportation management based on sustainable development remains relatively unstudied. This topic is highly relevant for development, as it can support the creation of a sustainable transportation system in the future. Therefore, further research in this area is expected to fill this gap.

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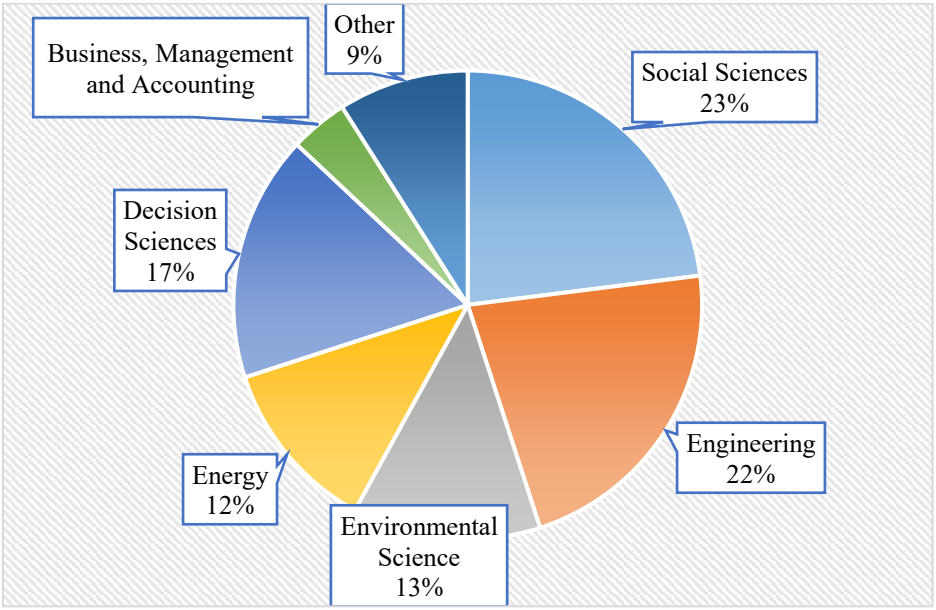

Fig. 2.
Related Subject Area of the Sustainable Development-Based Public Transportation Management
Source: Analysis Results, 2025

Fig. 2 shows the subject areas of sustainable development-based public transportation management. The author has discussed eight subject areas. Based on these eight subject areas, the most widely studied topics in sustainable development-based public transportation management originate from social sciences, engineering, environmental science, energy, decision sciences, business, management, and accounting, among others. The fields of social sciences, engineering, decision sciences, and environmental science are the most frequently discussed by the author. An example of an article on social sciences is Aydin et al. (2022), which discusses strategic planning for achieving sustainable urban mobility.

Moslem, Stevic, et al. (2023) argue that improving the quality of public transportation services is essential for achieving sustainable development. From the perspective of environmental science, Dyr et al. (2019) advocate for the introduction of compressed natural gas (CNG) fueled buses within public transport services as a measure to promote cleaner and more sustainable urban transport. Overall, Figure 2 illustrates the interconnection of various scholarly disciplines, suggesting that there is ample opportunity for cross-disciplinary Innovation within this subject area.

Table 1 presents a list of the top ten journals based on the number of published documents on the topic of sustainable development-based public transportation management. This table is based on an analysis of literature data from 2000 to 2025 (as of May 24, 2025), focusing on the number of publications in each journal. This helps researchers understand the primary sources of research in this field.

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No	Journal	Document
1	Sustainability Switzerland	23
2	Wit Transactions on the Built Environment	5
3	Transportation Research Part D Transport and Environment	5
4	Transportation Research Part A Policy and Practice	5
5	Sustainable Cities and Society	5
6	Transportation Research Record	4
7	Journal of Urban Planning and Development	4
8	Journal of Transportation Engineering	3
9	Computers, Environment and Urban Systems	3
10	Urban Public Transportation Systems	2

Table 1.
Top Ten Journals by Number of Documents
Source: Analysis results, 2025

Based on Table 1, the journal with the most publications is “Sustainability Switzerland” with 23 documents. Following this were four other journals, each with five documents, namely “Wit Transactions on the Built Environment”, “Transportation Research Part D Transport and Environment”, “Transportation Research Part A Policy and Practice”, and “Sustainable Cities and Society”. Furthermore, “Transportation Research Record” and “Journal of Urban Planning and Development” each have four documents. In comparison, “Journal of Transportation Engineering” and “Computers Environment and Urban Systems” have three documents, and “Urban Public Transportation Systems” has two documents. This is the distribution of publications in these journals during the period of analysis.

Among the publications most often analyzed in the context of sustainable development-oriented public transportation management is the interdisciplinary journal Sustainability. It integrates the environment, technology, public policy, and transportation. In this respect, the journal is the most influential, with the highest number of publications and citations. It often addresses topics related to urban sustainable transport (İnce, 2025), for instance, sustainable mobility in Switzerland, particularly in Basel (Ruesch et al., 2008; Fenton, 2016). The journal balances global and local perspectives (Schneebeli et al., 2004) and aligns them with the Sustainable Development Goals (SDGs) (Bader et al., 2024); thus, to date, it is the most important reference for several public transport systems striving to achieve sustainable development.

2. Most Productive Countries and Institutions

Analyzing various countries' studies within the framework of sustainable development-based public transportation management helps identify nations that have made strategic contributions to the development of new sustainable transportation. This

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analysis shows the level of resources each country is willing to allocate to support the development of effective, eco-friendly, and sustainable public transport.

