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Review Article

Knowledge Mapping and Thematic Evolution of Transportation Management System Research in Nigeria and South Africa: A South-South Scientometric Perspective

Nura Shehu Aliyu Yaro[1], Adeyinka Kabir Akanbi[2], Aliyu Mani Umar[3], Jacob Adedayo Adedeji[1*]

[1]*Sustainable Environment and Transportation Research Group (SET-RG), Department of Civil Engineering, Midlands, Durban University of Technology, Private Bag X01, Scottsville, Pietermaritzburg, South Africa.*
[2]*Department of Information Technology, Central University of Technology, Bloemfontein, Free State, South Africa*.
[3]*Department of Civil Engineering, Ahmadu Bello University, Zaria, Kaduna, Nigeria*.

[1*]*Corresponding Author : jacoba@dut.ac.za*

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Abstract *- This paper presents a comprehensive scientometric analysis of Transportation Management System (TMS) research in Nigeria and South Africa between 2005 and 2025, with a focus on Global South dynamics. Using data sourced from Scopus and visualized via VOSviewer, the study maps literature trends, publication types, keyword occurrences, institutional affiliations, and bibliometric coupling. The findings reveal a mature and diverse TMS research landscape in South Africa characterized by strong institutional collaboration and international visibility. Research themes include intelligent vehicle highway systems, adaptive traffic management, smart city planning, and decision support systems led by institutions such as the University of Cape Town, University of Johannesburg, CSIR, and the eThekwini Transport Authority. This reflects a well-integrated ecosystem between academia, industry, and government. In contrast, Nigeria demonstrates concentrated but emerging research activity, primarily from institutions such as the University of Lagos and the University of Ilorin. The focus is largely on urban traffic management, congestion reduction, and early-stage TMS initiatives. Despite some emphasis on data-driven approaches, keyword analysis shows limited thematic diversity in Nigerian literature. By comparing the two countries within the South–South framework, this study identifies a knowledge gap, particularly in Nigeria, which presents an opportunity to expand the research scope and thematic variety. Overall, the paper provides valuable strategic insights into the evolution of TMS research in Africa and underscores the importance of intelligent, sustainable and data-driven transport systems to increase the efficiency of resilience and environmental performance across the continent.*

Keywords *- Transportation Management Systems, Scientometric analysis, Smart mobility, South–south research dynamics.*

1. Introduction

The need for effective traffic and transportation management has been increasing in the rapidly urbanizing areas of the world, such as Nigeria and South Africa, because of the number of cars and the expansion of urban areas [1-3]. The need for effective traffic management has led to the formation of a new technology category known as the transportation management system [4, 5]. The idea of Transportation Management Systems (TMSs) has appeared to be a significant innovation area in the realm of transport infrastructure, which makes the best use of digital technology, data, and operations research capabilities to improve the effectiveness of traffic, alleviate congestion, and optimize logistics operations [4, 6]. The TMS has appeared to be a vital element in the management of transport in modern urban scenarios, offering a range of solutions in the areas of traffic management, route planning, traffic forecasting, and multimodal transport [7, 8]. The developments in the areas of Internet of Things (IoT), Machine Learning, Data Analytics, and Smart Transport Solutions, in the case of TMS, have enabled transport operations in a sustainable, efficient, and intelligent manner [5, 6, 9].

The use of TMS technology seems to have had a significant effect on managing traffic worldwide, improving accessibility, and facilitating sustainable transport policies [10, 11]. Although research on the TMS has been increasing worldwide, the development and application of the TMS in Nigeria and South Africa remain relatively limited [12, 13].

The generation, dissemination, and application of knowledge regarding TMS are not even, especially in the developing world, where the effects of urbanization, infrastructure, and congestion are considerable factors [13, 14]. Nigeria and South Africa offer interesting settings for investigating the adoption of the TMS, with various urban environments, new smart city provisions, and a government focus on sustainable transportation systems [13, 15]. Although TMS research has immense strategic relevance, it remains underexplored, with little knowledge of existing research trends, themes, and collaboration graphs, especially in the developing world [16, 17].

The literature on the TMS has largely emphasized technology applications, traffic optimization models, intelligent transport systems, and urban mobility concerns, but has addressed only the developed economy [18, 19]. In addition, the studies performed in Africa are primarily local, application-specific, or only apply to one mode of transportation and do not look across all of Africa at what is being done in the TMS and the structure of scientific knowledge surrounding the TMS, the evolution of the thematic literature, the ability of the institutions, and the collaboration of the institutions towards TMS development between countries.

Moreover, there is still a lack of understanding of South–South research in TMSs, such as Nigeria and South Africa, and how they collaborate and share knowledge over the long term, resulting in low rates of productive research. Thus, this study fills an important gap in the literature by performing a detailed scientometric analysis of TMS research in Nigeria and South Africa from 2005-2025. The bibliographic data used for this research were obtained via the Scopus database and visualized with VOSviewer software. This paper reviews the publication trends of TMS research, identifies keywords associated with TMS articles, assesses institutional productivity, describes collaborative research patterns, and creates bibliometric networks to determine the level of maturity and ability of TMS research environments in both nations.

This work is novel in its application of a comparative South–South scientometric framework beyond merely bibliometric reporting and in assessing the research maturity, thematic spread, institutional integration, and development of transportation research into ITSs in some selected African countries. This study offers a longitudinal comparison of the trends in ITS research development in Nigeria and South Africa over two decades, unlike prior studies, which tended to focus on an application and a single-country scenario. Policymakers, researchers, transport planners, and infrastructure investors should be provided with strategic directions and considerations to enhance the advancement of intelligence-driven and sustainable transportation systems in Africa.

2. Literature Review

2.1. Transportation Management Systems Evolution

Transport Management Systems (TMSs) have evolved from traditional traffic control systems to complex, sophisticated intelligent systems of data-driven mobility management aimed at optimizing transportation effectiveness, safety, and sustainability [20, 21]. The initial TMS used static methods of traffic engineering, manual tracking of vehicle dynamics, and a restricted signal control system, which were not effective enough to meet the challenges of diverse and fast-growing urban societies [22]. As urbanization progresses, together with rising motorization and freight development, transportation systems have transitioned to more intelligent, integrated solutions, harnessing digital technology, operating research, and real-time information for assisting in daily transportation decisions for people and goods [23, 24]. Today's TMS can incorporate a traffic monitoring system, a prediction modelling algorithm, a route planning package, a logistics coordinating platform, and intermodal transportation strategies to allow the TMS to support more flexible decision-making and be more responsive to traffic transportation situations [7, 24]. These advances in applications and services are based on new generation internet technologies, including IoT, artificial intelligence, machine learning, cloud computing, and big data [25, 26]. The traditional TMS systems have also been extended into extremely flexible systems, which can realize real-time sensing, prediction, and automation functions [7, 26]. Therefore, TMS systems have been regarded as key parts of smart mobility and smart city systems in many parts of the world today [26].

2.2. Intelligent Transportation Systems and Digital Mobility

ITS and digital mobility have transformed how the TMS operates by providing a new level of operational and conceptual foundation for the TMS [7, 27]. ITS technology allows for the convergence of communication systems, computational intelligence, and sensor-based data acquisition to improve transportation planning and operations. AI and machine learning techniques are increasingly leveraged for congestion prediction, traffic flow optimization, incident detection, and demand forecasting [7, 28]. IoT-enabled infrastructure (IoT-EI) also provides real-time data exchange between vehicles, traffic control centres, and road infrastructure, thus improving situational awareness and operational effectiveness. Furthermore, new smart mobility paradigms, such as Mobility-as-a-Service (MaaS), autonomous traffic management, and smart logistics platforms, are redefining the transportation ecosystem [29, 30]. Together, these innovations support the objectives of sustainable transportation by reducing congestion, emissions, and inefficiencies in urban mobility systems [7, 27].

2.3. Transportation Management Systems in Nigeria

Nigeria also has urban mobility problems, especially in the rapidly expanding cities of Lagos, Abuja, and Port Harcourt, where high traffic congestion, road accidents, and

inefficient logistics operations often exist [1, 31]. As these cities are experiencing rapid urbanization and population and car ownership expansion, they face hectic pressure on the current infrastructure and thus need the gradual implementation of the TMS to effectively control traffic and provide enhanced urban mobility [1, 32]. The Smart Transportation System projects that involve cutting-edge Nigerian technology include intelligent traffic control systems, vehicle location monitoring, traffic monitoring and control software, and routing optimization projects [33, 34]. Although these projects are at either the pilot or implementation stage, there appears to be increasing acceptance of the role of smart technologies in terms of traffic congestion and traffic safety needs [10, 34]. There are limitations to the implementation of the TMS in Nigeria, including fragmentation of policies, funding, technical capacity, and coordination of institutions, which affect the scalability of remedies to urban networks [35, 36].

