BILINGUAL PUBLISHING GROUP

Journal of Environmental & Earth Sciences

https://journals.bilpubgroup.com/index.php/jees

REVIEW

Impact of Metro Rail Transit Systems in Metropolitan Cities: A Bibliometric Analysis

Vikash Ranjan* , ***Shailendra K. Mandal***

Department of Architecture and Planning, National Institute of Technology Patna, Bihar 800005, India

ABSTRACT

The research investigates the evolving context of Metro Rail Transit (MRT) systems, using a thorough bibliometric analysis to identify patterns, trends, and significant contributors impacting scholarly debate. The study focuses on the effects of MRT systems in metropolitan cities, looking at both existing studies and new areas for future research. The primary goals are to examine the evolving publication scene, identify prominent individuals and entities, analyze keyword networks, and understand current research subjects. The study aims to provide a complete understanding of the effects of MRT systems to guide future research and inform urban planning decisions. Using bibliometric approaches, the study examines a varied dataset of scientific publications about MRT systems. The examination includes advancements in publication trends, identification of significant contributors, and analysis of keyword networks, titles, and abstracts to help untangle the complexity of MRT systems' impact. The study uncovers dynamic shifts in scholarly contributions, emphasizing research themes and identifying significant contributors, organizations, and countries fostering creative discussions. Transit-oriented development, environmental sustainability, and socioeconomic ramifications are key topics that match global goals. The study meets its aims, offering significant insights into the various effects of MRT systems in metropolitan areas. By analyzing growing trends, identifying major contributors, and explaining key topics, the research lays the groundwork for future investigations, directing educated urban planning decision-making. The study's future implications stem from its ability to drive further research, emphasizing the continued importance of investigating real-world consequences, ethical considerations, and fair access to emerging technologies. As urban mobility advances, this study offers the framework for informed decision-making and continuous innovation in metropolitan transit networks.

Keywords: Bibliometric analysis; Transit system; Transit oriented development; Transportation planning; Mobility

*CORRESPONDING AUTHOR:

Vikash Ranjan, Department of Architecture and Planning, National Institute of Technology Patna, Bihar 800005, India;
Email: vikashr.ph21.ar@nitp.ac.in

ARTICLE INFO

Received: 9 June 2024 | Revised: 9 July 2024 | Accepted: 11 July 2024 | Published Online: 30 July 2024
https://doi.org/10.30564/jees.v6i3.6734

CITATION

Ranjan, V., Mandal, S.K., 2024. Impact of Metro Rail Transit Systems in Metropolitan Cities: A Bibliometric Analysis. Journal of Environmental & Earth Sciences. 6(3): 25-39. DOI: https://doi.org/10.30564/jees.v6i3.6734

1. Introduction

Metropolitan cities are now seeing the urgent need for efficient and sustainable mobility solutions due to the tremendous urban issues they are facing such as traffic congestion, air pollution, limited public transportation infrastructure, rising population density, inadequate last-mile connectivity, increasing greenhouse gas emissions, and the need for sustainable and efficient mobility solutions. The advent of Metro Rail Transit (MRT) systems signifies a paradigmatic change, restructuring the mechanics of urban transport and socio-economic frameworks[1]. This paper explores the complex theoretical principles that form the basis of MRT systems, integrating urban planning, transportation engineering, and sustainability. The MRT serves as a crucial element in the planning of sustainable urban transportation. It combines the concepts of transit-oriented development and urban compactness, with the goal of creating interconnected metropolitan areas. This article emphasizes the dedication of MRT systems to environmental sustainability by highlighting specific actions focused on reducing carbon emissions and promoting eco-friendly public transportation choices. In addition to alleviating congestion, the socio-economic impacts are diverse and include increased economic productivity, improved job opportunities, and a noticeable increase in property prices along MRT transit corridors[2]. Using bibliometric analysis, this study aims to not only examine the current literature but also uncover significant research patterns that can provide helpful guidance for educated urban planning decisions.

The theoretical foundation supporting Metro Rail Transit (MRT) systems is a complex fusion of principles drawn from urban transportation planning, environmental sustainability, socioeconomic effect evaluation, technical integration, and human-centered design[3]. MRT systems embody a fundamental change in the way sustainable urban transport is planned, effectively combining transit-oriented development and urban compactness concepts. The system's theoretical sophistication is evident in its capacity to promote interconnected metropolitan areas, making it a visionary model for future city landscapes[4]. MRT systems play a significant role in promoting environmental sustainability by implementing tangible actions to reduce carbon emissions and actively advocating for eco-friendly public transport options.