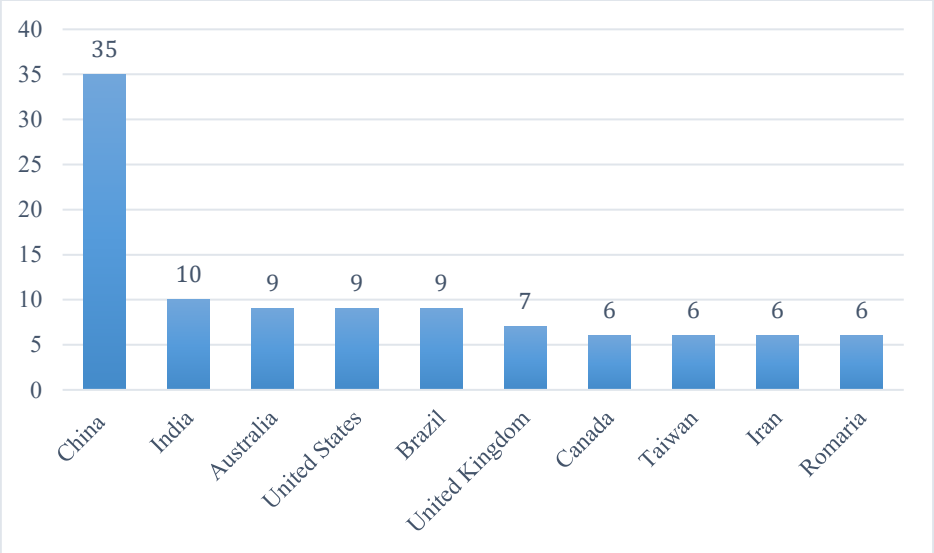

Fig. 3.
Ten Most Productive Countries
Source: Analysis results, 2025

Fig. 3 above illustrates the countries with the highest number of publications on sustainable development-based public transport management. Among the ten countries with the most publications, China is the most productive, producing 35 publications. India follows this with 10 publications. Other countries, such as the United Kingdom, Canada, Taiwan, and Iran, have a similar number of publications, around six to seven.

China is the most prolific country in publications related to sustainable development-based public transportation management. The following factors contribute to China's superiority and influence in sustainable transportation research and Innovation worldwide. The main driving factors are high urbanization and vehicle use, which create a need for environmentally friendly transportation research (Wang & Guo, 2011; Hou et al., 2023). Government support, the existence of a green transport strategy policy program, and the Belt and Road Initiative (BRI) encourage international research collaboration (Silin et al., 2018). Significant investment in technology, especially electric vehicles and intelligent transportation systems (L. Zhang et al., 2024). The role of state-owned enterprises and public-private partnerships, which enable large-scale research (Xiong et al., 2021; Zhou et al., 2018). China's hierarchical and rapid approach makes it a central hub for research collaboration, with high-volume publications and international collaborations (İnce, 2025).

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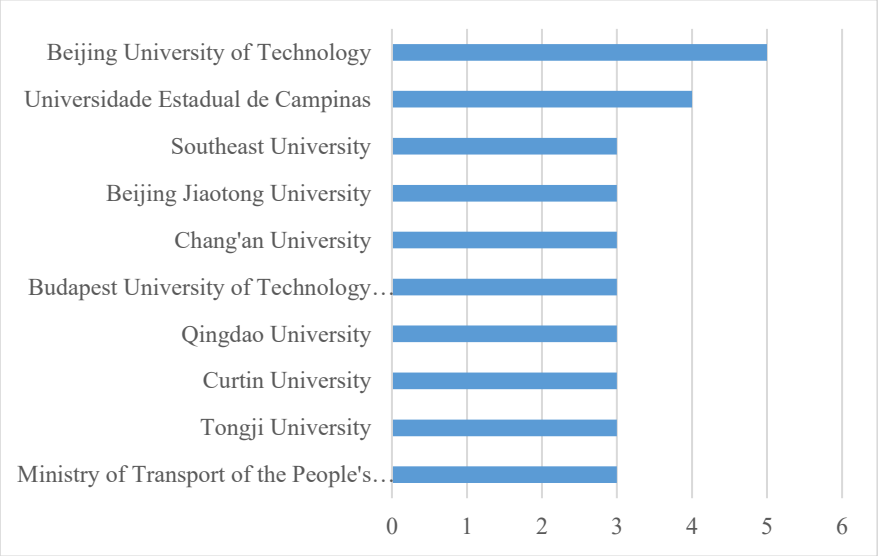

Fig. 4.
Ten Most Productive Institutions
Source: Analysis results, 2025

Fig. 4 presents the ten most productive institutions publishing research on public transport management in relation to sustainable development. Figure 4 above presents the 10 most productive institutions in publishing on the topic of public transport management based on sustainable development. The two most productive institutions are Beijing University of Technology, with five documents, and Universidade Estadual de Campinas (UNICAMP), with four documents. In addition, there are eight other institutions with three documents each: major universities in China (Southeast University, Beijing Jiaotong University, Chang'an University, Tongji University, Qingdao University), two international institutions (Budapest University of Technology and Economics, Curtin University), and the Ministry of Transport of the People's Republic of China.

The following are examples of frequently published research topics by Beijing University of Technology that focus on urban mobility management, such as private vehicle restriction policies, technology-based transportation system integration, and transit-oriented development (TOD) planning (Tan & Chen, 2011; Xu et al., 2017; Liu & Liao, 2025). Their research aims to address the challenges of urbanization and air pollution by developing sustainable public transportation. Meanwhile, Universidade Estadual de Campinas (UNICAMP) stands out for its experimental and innovative approach, transforming its campus into a living laboratory for sustainable mobility. Through the Sustainable Campus Project's main goals and the Living Lab for electric mobility in the public transportation system of the University of Campinas (UNICAMP), UNICAMP is developing electric buses, solar-powered charging stations, and a real-time monitoring system to measure the environmental impact of transportation (Ugarte et al., 2019; Fontenelle et al., 2022). This research focuses on social aspects such as user

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behavior and public policy in encouraging the transition towards green mobility (Maia et al., 2020). Thus, Beijing University of Technology contributes from the policy-driven Innovation and intelligent transportation system technology side, while UNICAMP strengthens the sustainability approach based directly on the campus environment.