Despite these challenges, research institutions, academic institutions, and the corporate sector are increasingly being tapped to undertake applied research related to the TMS, including predictive analysis, optimization of traffic flow, and urban mobility as addressed by local conditions [36]. Interestingly, safety and efficiency form the core of the concerns and focus of studies and piloting, and the reduction of accidents, congestion, and optimization of logistics serve as focal points [35, 37]. Moreover, the literature on the TMS in the Nigerian context also embraces the use of data and data analytics, which highlights the shift towards proactive approaches for the sustainable management of traffic, as opposed to the purely reactive management of traffic that has and still characterizes the transportation system in the country [36, 38]. Nigeria has the potential to be an emerging TMS destination for the southern-southern region. By scrutinizing published sources, citation rates, coauthorship, and keyword correlations, it is possible to extract the dynamics and impact of TMS research on the basis of the aforementioned techniques. Therefore, the paper offers a bibliometric analysis related to the research in TMS in Nigeria and South Africa from 2005--2025, which is based on publications in Scopus-indexed journals.

2.4. Transportation Management Systems in South Africa

The transportation system in South Africa involves the use of the TMS as an initiative to reduce urban mobility issues such as traffic congestion, road accidents, and logistics-related inefficiencies [39, 40]. The larger cities of Johannesburg, Cape Town, and Pretoria are practicing the use of TMS projects that involve real-time traffic tracking, dynamic traffic management, and optimal intelligent routes, which play important roles in supporting traffic optimization and urban mobility management [41, 42]. Apart from the conventional use of the TMS, the new initiatives involve the use of MaaS, eco-routing, and low integration of electric vehicles, which aim to promote the efficiency of multimodal transportation [43-45]. Safety continues to be emphasized, with predictive analysis Using Advanced Driver Assistance Systems (ADASs) being piloted in fleets to improve safety on roads and improve traffic control [46, 47]. In addition, the literature on the TMS in the context of the Republic of South Africa demonstrates an increasing institutional approach to research [3, 45]. The TMS research area brings together research in transportation fields, the government, and institutional entities providing technology, demonstrating an industry-level TMS environment that has matured beyond the early stages of transportation control to intelligent transportation systems [3, 48].

Second, the use of the TMS has been underscored by South African academics as being based on evidence-driven decision-making, traffic data analysis, simulation models, and scenario analysis with the aim of shedding light on policy and operational decisions [3, 49]. Researchers have also investigated the application of the TMS to optimize public transportation dependability, logistics, and multimodal transport systems, pointing out that scalable applications can also be developed for other developing nations with the same traffic challenges as South Africa [2, 50, 51]. The ever-changing research trends also reflect the focus on smart transportation applications using IoT technology. Big data analysis and smart modelling have been used to develop responsive transport systems that adapt to traffic dynamics and urban expansion [2, 12]. The review will also help explore the following research questions and aims to address the following: a) What are the trends in the publication and research growth of the TMS in Nigeria and South Africa; b) what are the themes, keyword clusters, and thematic development trends found in the TMS; and c) which are the most dominant publication sources and institutions? Through the systematic integration of TMS-related research in these developing countries, the proposed work contributes to the existing body of knowledge and assists in implementing intelligent and sustainable transportation solutions.

3. Methodology

This study adheres to the PRISMA 2020 guidelines for the systematic gathering and screening of literature to be used for bibliometric analysis. Bibliometric analysis is a quantitative and statistical method used to detect relationships, patterns, and trends in a research area; large quantities of literature can be processed effectively. Supplementary network analyses were also performed: co-citation analysis to assess the relationships between cited documents and sources, bibliographic coupling to assess the connections between countries and sources, and keyword co-occurrence analysis to determine thematic trends. The overall approach is based on scientometric mapping, which reveals the evolution of research on the TMS in Nigeria and South Africa during the period of 2005-2025 and provides insights into the productivity, collaboration patterns, and identification of emerging topics.

3.1. Data Collection

The reason for choosing the Scopus database as the main source was that it comprehensively indexes peer-reviewed literature, with high-quality metadata that are highly reliable for bibliometric analysis [52]. The search took place on October 28, 2025, with the TITLE-ABS-KEY search field and the search keywords: "Transportation Management System" OR TMS OR "traffic management" OR "transport optimization" OR "transport automation" OR "smart transport" OR "urban mobility" AND ("Nigeria" OR "South Africa"). This preliminary search yielded a total of 61 and 84 documents for Nigeria and South Africa, respectively. However, the documents were filtered further using predefined inclusion and exclusion criteria, as shown in Table 1. The criteria included relevance to the research conducted on TMS studies. Additionally, the articles should be peer reviewed, published as documents at a conference event, and their publication language should be English. This produced final datasets of 47 and 68 documents for Nigeria and South Africa, respectively, which were suitable for a thorough scientometric study.

Table 1. Data screening criteria for inclusion and exclusion

Criteria	Inclusion	Exclusion
Publication stage	Published	Article in press
Country	South Africa	Countries other than Nigeria or South Africa
Publication year	2005-2025	Before 2005
Language	English	Non-English
Subject area	Environmental Science and Engineering	Studies not related to Engineering and Environmental Science
Article type	Journal, conference paper, books, review	Concept, Editorial, and Retracted Papers

3.2. Data Analysis

This work assessed the contributions and progress made in TMS research that occurred between 2005 and 2025 by applying scientometric mapping. Among the critical parameters used in scientometric analysis were publication trends, document types, and thematic changes as defined by keywords used by the authors. This work employed VOSviewer software (Version 1.6.20) to create visual networks and scientometric mapping. Microsoft Excel software was used to organize the data as well as to present basic statistics. VOSviewer assisted in understanding the citation, coauthorship, and keyword structures by transforming all these relationships into visualization networks [53]. To visualize the data and perform network analyses, VOSviewer was used because it is robust in terms of creating and visualizing networked bibliometric sources via a complex method, including joint authorship, joint occurrence, bibliographic coupling, and co-citation analysis. VOSviewer also allows for the identification of knowledge structures, thematic groups, and collaboration patterns among large bibliographic datasets. For keyword co-occurrence, the visualization depicted keywords as nodes whose size denoted the number of times each keyword appeared, with the link thickness demonstrating the strength of the link between each keyword and the color of each cluster showing groups of keywords that belonged conceptually together on the basis of high levels of similarity between the keywords considered within the field of research [54]. This approach facilitated a comprehensive analysis of the trends in TMS research, the identification of top authors and institutions, the study of networking patterns, and the mapping of development trends in thematic areas, offering a panoramic view of the research scenario from a South-South perspective.

3.2.1. Annual Publication Trend

Figure 1 shows the annual publication trends for both Nigeria and South Africa. The temporal distribution of publications on the TMS in Nigeria and South Africa between 2005 and 2025 depicts an evolutionary development of erratic early contributions to sustained growth, where the full maturity and intensity of research are visibly different between the two countries. In the early emergence phase, which spanned the period between 2005 and 2009, the level of output was minimal and was largely exploratory. There was a consistent publication rate of one publication annually for the case of Nigeria. For South Africa, the records indicate a slightly higher level of output, with an average of two publications annually. This period represents the early emergence of TMS concepts in the field of transportation research on the continent due to the development of intelligent transportation and logistics systems externally. The formative growth phase is the period between 2010 and 2014. The record for the case of Nigeria indicates some growth punctuations that peaked in 2013.

On the other hand, the record for the case of South Africa indicates stable levels of output at two to three publications annually. This denotes a stronger anchoring of the research on TMS concepts within the transport and mobility national agenda. However, a more pronounced transition occurred during the acceleration and consolidation phases (2015–2019). During this period, the output, especially in the case of Nigeria, was more consistent, with an average of two to three publications annually. In the case of South Africa, there was a more pronounced surge, especially in 2018, which was a peak year, considering that the country had more advanced facilities in conducting research, including the inclusion of TMSs in intelligent transportation and logistics systems. The disruption and resilience phase (2020-2021) seems to indicate a decline in output in 2020, probably due to the disruptions caused by the COVID-19 pandemic. However, the increase in output in 2021, especially in countries such as South Africa, seems to

be an adaptive measure in relation to data and simulation-based TMS research. Both countries will enter a phase of expansion and maturation from 2022-2025. This is because this growth is sustained. In the case of Nigeria, it was in 2025 that it recorded its highest output in terms of six publications, indicating a rise in interest in relation to digital transport governance. In South Africa, leadership is sustained at an all-time high, with seven publications showing a mature and stable research path. In the overall context of continued leadership by South Africa, the recent acceleration in Nigeria appears to indicate a closing gap and a growing convergence of South–South TMS research agendas.