Theoretical principles in this field are demonstrated via concrete actions, establishing a standard for sustainable transport practices in urban areas. MRT systems transcend their function as mere transportation solutions and instead emerge as catalysts for significant socio-economic transformation[5]. Theoretical comprehension of their contributions encompasses improvements in economic efficiency, increased job availability, and the concrete rise in property prices along transportation routes[6]. The socio-economic structure of metropolitan regions is closely connected to the transformative capacity of MRT systems, creating a theoretical framework that goes beyond only transportation matters.

To thoroughly examine the theoretical foundations, it is essential to consider a broad range of factors, including urban planning principles, economic theories, sociological impacts, and environmental considerations, and the integration of technology. The integration of advanced technology, such as smart ticketing systems such as the National Ticketing Mobility Card in India and real-time data analytics, serves as a theoretical foundation that views MRT systems not just as transportation methods but also as technological ecosystems that contribute to urban efficiency. Theoretical concerns encompass the application of human-centric design concepts, transforming MRT stations into urban hubs specifically tailored to enhance user convenience[7]. The theoretical framework acknowledges the need to incorporate accessibility, safety, and aesthetic appeal in the design of the MRT system. It emphasizes the significance of considering the human experience and aims to redefine urban spaces by prioritizing the needs and experiences of the people who use them[6]. The MRT systems' theoretical sophistication rests in their comprehensive and transformational urban transit solution, achieved through the integration of multiple disciplines in a holistic approach.

This paper undertakes a bibliometric analysis to systematically review and synthesize the existing body of literature on the impact of metro rail transit systems in metropolitan cities. By exploring the theoretical foundations that guide the development and assessment of MRT systems, this study aims to contribute to a comprehensive understanding of their multifaceted influence on urban landscapes. Through a bibliometric lens, the paper seeks to identify key research trends, highlight gaps in the current knowledge base, and provide insights that can inform future research and policy decisions in the realm of urban transportation and planning.

This study aims to utilize bibliometric analysis to conduct a thorough investigation, focusing on providing a comprehensive and insightful understanding of the impact of metro rail transit (MRT) systems.This article intends to achieve the aim with the help of the following objectives:

i. Explore the changing publication landscape by examining the complex changes related to the influence of MRT systems. Analyse patterns and predict the future direction of scholarly contributions.
ii. Discover the pioneering individuals, institutions, and countries that are influencing the discussion on the impacts of MRT systems, providing valuable insights into the driving factors behind innovative research.
iii. Analyze the complex network of keywords, titles, and abstracts to uncover the intricate connections that shape the discussion and enhance our nuanced comprehension of the implications of the MRT system.
iv. Explore and analyze current research themes and trends: Provide a thorough explanation of the main research topics and upcoming trends found in the literature, offering guidance for future studies and informed judgments in urban planning.

In answering these questions and achieving the outlined objectives, this research provides a comprehensive and in-depth analysis of the advancements, trends, and trajectories in mass transit research. The findings hold the potential to inform researchers, and policymakers alike, fostering a deeper understanding of the field.

2. Methodology

This section provides a detailed description of the methodology utilized for conducting bibliometric and thematic analysis. The execution of the research can be broadly categorized into two distinct phases: Data Collection and Analysis. The complete methodology has been described in **Figure 1**.

2.1 Data Collection

First, bibliometric data was collected for the research using two Scientific databases; Scopus and Web of Science were used for data collecting. The bibliometric studies suggest using these two databases for due to their rigorous selection criteria and comprehensive coverage quality analysis[8, 9].

Scopus includes a vast array of academic journals, making it an extensive resource for bibliometric studies. Web of Science, while including fewer journals, applies stringent quality assurance criteria, ensuring the inclusion of high-impact research. Despite their popularity, this analysis does not include other grey literature databases such as Google Scholar. for including papers that are of international repute that meet rigorous academic standards. Moreover, Scopus and Web of Science provide advanced search queries and automatic extraction of bibliometric metadata, features that are lacking in Google Scholar[8]. Hence these two datasets are considered optimal for bibliometric study.