3. Author's Analysis by Co-Authorship

Co-authorship analysis is employed to examine collaboration patterns between authors and institutions, facilitating the mapping of collaborative networks that impact research productivity and quality (Mukhlisa & Hasan, 2024). Figure 5 and Table 2 show the visualization of the author network in the field of sustainable development-based public transportation management. This analysis aims to identify the most active and influential researchers in developing this topic based on the number of publications, citations, and the strength of inter-author relationships (total link strength).

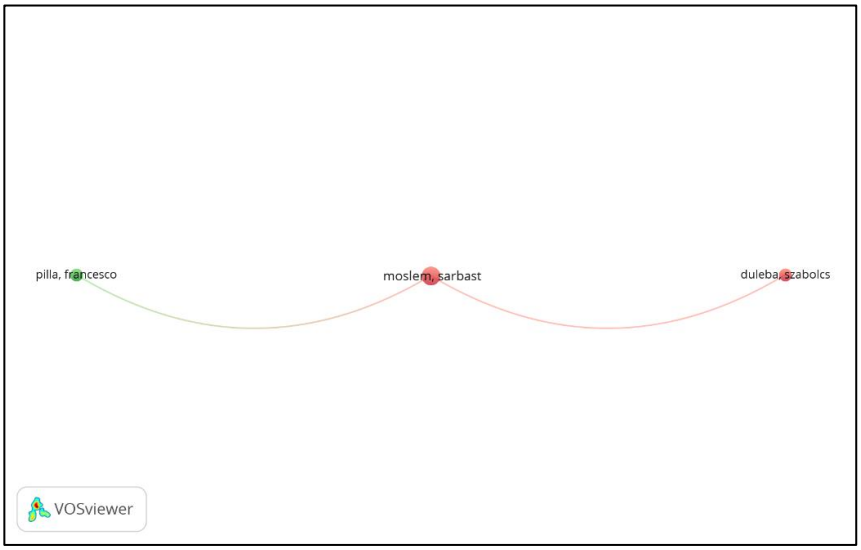

Fig 5.
Network visualisation of the Authors
Source: VOSviewer analysis results, 2025

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Author	Document	Citation	Total Link Strength
Moslem, Sarbast	4	228	4
Duleba, Szabolcs	2	177	2
Norman, Richard	2	10	2
Pilla, Francesco	2	51	2
Zhou, Heng	2	10	2
Wang, Jingjing	2	40	1
Weng, Jiancheng	2	44	1
Matsunaka, R.	2	22	0
Ong, Ardvin Kester S.	2	10	0
Xue, Yunqiang	2	7	0

Table 2.
Ten Most Productive Authors
Source: Analysis results, 2025

Based on analysis using VOSviewer, 483 authors have contributed to research on sustainable development-based public transport management. However, only 10 authors have at least two publications, indicating that only a small proportion of researchers are consistently active in this field. The most prolific author is Moslem, Sarbast, with four papers and a total of 228 citations. Duleba Szabolcs and Pilla Francesco are the two most prolific and influential authors with citations of 177 and 51, respectively.

The diverse yet convergent research implications of field luminaries underscore how many cross-disciplinary boundaries a body of work can cross. To illustrate this with two of the contributors, community-accountable transport system design must be centered on participatory-disruptive innovation systems (Krishnan et al., 2025), while sustainable improvements to the services of public transport systems that are vital to reducing transit congestion, urban noise, and CO_2 emissions must be qualitatively public (Moslem, Stevic, et al., 2023). The works of Ghorbanzadeh et al. (2019) and Alkharabsheh et al. (2021), on the other hand, assess public transport systems by focusing on the analytical balancing of system users' public transport expectations using the Grey-AHP and Interval Analytic Hierarchy Process (IAHP) quantitative frameworks.

Based on research in this domain, sustainable development-based public transport management research is mainly held by a handful of influential researchers. Among the most prolific in the literature are Moslem, Duleba, and Pilla, to whom the field remains open in terms of research collaboration at a global scale. The focus of this research remains on the service quality of transport systems, user expectations, and the integration of new quantitative frameworks into transport sector decision systems.

4. Co-Citation Analysis

Co-citation refers to an analytical approach that indicates how frequently an article is cited together with other articles, thereby determining the relationship between citations and the topic similarity and salience of the articles. (Mukhlisa & Hasan, 2024). In this

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case, 6,270 references cited. Out of these, 100 were sufficient to be relevant, that is to say, they passed the minimum threshold of being cited at least twice.

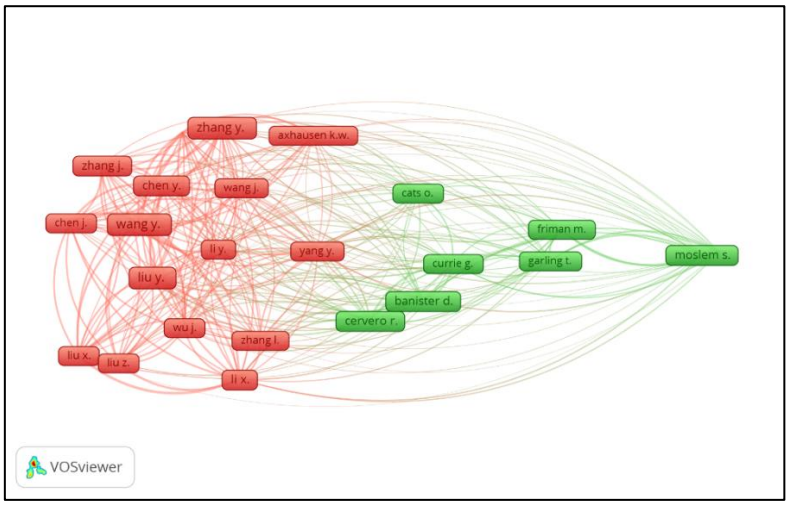

Fig. 6.
Network Visualization on Author Co-Citations
Source: VOSviewer analysis results, 2025

Figure 6 indicates that of 11,240 identified authors, 24 authors surpassed the minimum threshold of 20 citations. This is a visualization of co-citation analysis of the authors most frequently cited in the literature about the management of public transportation systems based on sustainable development. The visualization results show two main clusters: the first cluster (in red) consisting of 16 authors, and the second cluster (in green) consisting of 8 authors.