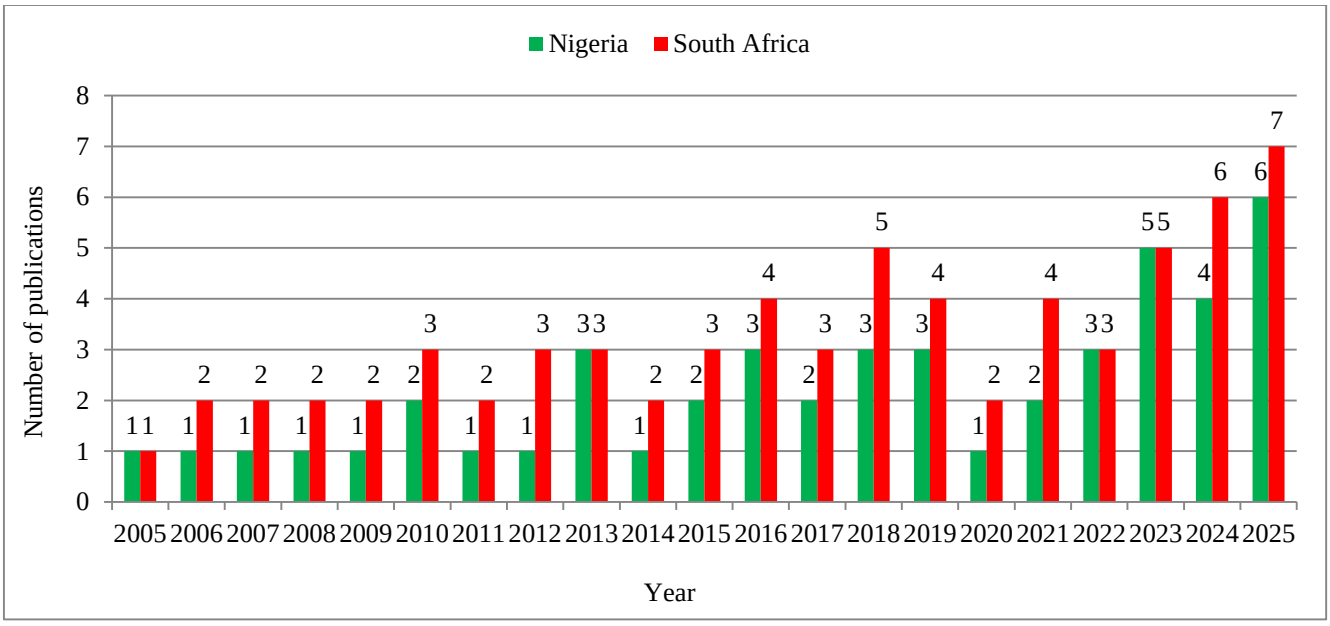


Fig. 1 Annual publication trends

3.2.2. Document

Figure 2 shows the document type distributions related to the TMS in Nigeria and South Africa from 2005-2025. Information on the distribution of various types of documents presents interesting insights into the progress and maturity of research in the respective field and the types of research being conducted in the domain of TMS in both Nigeria and South Africa, with overall indications of considerable reliance on journal article sources in both countries, reflecting the consolidation of TMS as a research domain in Africa. The majority of the publication output is represented by journal article publications, with 24 of the publications from Nigerian authors, followed by those from South African authors, which total 30 publications on the platform. This is due to the focus on empirical research, methodological investigation, and establishing theories, which are likely aligned with the guidelines set by top-notch peer-reviewed journals internationally. It is evident that, on average, there is a relatively greater number of article publications emanating from the authors of the South African nation than from those of the Nigerian nation, indicating institutional capacity, as well as funding and support. Conference-related outputs, which include conference papers and reviews, constitute the second-highest category of outputs and publications in this region. Nigeria has 11 conference papers and 8 reviews, whereas South Africa performs slightly better, with 17 conference papers and 9 reviews. This again emphasizes the importance of conferences in creating spaces for the presentation of new research, the development of new methodologies, and the examination of contemporary issues such as intelligent transportation systems, digital logistics, and data management in modern transportation systems, among others. South Africa again outperforms Nigeria in terms of scores in this category, which again emphasizes a greater presence in international research spaces and consortia.

Both countries have very few review articles, two for Nigeria and three for South Africa, which again suggests that large-scale synthesis, theory-building, and agenda-setting research have been minimal. Similarly, book publications and book chapter publications make a small contribution to the output, which is consistent with the applied and technically focused nature of TMS research and its preference for dissemination through journals rather than books. In particular, notes and short surveys are found only in South Africa and then only occasionally, although this suggests a more diverse publication strategy and a greater reliance on alternative formats for publishing scholarly work. In general, the publication type distribution for South Africa is more balanced, as would be expected in a relatively mature research environment, whereas the output in Nigeria has been more focused, with the potential for more high-quality reviews and conceptual work to be developed in a South–South research framework.

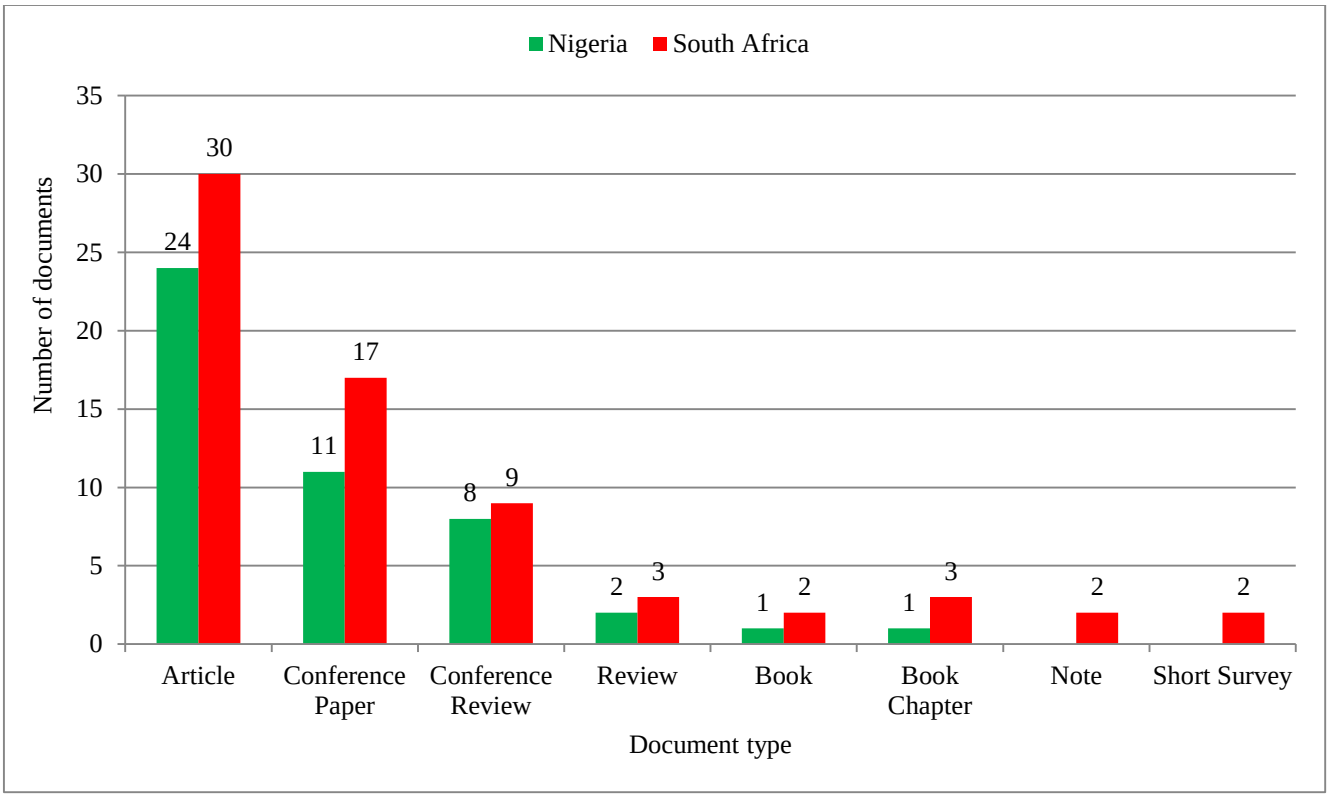


Fig. 2 Document type distribution

3.2.3 Keywords

Co-occurrence analysis of keywords reveals the intellectual organization, thematic orientation, and research orientation of TMS studies conducted in Nigeria and South Africa. Table 2 shows the keywords related to TMS studies in Nigeria and South Africa, and Figure 3 illustrates the co-occurrence network of the keywords for both Nigeria and South Africa. Overall, the analysis reveals themes that are shared within both countries but that are also distinct between the two countries in terms of their geographic context.