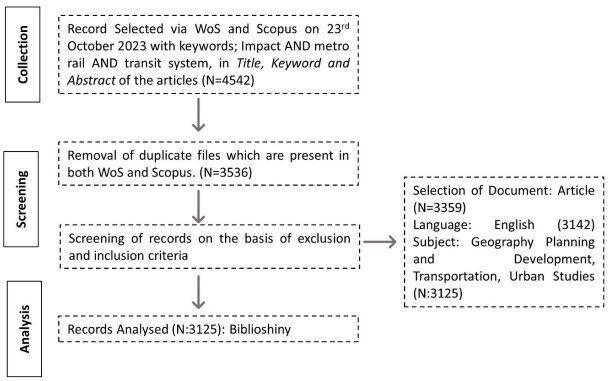

Figure 1. Methodology employed.

We recognize that including Google Scholar in future research could enhance the scope of our analysis. Future studies could integrate data from multiple databases to provide a more comprehensive review of the literature, encompassing a wider range of publications and perspectives. This approach would allow for a broader understanding of the impact of MRT on public health, quality of life, and last-mile connection, drawing from a diverse array of sources.

2.2 Analysis

The data was analyzed using Biblioshiny, a web-based bibliometric analysis tool built on the R programming language. Its easy-to-use interface makes bibliometric analysis accessible to academics of all levels. Biblioshiny visualizes data to help readers comprehend complex patterns in scholarly writing. The tool streamlines the analysis process by enabling real-time modifications of parameters and intuitive navigation. It integrates seamlessly with R programs like 'bibliometrix' to provide in-depth analytical capabilities. As a web-based solution, Biblioshiny eliminates the need for local software installations, offering users a convenient and accessible platform for conducting bibliometric analyses[10]. As a web-based solution, Biblioshiny requires no local installations, making it easy. The software program aids in the construction of graphical depictions of bibliometric data and assists in the creation of bibliometric networks that illustrate the connections among various entities such as publications, journals, keywords, and researchers.

3. Findings

The study examination explores the significant influence of MRT systems in major metropolitan areas, revealing paradigm shifts in the realm of urban transportation. By employing meticulous bibliometric and thematic analysis, the study offers a comprehensive perspective on the dynamic nature of MRT systems. The research emphasizes pivotal contributors, influential countries, noteworthy academic journals, and complex thematic patterns that delineate this ever-evolving discipline. This extensive investigation offers a nuanced comprehension of the significant influence that MRT systems have on major metropolitan areas, influencing the design of urban environments and transportation approaches.

3.1 Overview

The annual scientific production data shows that the publication on MRT System research was static from 1974–2002 but experienced a slow increase from 2003–2008 and since then a steady rise can be observed from 2009 onwards to 2023. Since the data acquisition was done in August 2023, the dip in no of production is apparent in **Figure 2**. Overall, the volume of MRT research has grown and continues to be of significant interest to scholars. Consequently, we can anticipate a continued rise in the number of publications in the coming years.

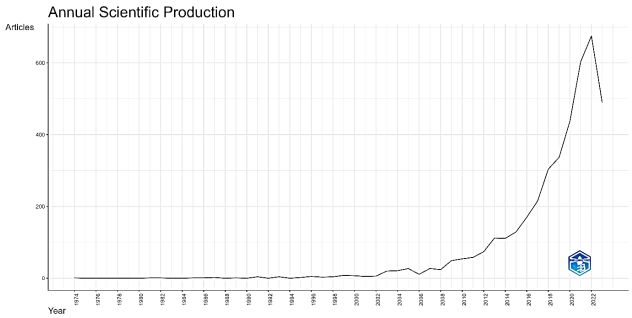

Figure 2. Annual scientific production.

In addition, the number of average article citations per year is presented in **Figure 3**, which shows that citations for MRT System studies have fluctuated widely. However, it clocked an average of 3.16 citations per year per document, which resonates with the average compared to other fields of study and gives the indication that there has been steadfast interest among scholars on MRT. However, this figure may not accurately represent the evolution because there has been a significant increase in the studies from 2009 but the initial years have been quite static leading to average citations per year per document.

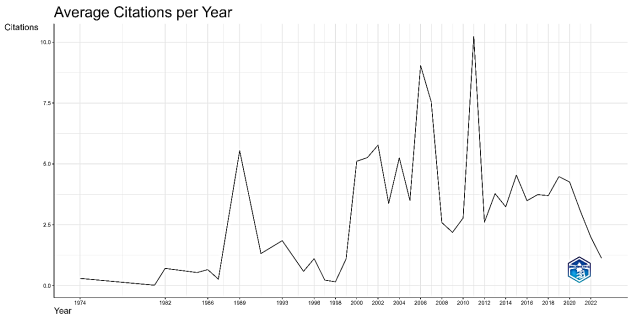

Figure 3. Annual scientific production average citations per year.