No	Author	Citation	Total Link Strength
1	Zhang Y.	45	519
2	Wang Y.	44	592
3	Liu Y.	42	505
4	Lin X.	37	482
5	Cervero R.	35	273
6	Banister D.	29	267
7	Moslem S.	28	318
8	Chen Y.	27	503
9	Zhang J.	27	406
10	Cats	26	156

Table 3.
Authors with the Most Citations
Source: Analysis results, 2025

Based on Table 3, it is evident that the research of 10 authors is related to several studies on sustainable development-based public transportation management. One of the most frequently cited authors in this study is Zhang Y., with a total of 45 citations. This suggests that the more frequently a topic is cited, the closer it is to the topic discussed in

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the research. Therefore, the higher the frequency of co-citation, the closer the topic is to the research discussed (Kamalia et al., 2024).

No	Title	Author	Journal	Year	Citation
1	Sustainable urban transportation: Performance indicators and some analytical approaches	Black, J.A., Paez, A., Suthanaya, P.A.	Journal of Urban Planning and Development, 128(4), pp. 184–209	2002	181
2	Urban transportation energy and carbon dioxide emission reduction strategies	Cheng, Y.-H., Chang, Y.-H., Lu, I.J.	Applied Energy, 157, pp. 953-973	2015	138
3	Sustainable urban transport planning considering different stakeholder groups by an interval-AHP decision support model	Ghorbanzadeh, O., Moslem, S., Blaschke, T., Duleba, S.	Sustainability (Switzerland), 11(1), 9	2019	123
4	A comparison of the sustainability of public and private transportation systems: Study of the Greater Toronto Area	Kennedy, C.A.	Transportation, 29(4), pp. 459–493	2022	111
5	Sustainable urban transit network design	Pternea, M., Kepaptsoglou, K., Karlaftis, M.G.	Transportation Research Part A: Policy and Practice, 77, pp. 276–291	2015	100
6	Sustainable and green transportation for a better quality of life: a case study	Abdel Wahed Ahmed, M.M., Abd El Monem, N.	HBRC Journal, 16(1), pp. 17–37	2020	84

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	of Greater Cairo, Egypt				
7	Sustainable and urban public transportation	Sinha, K.C.	Journal of Transportation Engineering, 129(4), pp. 331–341	2003	76
8	Assessing the sustainability of mobile depots: The case of urban freight distribution in Rio de Janeiro	Marujo, L.G., Goes, G.V., D'Agosto, M.A., ... Winkenbach, M., Bandeira, R.A.M.	Transportation Research Part D: Transport and Environment, 62, pp. 256–267	2018	71
9	Urban Public Transport: Planning Principles and Emerging Practice	McLeod, S., Scheurer, J., Curtis, C.	Journal of Planning Literature, 32(3), pp. 223-239	2017	70
10	Using an AHP-ISM-based method to study the vulnerability factors of the urban rail transit system	Song, L., Li, Q., List, G.F., Deng, Y., Lu, P.	Sustainability (Switzerland), 9(6), 1065	2017	58
11	Public transport accessibility measure based on weighted door-to-door travel time	Tahmasbi, B., Haghshenas, H.	Computers, Environment and Urban Systems, 76, pp. 163–177	2019	56
12	Energy Efficiency of Urban Transportation Systems in Xiamen, China. An Integrated approach	Meng, F., Liu, G., Yang, Z., ... Cui, S., Ulgiati, S.	Applied Energy, 186, pp. 234–248	2017	56
13	An integrated approach of multicriteria decision-making and grey theory for evaluating	Alkharabsheh, A., Moslem, S., Oubahman, L., Duleba, S.	Sustainability (Switzerland), 13(5), pp. 1-15, 2740	2021	54

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	urban public transportation systems				
14	Planning the location of a mobility hub for sustainable urban mobility	Aydin, N., Seker, S., Özkan, B.	Sustainable Cities and Society, 81, 103843	2022	53
15	Environmental co-benefits of public transportation improvement initiative: The case of Trans-Jogja bus systems in Yogyakarta, Indonesia	Dirgahayani, P.	Journal of Cleaner Production, 58, pp. 74–81	2013	52
16	Sustainable development solutions of public transportation: An integrated IMF SWARA and Fuzzy Bonferroni operator	Moslem, S., Stević, Ž., Tanackov, I., Pilla, F.	Sustainable Cities and Society, 93, 104530	2023	51
17	Walking to a public transport station: Empirical evidence on willingness and acceptance in Munich, Germany	Sarker, R.I., Mailer, M., Sikder, S.K.	Smart and Sustainable Built Environment, 9(1), pp. 38–53	2020	47
18	Analysis of public bus transportation in a Brazilian city based on the theory of complex networks using the P-space	De Bona, A.A., Fonseca, K.V.O., Rosa, M.O., Lüders, R., Delgado, M.R.B.S.	Mathematical Problems in Engineering, 2016, 3898762	2016	47

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19	Sustainable development of urban rail transit networks: A vulnerability perspective	Shi, J., Wen, S., Zhao, X., Wu, G.	Sustainability (Switzerland), 11(5), 1335	2019	43
20	Costs and benefits of using buses fuelled by natural gas in public transport	Dyr, T., Misiurski, P., Ziółkowska, K.	Journal of Cleaner Production, 225, pp. 1134–1146	2019	41

Table 3.
20 Most Cited Journal Article Publication Sources
Source: Analysis results, 2025

Table 3 illustrates that research on sustainable development-based public transportation management has garnered the attention of academics from diverse disciplines. The high number of citations to specific articles suggests that this topic has significant relevance to global efforts aimed at achieving a sustainable transportation system.