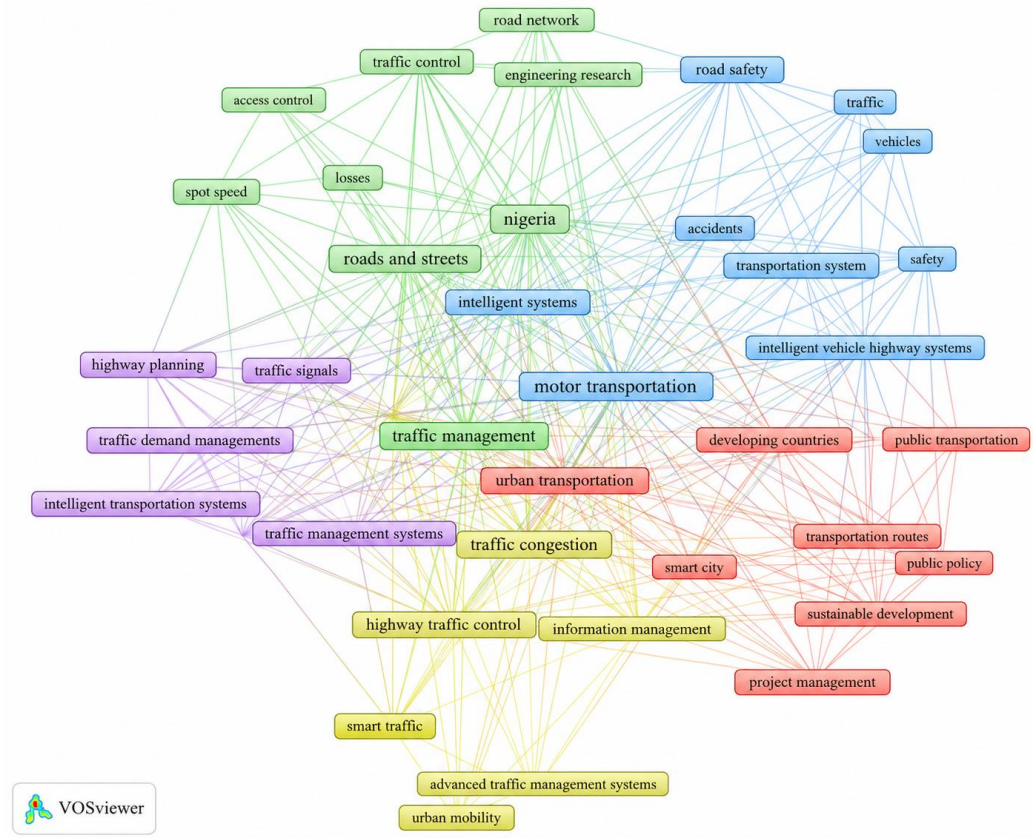
For Nigeria, the keywords that are most frequently used include 'Traffic Congestion', 'Traffic Management', 'Motor Transportation', and 'Urban Transportation', all of which exhibit both high frequency and Total Link Strength (TLS), indicating that there is a strong concentration of themes related to the operational performance challenges of traffic.

This indicates a primarily problem-oriented approach to research and, as such, focuses primarily on addressing issues around congestion, inefficiencies, and mobility constraints that exist in urban transport systems. In addition, the high frequency of the keyword 'Nigeria' further confirms that TMSs are being studied within the context of the country. Similarly, while there are still some foundational concepts, such as "traffic congestion" within South Africa's dataset, in general, the keyword structure overall is much more diverse (systems-oriented rather than just a list of keywords). High-frequency words such as "intelligent vehicle highway systems," "project management," "information management," "sustainable development," and "urban transport" all point to a broader integration of the technical, managerial, and policy aspects of transportation management systems. Additionally, keywords such as "artificial intelligence," "internet of things," and "global positioning system" indicate a stronger inclination towards intelligent, data-driven, and digitally enabled transport systems.

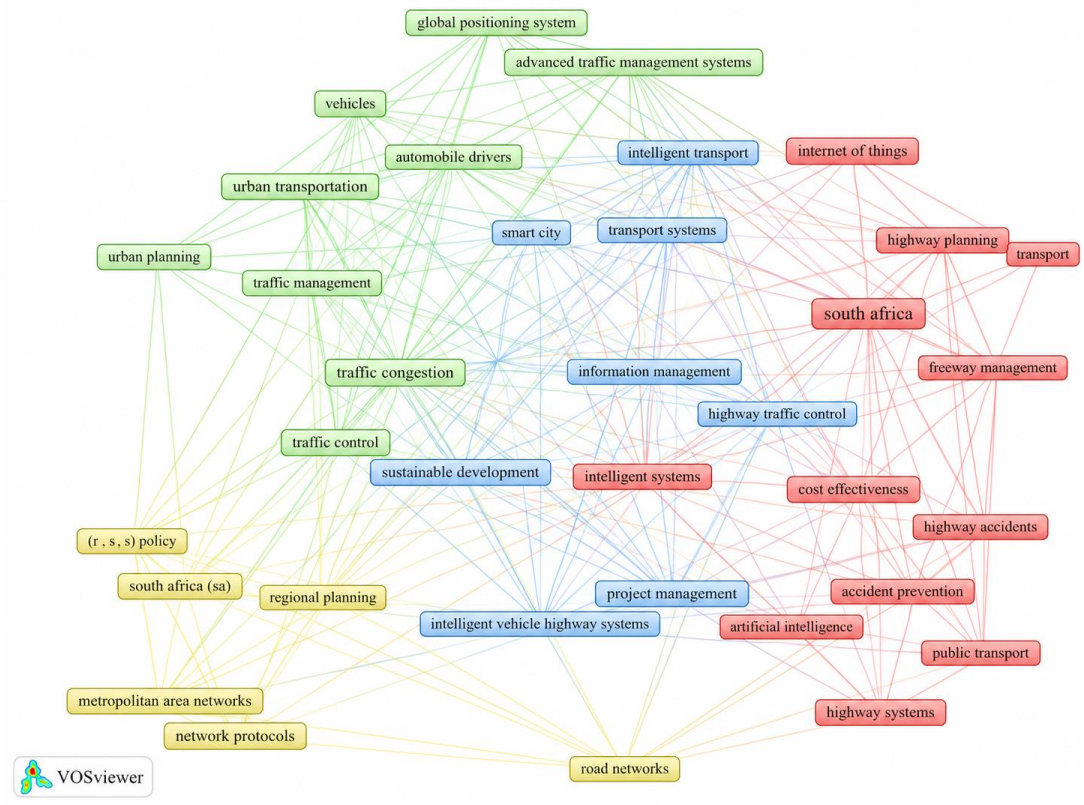
Finally, South Africa's TMS research strongly emphasizes the safety and performance of networks, as seen through the inclusion of keywords such as "accident prevention," "road networks," and "highway accidents." Collectively, these trends suggest a more advanced research ecosystem that includes technology, governance, and sustainability factors in the development of transport systems. The keyword structure of Nigeria’s research on smart mobility suggests an earlier stage of development focused mainly on practical challenges associated with operations or infrastructure, whereas research conducted in South Africa appears to have progressed further and encompasses a more holistic view of developing smart mobility through digital transformation and strategic approaches to the governance of transport systems. Nevertheless, the fact that many keywords appear in both countries provides evidence that researchers in both countries share an agenda of converging efforts towards developing sustainable and efficient transportation systems.

Table 2. Keywords related to TMS studies in Nigeria and South Africa

S/N	Nigeria				South Africa		
	Keyword	**Occ.**	**TLS**		**Keyword**	**Occ.**	**TLS**
1	Nigeria	10	61		South Africa	12	78
2	Traffic Congestion	10	68		Project Management	8	75
3	Motor Transportation	9	78		Traffic Congestion	8	50
4	Traffic Management	9	54		Accident Prevention	6	16
5	Roads And Streets	5	40		Highway Accidents	5	15
6	Traffic Management Systems	5	32		Highway Planning	5	22
7	Urban Transportation	5	45		Information Management	5	19
8	Transportation System	4	20		Intelligent Vehicle Highway Systems	5	27
9	Developing Countries	3	25		Sustainable Development	5	20
10	Information Management	3	28		(R, S, S) Policy	4	22
11	Intelligent Systems	3	29		Cost Effectiveness	4	18
12	Smart City	3	18		Intelligent Systems	4	26
13	Smart Traffic	3	20		Internet Of Things	4	11
14	Sustainable Development	3	21		Network Protocols	4	18
15	Traffic Control	3	22		Smart City	4	20
16	Vehicles	3	12		South Africa (Sa)	4	22
17	Access Control	2	7		Traffic Control	4	18
18	Accidents	2	17		Traffic Management	4	24
19	Advanced Traffic Management Systems	2	10		Advanced Traffic Management Systems	3	22
20	Engineering Research	2	15		Artificial Intelligence	3	8
21	Highway Planning	2	19		Automobile Drivers	3	20
22	Intelligent Transportation Systems	2	19		Freeway Management	3	16
23	Intelligent Vehicle Highway Systems	2	22		Global Positioning System	3	14
24	Losses	2	12		Highway Systems	3	10
25	Project Management	2	15		Intelligent Transport	3	27
26	Public Policy	2	18		Metropolitan Area Networks	3	18
27	Public Transportation	2	10		Public Transport	3	10
28	Road Network	2	15		Regional Planning	3	24
29	Road Safety	2	18		Road Networks	3	13
30	Safety	2	16		Transport	3	5
31	Spot Speed	2	13		Transport Systems	3	27
32	Traffic	2	11		Urban Planning	3	9
33	Traffic Demand Managements	2	19		Urban Transportation	3	22
34	Traffic Signals	2	18		Vehicles	3	15
35	Transportation Routes	2	16		-	-	-
36	Urban Mobility	2	10		-	-	-