The USA has been identified as the most contributing country, with 1250 publications (equivalent to 28% of total contributions), followed by China with 937 contributions (equivalent to 21% of total publications). The contributions of these two countries account for almost half of the total publications. UK (225 publications) Australia (216 contributions) and Canada (183 Contributions) are in third, fourth, and fifth place, respectively. India on the other hand is next to Canada with 3.3% (149 contribution) and ranking second highest in Asia.

3.2 Institutions, Countries, and Journals

The most relevant institutions in the field are Southeast University, Tongji University, Beijing Jiaotong University, University of California, and Southwest Jiaotong University. **Figure 4** shows that these institutions are at the forefront of MRT research. For example, Southeast University has over 120 research documents on the multimodal system and the impact of MRT in cities. These studies gave researchers insights into the nuances of transportation systems and the value they may add, in the cities, along with the areas that need more focus.

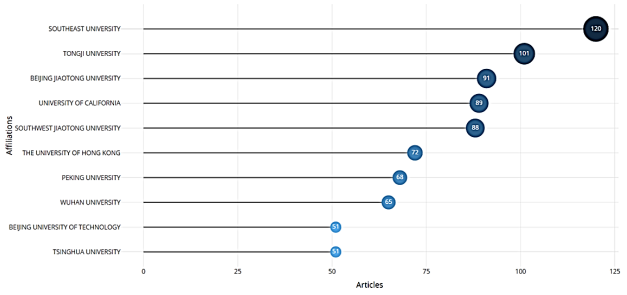

Figure 4. Ten most relevant institutions in the bibliometric analysis.

The collaboration network of institutions, shown in **Figure 5** shows three main groups. The first consisted of

Tongji University, Southeast Jiaotong University and Southwest Jiaotong University and the University of Hong Kong. The next major group consist of Beijing Jiaotong University, Tsinghua University, University of Tokyo, University of Waterloo, Beihang University. Along with that, the third group consist of University of California, Peking University, University of Maryland, Arizona State University, University of Pennsylvania and MIT. There are other few institutions which are merging and have started to form their own collaboration of work which consist of University of Toronto, University of Utah, Mcgill University and Zhejiang University.

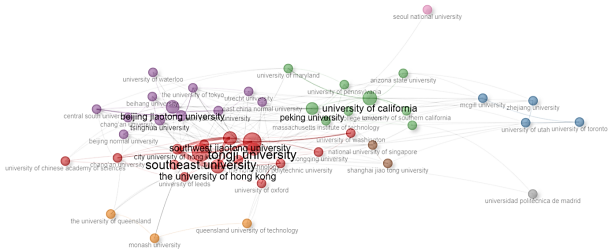

Figure 5. Collaboration between institutions.

The USA and China, shown in the red cluster, are the leading countries regarding the number of publications in the field. Besides these, the other countries that are producing studies in the field are significantly behind in numbers with almost equal share. The collaboration network among countries, as shown in **Figure 6**, shows three main groups. One comprises the USA, China, Singapore, India, Israel, Pakistan, Bangladesh, Korea, Chile etc. The cluster that is shown in green colour consists of the countries such as Portugal, Netherlands, Germany, and Spain. The third prominent cluster in yellow colour consists of UK, Brazil, Belgium, and South Africa. The other clusters have fewer in numbers of collaborations within the network.

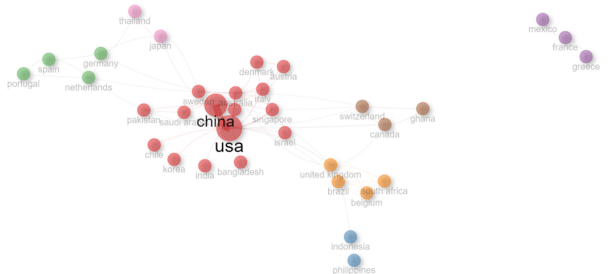

Figure 6. Collaboration between countries.

There is an insignificant number of multiple-country collaborations in this field, as shown in **Figure 7** China and the USA have the highest number of multiple-country collaborations, as evidenced by the collaboration map shown in **Figure 8**. These figures suggest that there is scope for international collaboration among other countries in this rapidly evolving field transportation and mobility.