The most cited paper is Black et al. (2002) "Sustainable urban transportation: Performance indicators and some analytical approaches." This paper assesses the sustainability of urban transportation and the objectives and performance indicators for evaluating transportation sustainability. It also advocates for the coordination of transportation and land use policies. On the other hand, Cheng et al. (2015), "Urban transportation energy and carbon dioxide emission reduction strategies," focus on strategies for improving the energy efficiency of urban transportation and reducing urban transportation carbon emissions. This strengthens the matrix between public transport management and the transition to renewable energy as one of the objectives of sustainable transportation. Other works (Ghorbanzadeh et al., 2019; Moslem, Stević, et al., 2023; Alkharabsheh et al., 2021) published in the journals Sustainability (Switzerland) and Sustainable Cities and Society, referred to in the provided introduction, also mentioned the quality of public transport using multicriteria analysis models (AHP, Grey-AHP, IMF SWARA) as a technique.

Research on sustainable transportation continues to be conducted worldwide under various conditions. It is not the case that only developed countries engage in this research—developing countries also passionately pursue this topic. This clearly indicates that the development of sustainable transportation modes is a global concern. Several innovations aim to improve the efficiency and reduce the environmental impact of public transportation in the developing world. For instance, in Dirgahayani's (2013) research on the Trans-Jogja bus system in Indonesia, the author argues in favor of the social and

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environmental value of implementing sustainable public transportation in developing countries.

As the following example illustrates, the most significant impact is typically published in the most reputable international journals:

- Sustainability (Switzerland)
- Sustainable Cities and Society
- Applied Energy
- Journal of Urban Planning and Development
- Transportation Research Part: A, Policy and Practice & Part D: Transport and Environment

These publications highlight the key features of the literature on sustainable modes of transport, including the challenges surrounding sustainability, technology, and the policies of the transport system, particularly in the context of public transport.

Analysis of the 20 most cited publications suggests that a growing body of literature exists on the management of public transportation, with a focus on sustainable development, in several countries. While there is a predominance of literature that examines the technological aspects, such as innovations and energy efficiency of transport systems, there is a significant gap in integrating research on the management of public transport systems from a technological, operational, and policy perspective, as well as from the perspective of innovations in renewable energy. Sustainable transport systems will require research that is far more holistic than what is currently available. Therefore, it is crucial to develop a more integrative approach that combines technological Innovation, public policy, and user behavior so that research in this area can make a more tangible contribution to the implementation of sustainable transportation policies in cities.

5. Keyword and Cluster Analysis by Co-Occurrence

5.1 Keyword Co-Occurrence (keyword)

Keyword analysis in bibliographic research is used to identify trends and relationships between research topics. With this keyword mapping, researchers can identify the primary focus of the research, frequently discussed research topics, and identify opportunities for future research development. Based on Fig. 7, the co-occurrence visualization results show the size of the dots, which depict the frequency of keyword appearance. At the same time, the connecting lines indicate the level of interrelationship between research themes. The keywords with the highest frequency of occurrence in the topic of public transportation management based on sustainable development are listed in Table 4 below.

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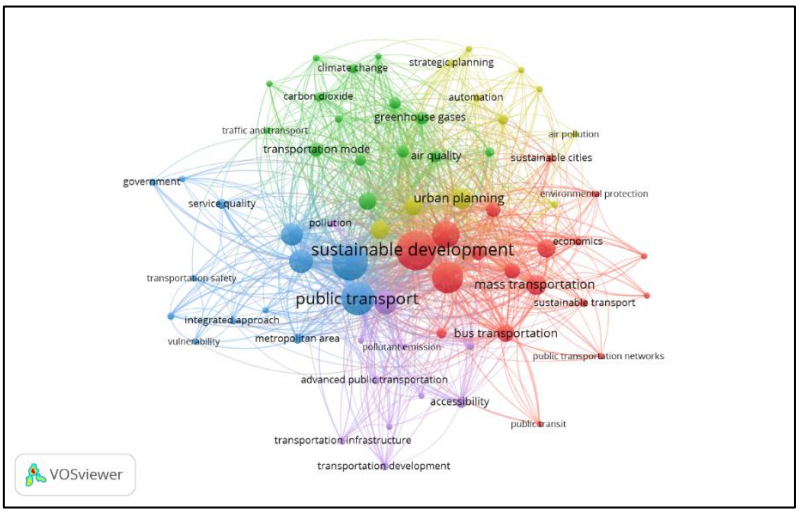

Fig. 7
Network Visualization Keyword Co-Occurrence
Source: VOSviewer analysis results, 2025

No	Keyword	Occorrences	Year
1	Sustainable development	100	2016
2	Urban transport	84	2017
3	Public transport	71	2018
4	Urban transportation	61	2019
5	Public transportation	50	2016
6	Sustainability	38	2017
7	Sustainable transportation	35	2019
8	Transportation system	31	2019
9	Urban planning	28	2014
10	Mass transportation	27	2015
11	Renewable energy resources	24	2015
12	Transportation planning	23	2014
13	Public transport systems	22	2016
14	Accessibility	22	2018
15	Traffic congestion	21	2018

Table 4.
Keywords with the Highest Frequency of Appearance
Source: Analysis Results, 2025

In the context of managing public transportation from a sustainability perspective, the most significant keywords are “sustainable development,” “urban transport,” and “public transport.” These conclusions also align with the findings of C. Zhang et al.

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(2025), in that the realization of sustainably developed urban transport is rooted in the equitable and even growth of urban spaces, supported by strong state intervention.

In contrast to the more extensively explored areas of research, such as sustainable development and urban transport, the integration of renewable energy systems and sustainable public transport management remains an under-researched area. Previous research, such as that by Stinga et al. (2010), has demonstrated that the adoption of Intelligent Transportation Systems (ITS) increases public transport use while decreasing road transport usage, thereby reducing CO_2 emissions. Moreover, the use of CNG as an alternative fuel in public transportation systems, despite high investment and maintenance costs, increases energy efficiency while improving air quality (Dyr et al., 2019). Sophisticated transport systems, such as those in Brazil, which utilize ethanol and biodiesel, also highlight the importance of renewable energy in achieving a sustainable public transportation system (Berni et al., 2012; Devi et al., 2022).