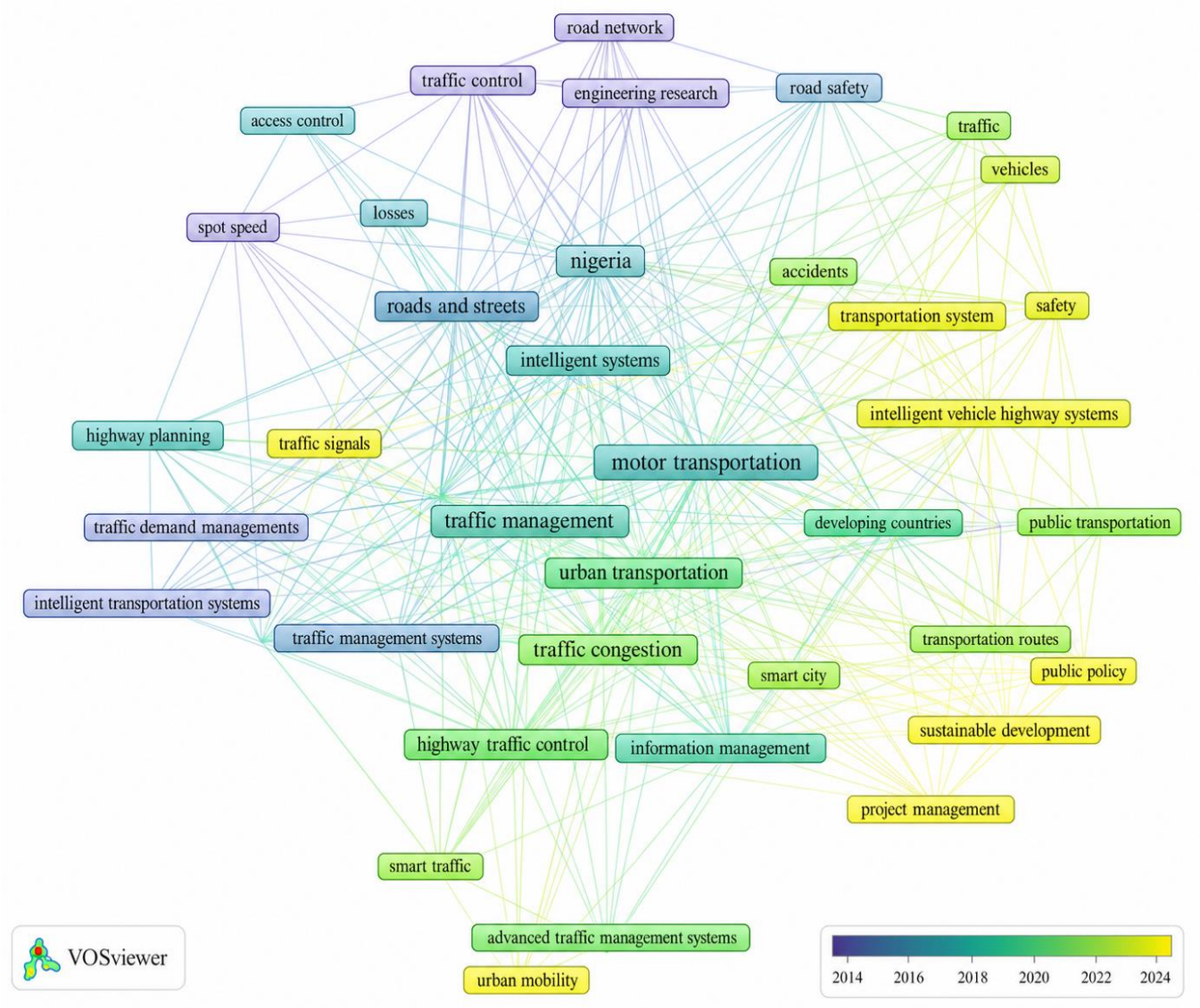
(a)



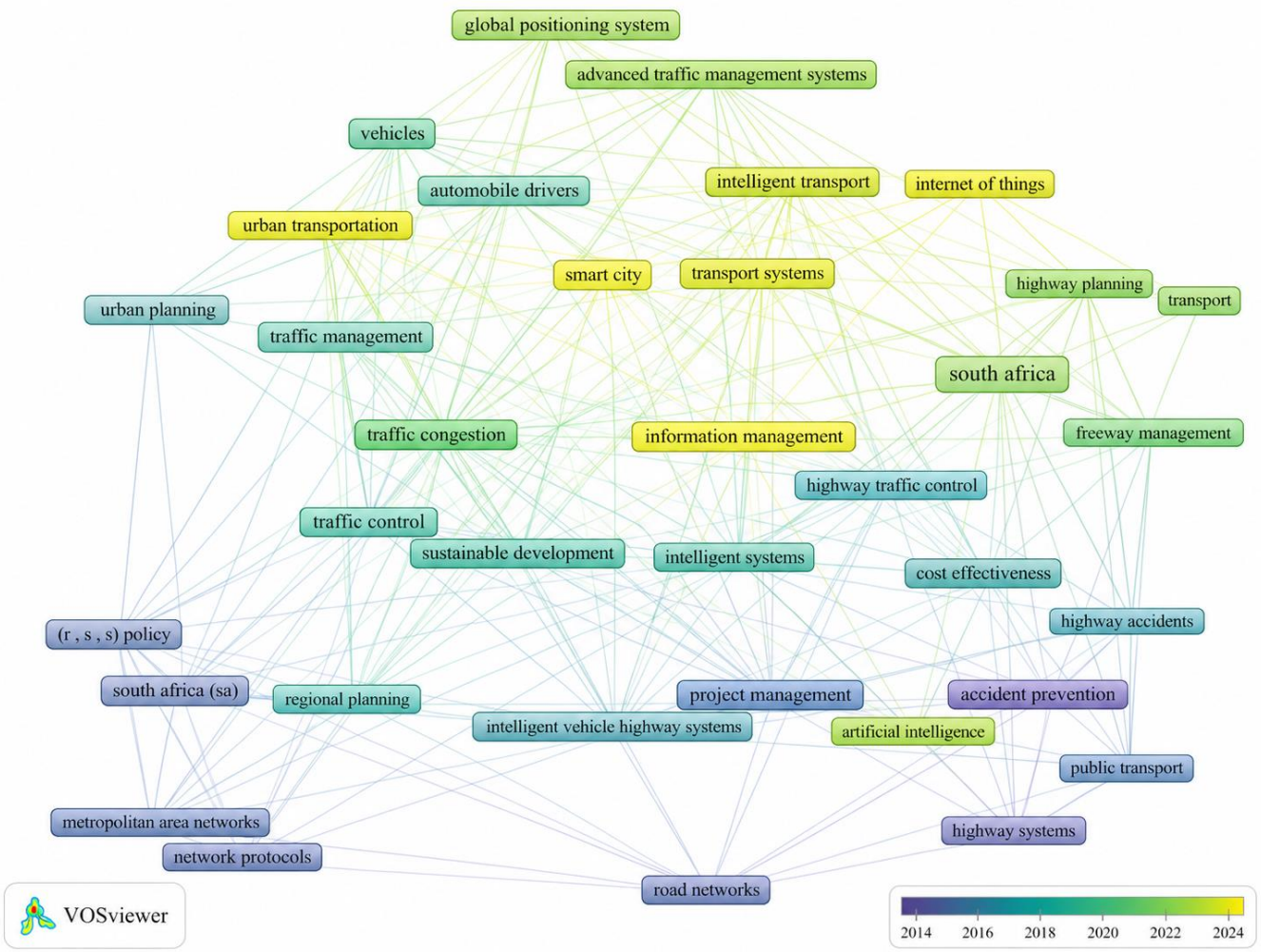
(b)

Fig. 3 Keywords co-occurrences related to TMS studies in (a) Nigeria and (b) South Africa.

Figure 4 shows the keyword overlay visualization related to TMS studies in (a) Nigeria and (b) South Africa. The overlays provide evidence of the changing thematic evolution of both countries by showing that the themes at older study dates are primarily foundational, as they pertain to the transport infrastructure, traffic management, and public policy research themes of previous studies. In newer studies in Nigeria, there has been an increased emphasis on themes related to smart cities, ITSs, and sustainable modes. This finding suggests a transition from traditional models of transport research to the use of intelligent models for the study of transport. The most recent research within Africa was conducted within South Africa, and these studies are significantly clustered together. This means that many studies have been conducted on the IoT, smart cities, ITSs, information management, and urban mobility integration within South Africa. The research ecosystem is thus well developed and enabled by digital infrastructure, real-time data analytics, and systems integration strategies, which are aligned with smart city development frameworks. The analysis indicates an obvious difference in maturity between the two nations. Nigerian TMS studies mainly use foundational and problem-oriented approaches, whereas South African research has integrated digital technology and smart mobility at a more advanced level. The analysis also corroborates the overall results from the scientometric analysis and confirms the potential for large amounts of South-to-South knowledge exchange, especially with respect to topics of IoT-enabled transport systems, data-based traffic management, and intelligent urban transportation system planning.



(a)



(b)

Fig. 4 Overlay visualization of keywords related to TMS studies in (a) Nigeria and (b) South Africa.

The visualization also shows that a major improvement to the TMS has taken place as a result of digitalization, essentially providing transportation organizations with technology adoption through digital transformation, utilizing IoT, AI, and, to a limited extent, blockchain. All of these technologies provide the ability to collect information on transportation system operations in real time and improve the accuracy of forecasting future events, utilizing that data, in addition to enabling organizations in the transportation industry to supply each other with secure and verified data. By employing the IoT, a user has a continual opportunity to check the condition of traffic, vehicles, and transportation infrastructure, whereas AI enables companies to predict traffic delays, develop better optimized routes over larger regions, and adjust traffic signals in real time relative to the prevailing traffic conditions within the area. The review revealed that keywords associated with the IoT and AI are widely used in the scholarly literature published by South African authors, indicating a trend toward intelligent transportation and smart transport governance. Although research related to blockchain is relatively limited, blockchain studies are supported in the literature, indicating that blockchain has promising application opportunities in secure logistics, transport data integrity, and decentralized mobility systems. The addition of these digital technologies will allow for the creation of the next generation of TMS frameworks and will assist with improvements in the development of intelligent, efficient, and sustainable transportation systems.