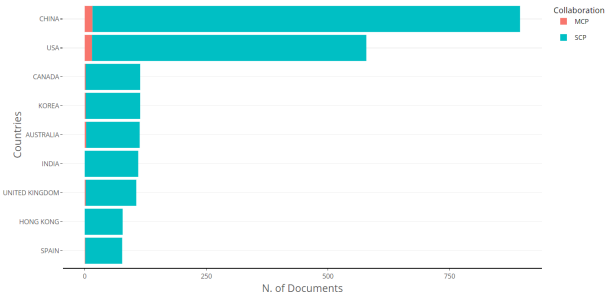

Figure 7. Corresponding author's countries.

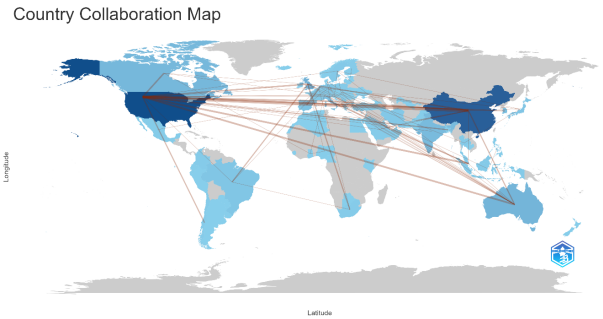

Figure 8. Country collaboration map.

The bibliometric analysis of sources by Bradford's Law, shown in **Figure 9**, revealed that the top journals producing documents in this field are Sustainability (Switzerland), Journal of Transport Geography, Transportation Research Record, Cities, and Transportation Research Part A: Policy and Practice. These journals are highly respected and have a strong reputation for publishing high-quality research. The diversity of journals on this list is also noteworthy. It includes journals from various domains, including sustainability, policy and practice, and its impact on cities. This reflects the intensive nature of research in this field.

3.3 Document Analysis

We reviewed documents with the highest number of global and local citations, as well as those that were most frequently referenced. In bibliometric analysis, *global citations* refer to the cumulative count of citations a document has received across all indexed sources, such as Scopus, Web of Science (WOS), or Google Scholar. This metric provides insight into the document's overall impact and recognition within the broader academic community. *Local*

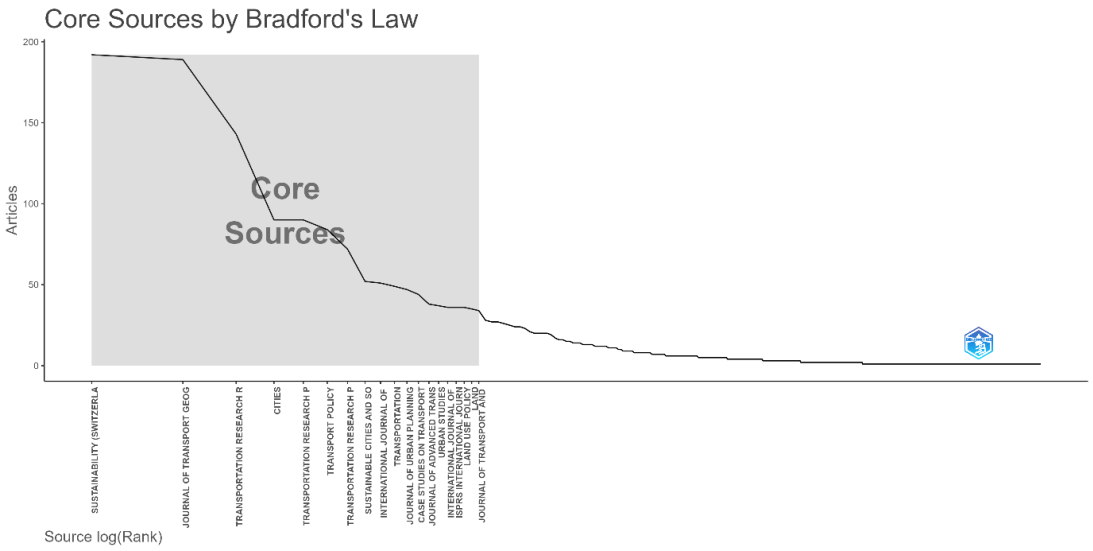

Figure 9. Sources by Bradford's Law.

citations, on the other hand, refer to the number of times a document has been cited within the same specific database or search context. This helps in understanding the document's influence and relevance within a particular dataset or field of study, as illustrated in **Figure 10**. By analyzing both global and local citations, we aimed to capture a comprehensive view of each document's significance. We conducted an in-depth study of these highly cited documents, summarizing their methodologies, tools used, and major findings.