5.2 Co-Occurrence Cluster

Kamalia et al. (2024) emphasize the significance of cluster analysis in bibliometric studies, which enables the assessment of connections and interrelationships among keywords or research areas. This method provides insights into the network visualization and assists in revealing groupings of research themes and patterns. This, in turn, helps to determine the research focus and emerging trends in the literature. In this case, the focus is specifically in the field of sustainable development and public transportation management.

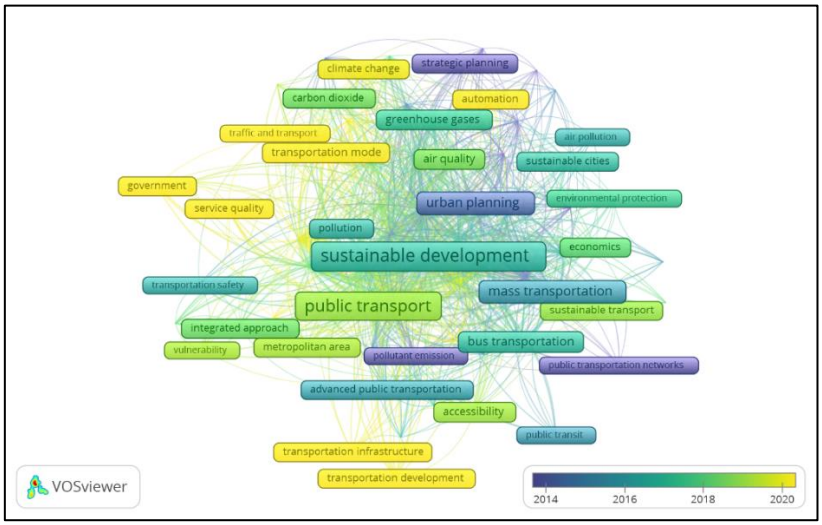

Fig. 8
Overlay Visualization of Clusters and Keywords on Connectivity
Source: VOSviewer analysis results, 2025

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Based on the results of the cluster analysis, five main clusters were identified, reflecting the focus and trends in research on public transportation management in the context of sustainable development. Details of each cluster are presented in the following table:

Cluster	Keyword	Occurences	Link	Total Link Strength	Research Trends
1	Bus transportation, economics, environmental protection, mass transportation, multimodal transportation, planning, public transit, public transport systems, public transportation, public transportation network, public transportation systems, rail transit systems, sustainable cities, sustainable development, sustainable transport, urban development, urban mobility, urban transportation	354	551	2.187	Sustainable development and urban transportation
2	Air quality, carbon dioxide, climate change, environmental impact, environmental management, gas emissions, green transportation, greenhouse gases, population density, public policy, traffic and transport, traffic congestion, transportation mode, transportation policy, urbanization	115	448	912	Traffic congestion and transportation mode

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3	Environmental sustainability, government, integrated approach, metropolitan area, public transport, railway transport, safety, service quality, sustainability, transportation safety, transportation systems, urban transport, vulnerability	262	353	1.515	Urban transport and public transport
4	Air pollution, automation, economic and social effects, social aspects, strategy planning, transport planning, transport systems, transportation, transportation management, transportation planning, urban planning	107	268	662	Urban planning and transportation planning
5	Accessibility, advanced transportation systems, pollutant emission, pollution, renewable energy resources, sustainable transportation, traffic management, transportation development, transportation infrastructure, transportation policies, urban public transport	225	77	462	Sustainable transportation and renewable energy resources

Table 5.
Name of Items in the Five Clusters
Source: Analysis results, 2025

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Based on Fig. 8 and Table 5, the five clusters identified are not isolated but are conceptually interconnected, reflecting the intellectual evolution of the field of public transportation management in relation to sustainable development.

a. Sustainable Development and Urban Transportation

In this first cluster, sustainable development and urban transportation serve as the primary foundations for developing a public transportation system to support sustainable urban development. Public transport can mitigate environmental effects and promote inclusive growth in cities, as indicated by phrases such as bus transport, urban mobility, and environmental safeguarding.

Utilizing various forms of public transport is one way to conserve urban areas. Buses and light rail transit systems help make urban transportation efficient and eco-friendly by easing congestion and reducing emissions (Holmgren & Ivehammar, 2020; Silva et al., 2023; Velikova & Gatovski, 2023). The introduction of electric buses to public transportation is a significant innovation, as it helps reduce the environmental harm caused by the transportation fleet by lowering greenhouse gas emissions and improving public health (Carmona et al., 2022; Sabet & Farooq, 2025). The use of Green Public Procurement (GPP) in the purchase of public transport services helps manage environmental, social, and economic sustainability (Timm et al., 2025). Sustainable transport requires a Transit-Oriented Development system, as well as the integration of urban planning and public transport to improve service quality. The primary aim of these initiatives is to encourage a behavioral shift among private transport users toward public transport (Velikova & Gatovski, 2023; Chuang et al., 2023; Al Nafees et al., 2024; Sogbe et al., 2025).

Sustainable urban transportation systems present challenges such as inadequate infrastructure, high capital requirements, and the tendency of the population to prefer cars over public transit (Carteni, 2015; Anthony Jr., 2023; Perez & Pereira, 2025). The introduction of impactful policies will require a balancing act that factors the incorporation of clean technologies and the deployment of operational AI, the Internet of Things (IoT), and their Governance to minimize inefficiencies and their consequent adverse effects on the environment (Wu et al., 2023; Kailash Varma et al., 2024; Shafik, 2025).

b. Traffic Congestion and Transportation Mode

Transportation Mode and Traffic Congestion in the second cluster evolved due to a policy change, which shifted from just building roads to building a comprehensive green mobility system. The impact of Traffic Jams, Atmospheric Pollutants, and Greenhouse Gases (GHGs) is the primary focus of the cluster. This research, unlike the construction of transport infrastructures and the provision of services to clients, aims to demonstrate the potential of clean, efficient, and sustainable transport systems to contribute to the development of transformative urban centers.