3.2.4. Bibliographic Coupling of Publication Sources

The analysis of the sources of publications in terms of bibliographic coupling indicates considerable differences in the underlying knowledge bases, citation influence, and disciplinary foundations related to the research area. Table 3 shows the top 8 publication sources related to TMS studies in Nigeria and South Africa, whereas Figure 5 depicts the publication source bibliometric map related to TMS studies in (a) Nigeria and (b) South Africa. In total, the findings demonstrate variations in the quality of sources, levels of citation, and closeness of themes, all of which contribute to

differences in levels of maturity and international awareness. For the Nigerian corpus, the publication sources present a degree of fragmentation in their distribution across multidisciplinary engineering journals. Few sources focus on core journals that deal exclusively with transportation.

For example, the International Journal of Engineering Research and Technology, Advanced Materials Research, and other similar journals feature a very small number of published research papers with minimal citation impact.

These focus on minimal integration into high-impact research in the realm of transportation research. However, journals such as the IEEE Access and Transportation Research Record, despite having a small number of research papers in the transportation field, have relatively high numbers of citations. When Nigerian research in the field of transportation management systems is published in internationally recognizable forums that are technically very robust, a better impact is achieved in terms of scholarship.

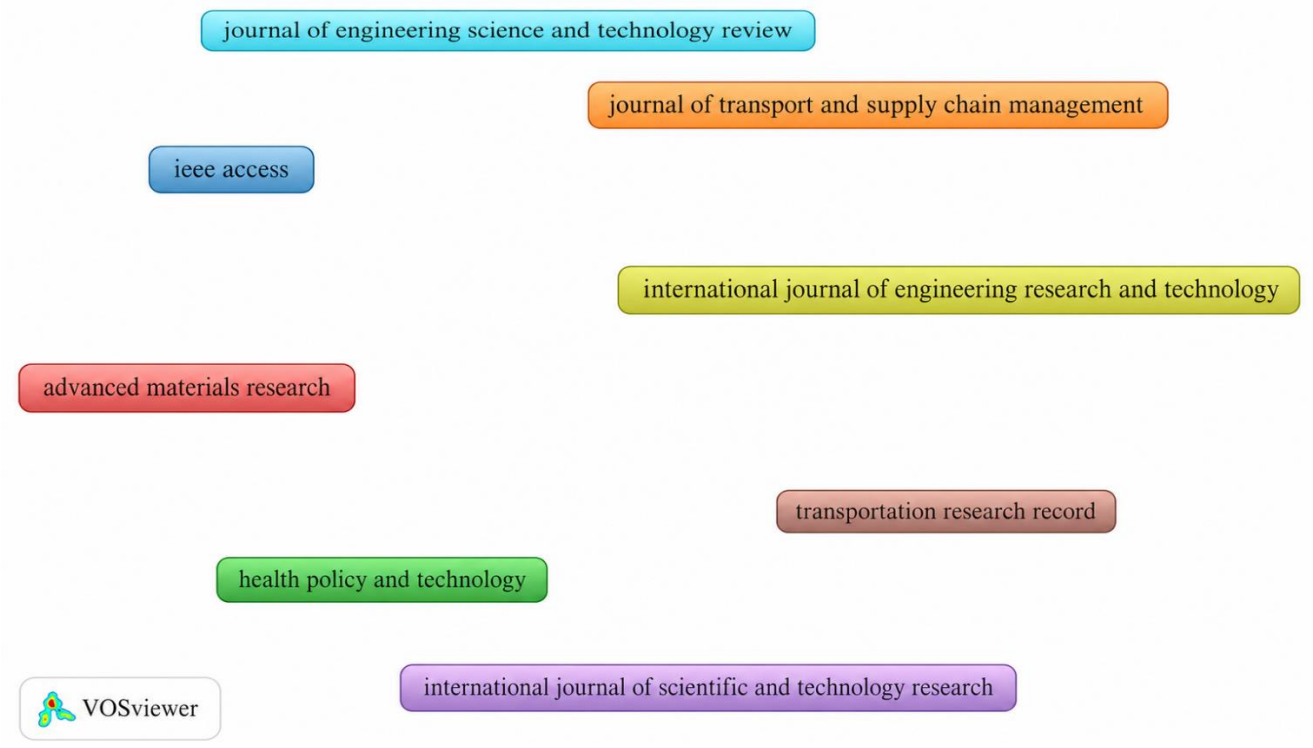
However, it is apparent that South Africa's publications have a stronger clustering in high-impact journals in the transportation and engineering fields, which is a reflection of the maturity and globalization of this region. Some of the leading publications are from Transportation Research Part F: Traffic Psychology and Behaviour, indicating two research publications and 52 citations, thereby establishing its position in terms of the connectivity and influence of its research content.

Table 3. Top 8 publication sources related to TMS studies in Nigeria and South Africa

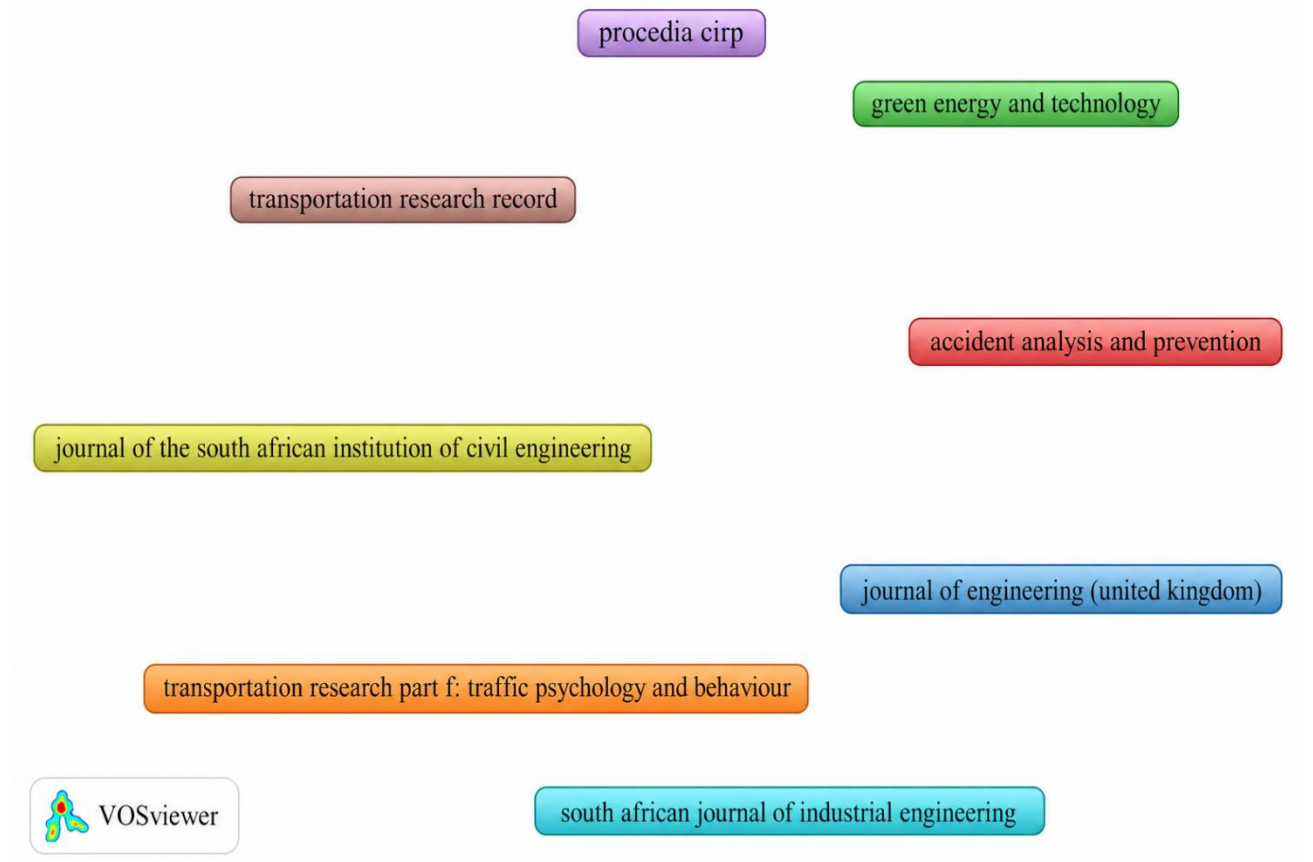
S/N	Nigeria				South Africa		
	Source	**Article**	**Citations**		**source**	**Article**	**Citations**
1	International Journal of Engineering Research and Technology	2	2		Transportation Research Part F: Traffic Psychology and Behaviour	2	52
2	Advanced Materials Research	1	2		Accident Analysis and Prevention	1	10
3	Health Policy and Technology	1	7		Green Energy and Technology	1	11
4	IEEE Access	1	30		Journal Of Engineering (United Kingdom)	1	3
5	International Journal of Scientific and Technology Research	1	7		Journal of the South African Institution of Civil Engineering	1	7
6	Transportation Research Record	1	21		Procedia CIRP	1	18
7	Journal Of Transport and Supply Chain Management	1	3		South African Journal of Industrial Engineering	1	4
8	Journal Of Engineering Science and Technology Review	1	19		Transportation Research Record	1	6

Another prominent publication is indicated in the publication of Accident Analysis and Prevention and Green Energy and Technology, reflecting the focus of the research community on safety and sustainability attributes in traffic management and research. Notably, in this context, the publication of the Procedia CIRP, which indicates an important publication outlet for research content with one article featuring 18 citations in this region, has been published.