The subsequent table (**Table 1**) presents a succinct summary and evaluation of seminal works in the domains of transportation and urban planning, wherein each contributes unique perspectives and approaches. The references provided, which range from literature surveys to Monte Carlo risk analysis, make valuable contributions to the continuous dialogue surrounding crucial elements in the domains of transportation and urban development, including public values, decision-making processes, economic influences, and environmental considerations. The table provides an overview of the various tools and methodologies utilized in these studies, illuminating their merits and areas that require enhancement.

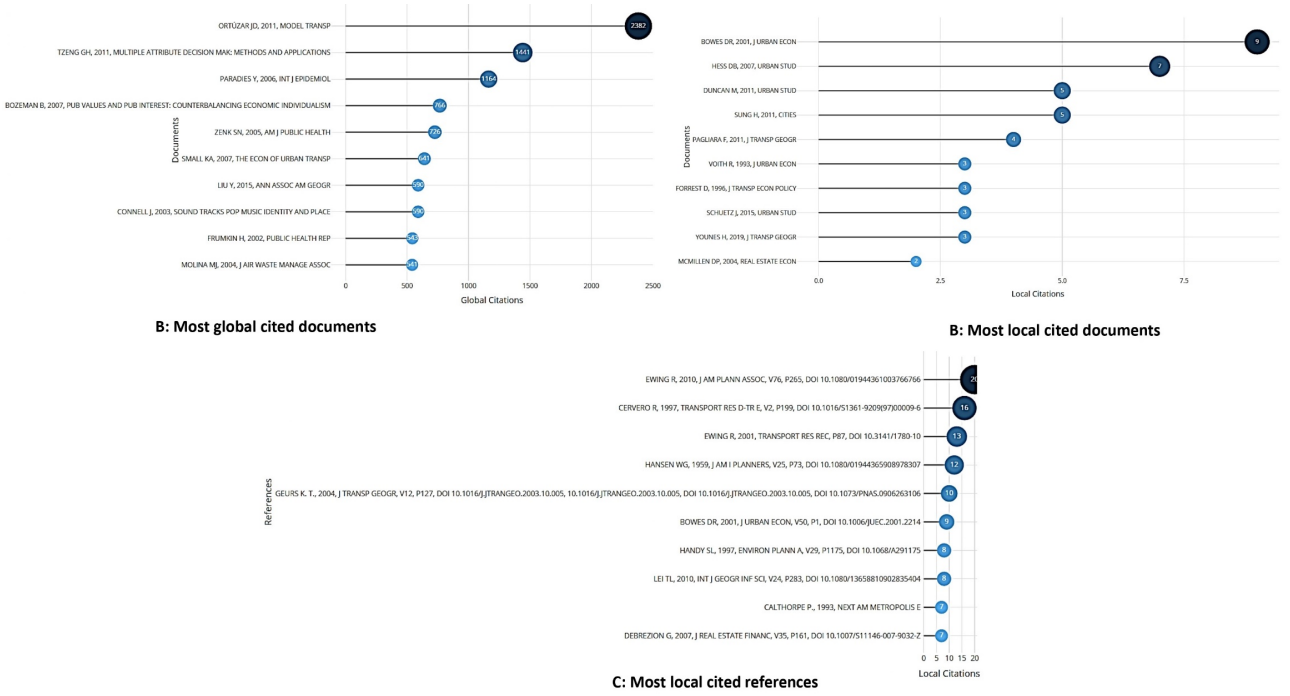

Figure 10. Most cited references and documents.

Table 1. List of most cited documents (globally and locally).