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Policies on urban disincentives such as sustainable transport subsidies, carbon taxes, and congestion pricing, as well as the promotion of active transport, have been shown to improve urban air quality and emissions over time. Traffic congestion and rising CO_2 emissions in Jinan, Mumbai, and Jakarta, along with the associated unmanaged flows, have been shown to necessitate policies aimed at the sustainable management of road space (Bharadwaj et al., 2017; Wei et al., 2023; Ernyasih et al., 2025). The sustainable management of road traffic has been proposed by Uddin (2013) and Suryani et al. (2025) to include carbon taxes, discouraging private car use, and increasing public transport availability, thereby providing sustainable mobility.

Innovative approaches involving emerging technologies can foster more environmentally friendly transportation. For instance, research shows that a carbon-emission tax on traffic in Panjin, China, has yielded positive outcomes in traffic management and a reduction in exhaust emissions. Additionally, a study shows that a distance- and time-based congestion pricing system can reduce carbon emissions by 23% (L. Yang et al., 2018). Furthermore, the Beijing government is endorsing other environmentally positive measures, such as encouraging the use of public transportation and non-motorized vehicles (Y. Yang et al., 2017). Moreover, AI-powered innovative transportation systems have been documented to reduce carbon emissions through traffic management (El Haddad Imane et al., 2025). Excessively complex integrated land use patterns mitigate and reduce congestion in the vehicle system, thereby improving mobility and reducing carbon emissions (X. Yang et al., 2024).

c. Urban Transport and Public Transport

The third cluster, Urban Transport and Public Transport, encompasses studies on Governance, safety, and the quality of public services. In these studies, the sustainability of public transport services and the government's role in integrated transport provision determine the level of service achieved, as well as the system's efficiency and public service quality (Shramenko & Hupfer, 2023; Cappelli, 2018). For example, an Algerian study illustrated that while service quality improvements followed transport sector liberalization, the more public sector controls there are, the more sustained refinements of service quality will be possible (Houria & Farès, 2019). In addition, studies in Kumasi and Dar es Salaam showed that safety is a critical factor in establishing user confidence in the public transport system (Henezi & Winkler, 2023; Dumedah et al., 2025). At the same time, the level of service provided, in terms of comfort, reliability, and accessibility, is a crucial determinant of user satisfaction when switching to public transportation (Oliveira et al., 2022; Dumedah et al., 2025).

d. Urban Planning and Transportation Planning

Cluster 4 (Urban Planning and Transportation Planning) illustrates the degree of active and passive relationships that spatial planning and transportation systems provide (e.g., the spacing and social networks of a city that would be built over time, and the modalities of movement employed). The emphasis of this cluster is on determining the

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cross-spatial, social, economic, and technological policy relations necessary for establishing a viable transport system within a given network. The objective of transport system planning is to provide a just urban transport system for a city, and for a given period, a sustainable and efficient system.

The fourth cluster, which integrates Urban Planning and Transportation Planning, assembles the different channels of socio-spatial and modal networks within a city. Approached with a land planning model that utilizes a two-way interaction, a predicted set of policy impacts from transport networks and land uses can be triggered by the interaction of transport and land policies, thereby informing urban planning (Wegener, 2021). Planning integration ensures the provision of pattern mobility and system order transport provision by managing urban sprawl. The provision of spatial planning and transport networks with a given degree of coordinated set optimal accessibility is sustained by the interaction of the two systems (Su et al., 2013).

Additionally, it is imperative to incorporate socio-economic and ecological variables to achieve a comprehensive and low-emission transport system. The integration of planning approaches warrants policy and institutional backing, as demonstrated by the initiative of the Ministry of Housing and Urban-Rural Development of the People's Republic of China, which advocates for aligning urban transport master plans with urban master plans to foster integrated planning. The successful integration of all system components requires firm policy and institutional backing—the urban transport systems. Given future uncertainties, transport systems must engage in resilient and sustainable development (Su et al., 2013).

e. Sustainable Transportation and Renewable Energy Resources

Cluster 5 (Sustainable Transportation and Renewable Energy Resources) reflects current studies concerning the intersection of advancing technology and the renewal of public transport. There is a shifting focus in this cluster from research on improving the efficiency of transport systems to a research focus on decarbonizing transport systems through the use of alternative fuels and clean energy. This shift from concerns about operational efficiency to system decarbonization aligns with the global goal of achieving net-zero emissions. In transportation, decarbonization is made possible through the adoption of low-carbon technologies and the integration of new renewable energy sources, as identified by Sayeed and Manikandan (2024), including solar, wind, biofuels, compressed natural gas (CNG), and other lower-carbon technologies.

The ecosystem of EVs, renewable microgrids, and V2G technologies is a key focus area of research on green and flexible transportation infrastructure. The combination of smart grids with cutting-edge artificial intelligence and machine learning technologies is anticipated to enhance the systems used to manage and control the energy of transport subsystems and the circulation of renewables (Cicek et al., 2022; Wan et al., 2024). The integration of technologies is a necessary but not sufficient condition for the leap to low-carbon transport. A stronger framework concerning policies, public-private

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partnerships, and, most importantly, community engagement related to infrastructure is critical (Jain et al., 2025).

The temporal limitations of current renewable energy initiatives have been noted, along with inefficient energy storage, regulatory, and economic issues (Sayeed & Manikandan, 2024). Future studies will focus on developing more agile, dynamic, and robust systems to address fluctuations in electricity demand and the economic and technological challenges associated with adopting clean energy in the transport sector (Wan et al., 2024). Their operational energy, driven by the intersection of technology and clean energy policy, which this cluster relies on, holds the potential for sustainable transport systems in the future with low or zero emissions.