The CIRP indicates an outlet for research content in the domain of production engineering, logistics, intelligent systems, etc., reflecting the applied and technology-driven attributes of the TMS, such as traffic management, intelligent vehicles, etc. The relevance of such attributes in South Africa indicates their tendency to publish research in journals and conference content, promoting research and developments in this domain at an early stage. Comparatively, South Africa has higher source centrality measures and citation concentration, which indicate a more cohesive publication environment. Nigeria shows a scattered distribution of sources, indicating an emerging research field that is in the early stages of developing a core set of publication outlets. Examining these findings from a South–South collaboration perspective, we highlight the importance of Nigerian scholars targeting top-tier transportation journals to maximize their effects on bibliographic coupling in TMS research.



(a)



(b)

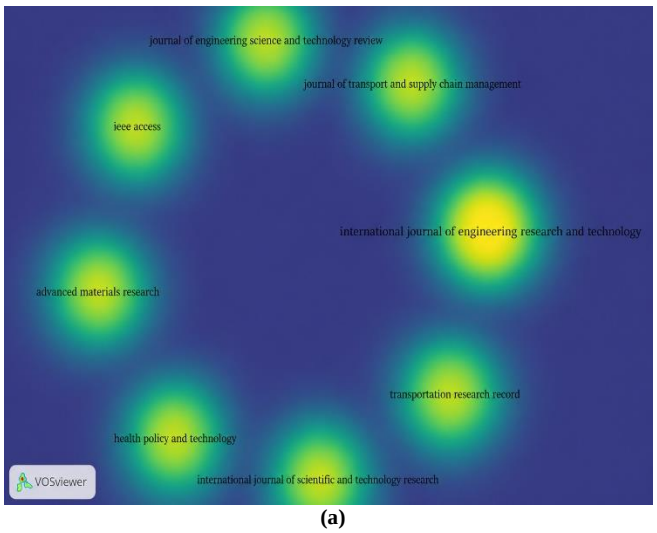
Fig. 5 Publication source bibliometric map related to TMS studies in (a) Nigeria and (b) South Africa.

Figure 6 Density bibliometric map related to TMS studies in (a) Nigeria and (b) South Africa via VOS Viewer software. According to the density map, the brighter yellow colors in the graph represent regions that have been researched, whereas the darker regions represent regions that have not yet been or have less focus in research. For Nigeria, the density map reveals developing densities around traffic management in major city hubs, projects for TMS implementation, and transport planning around Lagos, Abuja, and Port Harcourt.

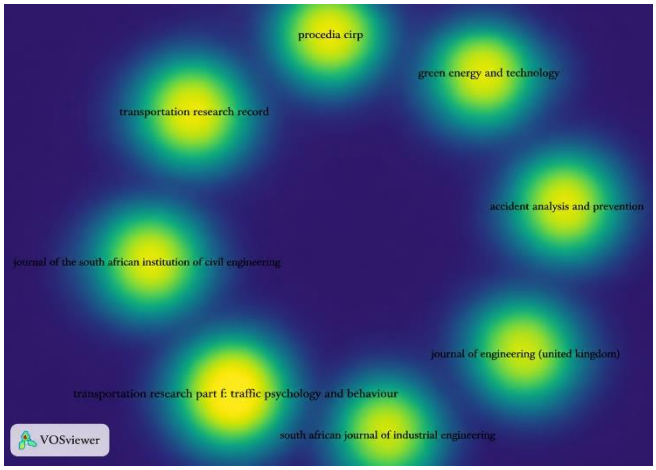
The map indicates a level of research intensity at the local level, which is primarily a result of applied research as opposed to a wider level of research encompassing the integration of technologies. The darker spots within Nigeria illustrate deficiencies in the integration of smart mobility solutions, traffic management, and systems-level studies of TMSs. For South Africa, there is a greater focus of research in areas such as intelligent transport systems, traffic management, smart urban development, urban mobility, and information management, as revealed by densely highlighted areas of research around Johannesburg.

The lighter areas of such research work, therefore, highlight new areas of research that are less explored, including electric vehicle integrations, predictive analytics of multimodal transportation, and conceptual frameworks for the implementation of policies. There is also a greater focus of research within South Africa related to the management of transportation.

The density map, however, shows a paradigm shift in the contrast between the two nations. While South Africa has a highly focused and specialized research base, which is also highly developed in terms of technology, research in Nigeria is beginning to emerge in a localized manner and is being conducted more practically, which makes the issue of the South–South gap even more apparent.



(a)



(b)

Fig. 6 Density bibliometric map related to TMS studies in, (a) Nigeria, and (b) South Africa.

3.2.5. Affiliation and Institutional Contributions

Figure 7 shows the most affiliations related to TMS studies in Nigeria. According to the general analysis of institutional contributions, TMS research in Nigeria is conducted mostly by a handful of top universities, which is an expected phenomenon because of the distribution of resources as well as expertise.

For example, the University of Lagos, along with the University of Ilorin, has contributed four publications, establishing themselves as the dominant institutions driving TMS research, as well as having established programs for civil engineering, funding, etc. Institutions, such as the Federal University of Technology, Minna; the Federal University of Technology, Akure; Bells University of Technology; and Covenant University, all have three publications.

These institutions seem to be developing the scope of TMS, with most of the authors concentrating on the practical aspects of traffic management, traffic, and urban mobility. The increasing number of publications implies that institutions are developing an interest in the field. In addition, several other institutions, such as the University of Ibadan, Ahmadu Bello University, the University of Nigeria, Nsukka, and Nile University of Nigeria, published two research documents, albeit with reduced frequency.

Although smaller, such institutions contributed diversity to the research, implying a gradual spread and permeation of TMS research. Similarly, Nigerian TMS research has also portrayed moderately concentrated knowledge production, with flagship institutions taking the lead in knowledge production, whereas smaller universities offered incremental diversification in the knowledge production process, hence strengthening interinstitutional collaboration for the enhancement of the TMS research network in the country as a whole.

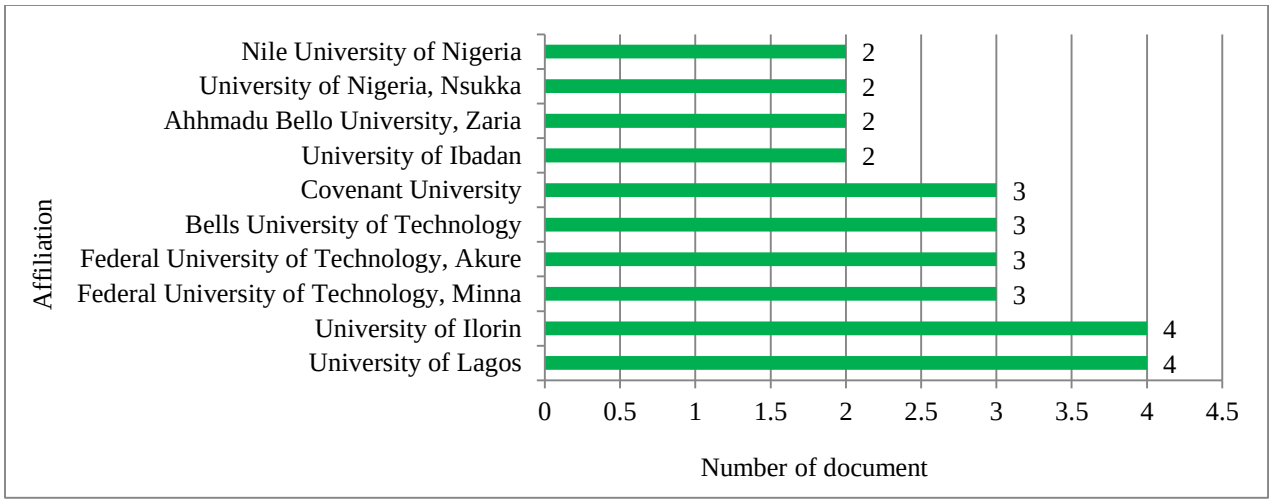


Fig. 7 Most affiliations related to TMS studies in Nigeria

Figure 8 shows the most affiliations related to TMS studies in South Africa. South Africa has exhibited an exemplary TMS research scenario that presents an equally strong but integrated academic and research scenario in terms of combining the best universities in South Africa, along with important academic research institutions of the government. First, in this context, the University of Cape Town and the University of Johannesburg each feature seven publications. These institutions have been found to exhibit high academic research potential, academic collaboration, academic leadership in terms of urban mobility, traffic management, intelligent transport systems, civil and transportation engineering programs, important academic research funding, academic interaction at local and international levels, etc. Another key contribution is made by the eThekwini Transport Authority and the Council for Scientific and Industrial Research (CSIR), which have produced six publications. This also shows the incorporation of applied, policy-oriented, and technological research in the TMS research agenda of South Africa. It has also been noted that institutions play a role in traffic operations, infrastructure, and transport system management. This acts as a link between theoretical and applied research. Other key contributors of particular interest include the University of Pretoria with 5, Durban University of Technology with 4, Tshwane University of Technology with 4, the University of Kwa-Zulu Natal with 3, Stellenbosch University with 3, and the South African National Roads Agency SOC Ltd. with 3. While the above-named institutions increase the width of TMS studies, the focus is on including the depth of TMS studies, which involves both the Academic and the Government sides of TMS research initiatives. Overall, South Africa presents a research-friendly context for the TMS, with high institutional maturity based on high levels of collaborative work among institutions, available diversity of expertise, and effective dissemination of research findings. Compared with those in Nigeria, the institutions involved, both universities and research authorities, offer a guarantee for advancing scientific research.