S.No.	Title	TooL/Method	Remarks
1.	Modelling Transport[11]	Monte Carlo Risk Analysis	Criticizing large-scale models, the critique emphasizes clear, segmented models for in-scoped demand. Insufficient market identification might lead to overestimating economic performance. The text suggests willingness-to-pay studies, benchmarking, and carefully induced traffic. Risk analysis supplements traffic estimates in the book's holistic transportation modeling approach.
2.	Multiple Attribute Decision Making: Methods and Applications[12]	Novel hybrid MADM model combining DEMATEL and ANP with VIKOR procedures etc.	The book presents a variety of MADM approaches for various transportation industries. Infrastructure development, alternative energy, and vehicle fleet management decision-makers can use this complete toolkit to structure preferences and evaluate trade-offs. The hybrid MADM model incorporating DEMATEL, ANP, and VIKOR methods offers a novel approach to transportation research. This hybrid model could improve multidimensional decision assistance for transportation network optimization and development project prioritization.
3.	Public Values and Public Interest: Counterbalancing Economic Individualism[13]	Review	The book's focus on policy debate fairness is timely for public transit. As cities struggle with fairness, accessibility, and environmental sustainability, Bozeman's work invites reevaluation of principles to guarantee that public transportation policies promote social well-being and justice.
4.	The Economics of Urban Transportation[14]	Review	Analyses current urban transportation research and identifies new topics and their implications for future research. The authors predict five important themes—reliability, safety, road-pricing design, institutional reforms, and urban goods movement—while emphasizing applied theory's evolution and economic models' rising complexity. The book predicts a shift towards more practical and useful academic research, allowing economists to advise policymakers. However, the book's reliance on previously covered issues may limit the investigation of different and unique views in urban transportation's fast-evolving field. The critique may also advise prioritizing environmental issues, firm and household spatial behavior, and parking as research areas.
5.	Megacities and Atmospheric Pollution[15]	Case Study	The case study method provides a full understanding of megacity air pollution issues, but it does not explore policy actions and their results. The report stresses the need for a holistic approach to transportation environmental issues due to their complexity. The study acknowledges improvements, but a deeper exploration of successful techniques and observable consequences from implemented regulations would improve its practical usefulness for policymakers and researchers.

Table 1 continued

S.No.	Title	TooL/Method	Remarks
6.	Travel and the Built Environment: A Meta-Analysis [16]	Meta-Analysis	The authors assessed effect sizes and revised previous work to better understand transport trip demand dynamics. Critics point to the meta-analysis's lack of explanation of the transportation studies' methodology. Understanding these approaches' quality and diversity would improve transparency and reliability. While the meta-analysis finds travel variables inelastic to built environment changes, it does not examine moderating factors or contextual details that may affect transportation elasticities. The conclusions would be strengthened by acknowledging transportation study variability and performing subgroup analysis on crucial variables. Finally, the meta-analysis's practical recommendations for transport planning and policy are limited by the lack of a detailed discussion of the findings' consequences.
7.	Accessibility evaluation of land-use and transport strategies: review and research directions [17]	Literature Survey	The paper emphasizes the shortcomings of present accessibility measures, which fail theoretical standards. Infrastructure-based measurements like road network average speed are unsuitable since they exclude land use and temporal and individual factors. However, complicated location- and utility-based measures are effective instruments that defeat infrastructure-based ones. While useful for capturing individuals' accessibility valuations, these sophisticated metrics fail to incorporate spatial-temporal restrictions.
8.	Identifying the Impacts of Rail Transit Stations on Residential Property Values [18]	hedonic price mode	The study examines distance from downtown and neighborhood median income as contextual factors, but it may benefit from a more detailed examination of other external factors that may affect rail station and property values. Neighborhood amenities, public infrastructure, and local development plans may help clarify.
9.	Mapping transit-based access: integrating GIS, routes, and schedules [19]	GIS	The study examines accessibility, particularly transit services, and its historical difficulties in defining and quantifying it. The review critically evaluates transit service access measurement methodologies, exposing flaws. Considering these limitations, the study suggests new modifications and an extended GIS data structure to include transportation service temporal aspects to fill gaps. Mapping Santa Barbara's transit accessibility shows these refined measures in action. The examples demonstrate how the proposed methods can display useful transit service analysis and planning data.
10	The Impact of Rail Transport on Real Estate Prices: An Empirical Analysis of the Dutch Housing Markets [20]	Hedonic Pricing Model	The study emphasizes rivalry between railway stations due to the difficulty of station accessibility. The interplay between train stations makes accessibility complicated, thus the nearest and most commonly chosen reference stations emphasize this.

3.4 Content Analysis

This extensive investigation examined the frequency and co-occurrence networks of words obtained from Keywords Plus, Author's Keywords, Titles (unigram and bigram), and Abstracts (unigram and bigram). In Biblioshiny analysis, **unigrams** refer to individual words extracted from document titles, helping to identify the most frequently used terms and general themes in the research. **Bigrams** involve pairs of consecutive words, which reveal commonly used phrases and more specific concepts. Analyzing both unigrams and bigrams provides a detailed understanding of the prevalent terminology and thematic patterns within the titles, offering insights into emerging trends and key topics in the field The analysis of the word cloud and co-occurrence networks unveiled fascinating patterns and connections between terms, providing insights into the fundamental framework of the discipline.