Research on the management of public transport systems for sustainable development is beginning to incorporate clean technologies and decarbonization policies. The five clusters indicate a shift in attention from core issues of infrastructure and operations to strategic challenges, including energy efficiency, the green shift, and the integration of new urban transport policy innovations. The management of transport systems from renewable energy sources is an opportunity that should be prioritized to enable the integration of sustainable urban planning. The shift to a clean energy transport system, utilizing compressed gas, biogas, natural gas, and electricity, will require the alignment of transport systems and regional energy integration. This represents a significant opportunity to achieve emissions reductions, fossil fuel savings, increased efficiency, and social equity, as well as net-zero emissions and low-carbon urban development.

6. Future Research Opportunities

After examining 153 documents related to sustainable development in public transport management, it has been established that considerable work remains to be done in researching this subject. Much of the work done is still focused on the majors of infrastructure, urban Governance, and service quality. The incorporation of renewable energy still requires considerable work and attention. This is evident in the analysis of keyword co-occurrences, where the keyword “renewable energy resources” is mentioned 24 times, alongside significant terms such as “sustainable development” and “urban transport.”

Renewable energy integration in public transport management is a developing research area. This particularly relates to how the integration of renewable energy can enhance the urban sustainability of public transportation systems. The construction of sustainable transport systems, focusing on alternative low-emission technologies, should also incorporate integrated solutions that coordinate the energy and transport sectors. Such systems are particularly challenging in developing regions, where weak infrastructure and cross-sectoral information systems limit the capacity to facilitate a clean energy transition. The existing barriers to the clean energy transition in developing cities compound this. Effective transport systems, designed to be clean and sustainable,

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therefore require a cross-sectoral research and policy framework that integrates energy and transport systems planning.

Analysts correctly forecasted that the transportation sector would become the largest emitter of greenhouse gases in the upcoming decades. The sector is a major user of fossil fuels, a factor that contributes to a predicted 70% increase in emissions in the sector, according to the United Nations. Global targets for emissions and fossil fuel use necessitate an innovative approach for emissions reductions in the sector. International treaties, such as the Paris Agreement, and sustainability and climate initiatives within the United Nations, which encompass the 2030 Sustainable Development Goals and the 2050 Net Zero target, aim to guide low-emission urban mobility. The integration of renewable energy into sustainable transportation fuel policies must become a priority in future research to provide the necessary climate and transportation policies for low-emission urban mobility systems. Therefore, the incorporation of all facets of low-carbon transportation, particularly policies to be formulated in accordance with the National Development Goals, must ensure that these positions encompass the decarbonization of large industrial sectors.

CONCLUSION

The sustainable development management of public transportation systems, as revealed through bibliometric network analysis, is another strategy for mitigating urbanization challenges and promoting sustainable urbanization and development, thereby enhancing urban efficiency for environmental protection, equity, and justice. Although the growth in the volume of publications and thematic variations continues to increase, albeit erratically, this study reveals a consistent increase as a result of bibliometric mapping using VOSviewer. There is a substantiated concentration of outputs relating to this theme in a small number of countries (China, India, and Australia), with international co-authorship exhibiting a similar uneven pattern. Although the literature on this theme addresses sustainable development, urban transport, and public transport, the limited scholarship on low-carbon energy resources used in public transport systems presents a unique and valuable research opportunity to explore.

A cluster and keyword analysis led to the identification of and consolidation of findings onto five principal research areas: sustainable development and urban transportation, traffic congestion and transportation modes, urban transport and public transport, urban planning and transportation planning, and sustainable transportation and renewable energy resources. Collaboration network visuals reveal close and collaborative relationships among researchers and research institutions across multiple countries, although some countries are underrepresented.The findings indicate that knowledge advancing the management of public transport in conjunction with sustainable development remains limited to a few countries, resulting in innovations and solutions that do not meet global requirements, particularly those innovations that developing

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countries require. The limited collaboration between research domains and across countries may contribute to the insufficient integration of knowledge and the adoption of best practices worldwide for the sustainable development of public transport systems. In addition, the co-occurrence results suggest that the incorporation of renewables into public transport systems is a significant gap, despite its importance to the global decarbonization agenda and the target of achieving Net Zero Emissions by 2050.

The results underscore the need for a comprehensive framework that integrates the management of public transportation with the adoption of renewable energy sources, thereby advancing the theory of sustainable transportation systems. This construct aims to advance theory on the management of sustainable transport systems, drawing on interdisciplinary contributions that encompass engineering, public policy, and social dimensions. The findings can also serve as a practical starting point to advance policy efforts and evidence in the sustainable public transport sector, particularly in efforts to prioritize the clean energy policy agenda in Indonesia.

Building on the research findings, several initiatives can be implemented to strengthen the trajectory of sustainable transportation growth in Indonesia. Developing a national research roadmap to eliminate silos and integrate the 'energy transition and green transportation' agendas is of utmost priority. Third, fostering the establishment of cross-institutional and cross-national research collaborations is crucial to boost synergistic global partnerships and expedite the circulation of innovative ideas and knowledge. Fourth, investing in data-driven responsiveness and adaptive, evidence-based intelligent transportation systems is key to addressing the research gaps in engineering and systems planning for transportation. Lastly, strengthening the government's capacity to undertake low-carbon transportation planning is crucial to making the processes more inclusive, participatory, and aligned with the principles of sustainable development.

This research contributes to the theory and empirical research on sustainable transportation management and practice, aiming to achieve the Sustainable Development Goals and Net Zero Emission 2050 goals. The findings of the analysis should inform public policies and guide the development of a sustainable transportation policy framework for the Indonesian public transport system, which needs to be reconfigured to enhance its efficiency, inclusivity, and competitiveness in meeting the challenges of climate change and urbanization.

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