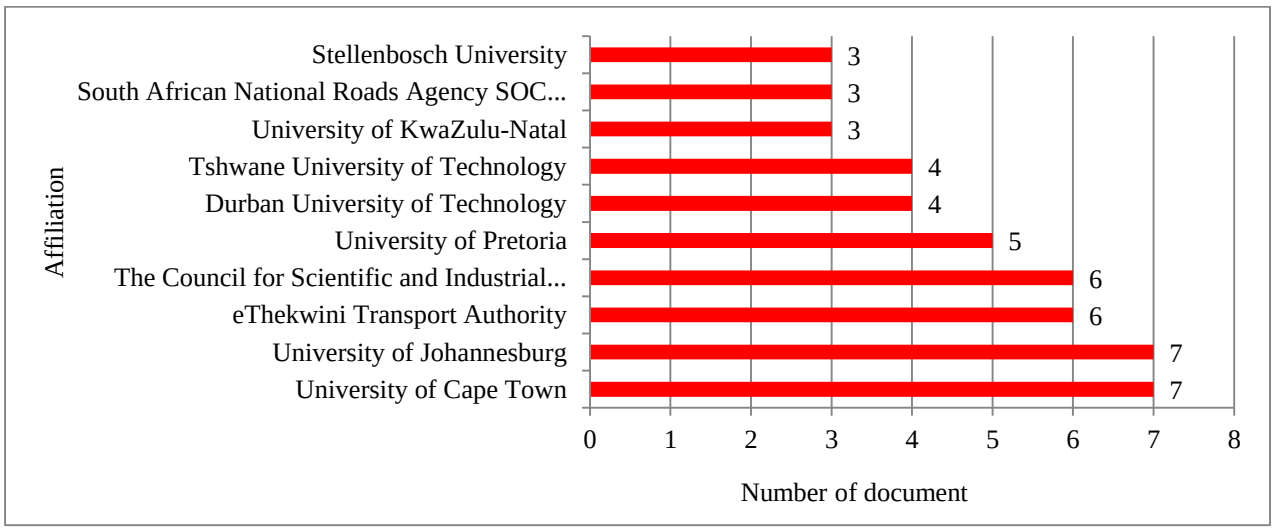


Fig. 8 Most affiliations related to TMS studies in South Africa

3.3. TMS alignment with Sustainable Development Goals

The research conducted under the umbrella of the TMS disciplines strongly aligns with three of the United Nations' 17 Sustainable Development Goals (SDGs): SDG3 Good Health and Well-being; SDG9 Industry, Innovation and Infrastructure; and SDG11 Sustainable Cities and Communities.

Efficient and well-designed urban transport systems are highly important for the prevention of road accidents, a solution for urban traffic congestion, and the minimization of negative environmental effects such as poor air quality. Therefore, TMS research contributes to SDG3 directly through the promotion of urban health and well-being. Robust engagement of TMS researchers from South Africa regarding urban traffic safety concerns and accident prevention suggests a strategic alignment of TMS research priorities.

Similarly, even though TMS research is quite new and has only begun to emerge from Nigeria, the promising research conducted under the urban traffic control and traffic congestion disciplines suggests an intention targeted towards improving urban traffic safety. Similarly, with the use of innovative technologies in transport infrastructure, intelligent technologies, and data-based decision-making techniques, it is possible to achieve the 9th goal, as the development of intelligent vehicle highway systems, intelligent signal systems, and intelligent city systems may be viewed as a reflection of the integration and application of technologies in transport infrastructure systems and their contribution to the attainment of sustainable and resilient industrial developments, as reflected in the divergent and pluralistic nature of South Africa, which is characterized by its research and governmental bodies, whereas the push towards data analysis and intelligent transport systems in Nigeria reflects the avenues towards the integration of technologies.

Finally, with human mobility, ease in reducing congestion, and efficiency in transport systems, the TMS ensures direct contributions to the attainment of the 11th goal, as it addresses issues such as sustainable cities and communities resilient to challenges. Therefore, planning for intelligent transport systems presents an opportunity for environmentally friendly transportation systems to flourish. When the TMS is realigned to the SDGs, one realizes that the TMS has a twofold impact on the advancement of science and nature; it is strategic for regional development, especially in Africa.

Therefore, the South–South discussion aims to fill a knowledge gap, with South Africa performing better in terms of conceptual, interdisciplinary, and intelligent technologies, whereas Nigeria has the potential for capacity building, collaboration, and knowledge sharing. However, the findings also indicate that there is a need for the development of TMS systems to achieve a sustainable, secure, and efficient system.

3.4. Policy and Socioeconomic Impact of the TMS in Nigeria and South Africa

The differences between Nigeria's and South Africa's TMS research show that there are differences in their respective transportation sectors' institutional capacity, technological readiness, and policy integration. South Africa has a greater degree of research diversification as well as a greater degree of collaboration among its institutions and thus has more mature transportation governance structures and a greater ability to implement intelligent transportation solutions than does Nigeria. The socioeconomic implications of these differences in TMS research include increased efficiency on roadways, reduced productivity losses due to congestion, improved safety on roadways, and better integration of smart mobility systems into urban planning strategies. The degree of alignment between research outputs and education policy implementation shows that South Africa has a relatively mature innovation ecosystem in which research conducted at universities has an active impact on both the development of transportation policy and the operational decisions made in support of that policy. The development of research on the TMS in Nigeria shows a growing relationship between research and policy, with most intelligent transportation projects now being at the beginning of their implementation or pilot phases. The lack of developed projects creates ongoing socioeconomic problems within the country, including high congestion costs, poor freight logistics, increased travel time, and decreased urban productivity. Through data-driven transport research, the positive direction toward evidence-based transportation policy development and smart mobility planning is confirmed.

Overall, the study shows that it is important to create a stronger connection between transportation research and policy development to improve socioeconomic outcomes. To convert scientific research into practical solutions that provide greater efficiency in urban mobility, increased economic productivity, and sustainability for African cities, there needs to be an investment in intelligent transportation systems, building capacity for research, and developing political partnerships.

4. Conclusion

This research provides a comprehensive scientometric analysis of the research works accomplished in relation to the TMS within the time frame of 2000-2025, in relation to the knowledge structures and research gaps that exist between South Africa and Nigeria. The results revealed that there is an analytically mature TMS environment in South Africa, which is diverse, globally prominent, and a combination of both applied and theoretical research and is associated with advanced technologies such as intelligent vehicle highway systems and smart city systems. Therefore, universities such as the University of Cape Town, University of Johannesburg, and CSIR, among others, and research institutions such as the eThekwini Transport Authority have all incorporated an

excellent academic progress environment with equally excellent applications. In contrast, for the nation of Nigeria, patterns of emerging but concentrated research trends are clearly visible, mainly focusing on urban traffic management, alleviating traffic congestion, and TMS pilot program implementation scenarios. The overall output of research is aggregated mainly at a handful of flagship educational institutions, narrowing the context of the themes explored but showing an optimistic panorama of increased interest in data solutions, intelligent systems, and intelligent mobility solutions. This South–South approach serves to highlight the knowledge and capability gap between South Africa, which is a leader in conceptualization as well as in the application of knowledge in the field of TMS, and Nigeria, which offers prospects for capacity building in such an initiative, collaboration between institutions of both countries, and engagement in a regional effort. This study serves to underscore the significance of TMS development in the establishment of an efficient, reliable, sustainable, safe, inclusive, and environmentally friendly transport sector. This review provides a strategic roadmap for further research on the TMS in Africa and emphasizes the importance of building institutional capacity, diversifying themes, and intelligent data approaches for a more efficient and sustainable transportation system in Africa. Additionally, the review provides an important complement and an understanding of the knowledge gaps and opportunities in South–South collaboration and ensures that further analyses concerning publication patterns, keyword connections, and thematic development are appropriately addressed to ensure successful TMS development on the basis of scientific knowledge.

Conflicts of Interest

The author(s) declare(s) that there are no conflicts of interest regarding the publication of this paper.

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