Author's Keywords

Figure 11 displays the co-occurrence network of the Author's Keywords, which exhibited the formation of two separate word clusters. The group included terms such as "accessibility", "public transport", "transit-oriented development", "spatial analysis", "sustainable mobility", "shared mobility" and "walkability". The second cluster comprised phrases such as "built environment", "public transit", "covid-19", "travel behavior", and "mode choice", along with "big data", "smart card data" and "machine learning" The divide emphasizes the binary characteristic of research on the transit system. The initial cohort concentrates on the broader domains that the research is focused [21–23]. The secondary cohort identifies the key term that depicts the newer transitions in the transit system research such as its impact on the built environment, the new techniques that can be used, and the factors that affect the design and planning of these systems [24–26]. Other smaller clusters are comprised of key terms that are also addressed in the newer research such as environmental impact, sustainability, pollution, housing prices, etc [20, 27, 28]. These are either newer research that is emerging and hence have not developed a good network or are insignificant in addressing the broader domains.

Keywords Plus

The co-occurrence network of Keywords Plus, as depicted in **Figure 12**, unveiled three notable word clusters. One category comprised broad phrases such as "urban transportation", "public transport", "metro system", and "accessibility", "land use", "travel behavior", "metropolitan system", "urban planning" along with the major countries publishing studies such as "China", "United States" etc [16, 19, 20]. The second cluster included more specific units and phenomena such as "subway stations", "urban areas", "walking" and " transportation" [25, 29]. The third cluster consists of impacts such as "environmental monitoring", "air quality", "air pollution", "particulate matter", and "traffic and transport" etc [4, 7]. The under-representation of so many other issues such as public health, quality of life, last mile connectivity, para-transit, etc implies the lack of insights in the studies to become more prominent ones in the cluster. Also, the results are less or more in resonance with the authors' keywords diagram.

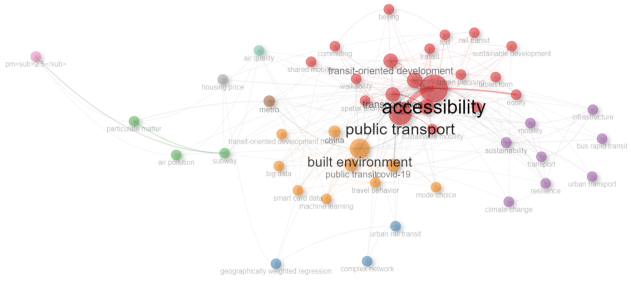

Figure 11. Co-occurrence network diagram of author's keywords.

Titles (Unigrams and Bigrams)

The network of co-occurrence between titles (unigrams), as depicted in **Figure 13**, exhibited two main groups. One set included of terms such as "transit", "urban", "transport", "public", and "development", "accessibility", "assessment", "mobility", "approach", "rapid", "review", "infrastructure", "housing", "change", "planning", "metropolitan", and "sustainable" [11, 30, 31]. The second cluster included phrases such as "factors", "impacts" "analysis", "metro", "rail", "evidence", "effects", "stations", "subways" etc [14, 20, 32] about specific types of key terms that are associated with the purpose or intention of the first cluster, focussing on the aftermaths and effects of the studies.

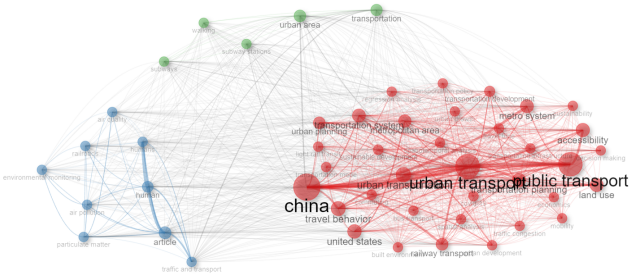

Figure 12. Co-occurrence network diagram of Keyword Plus.

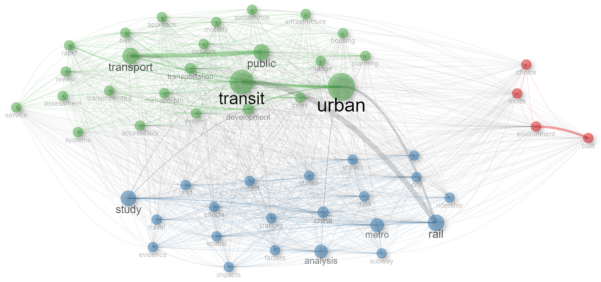

Figure 13. Co-occurrence network diagram of unigrams in titles.

Unlike the unigrams network, the titles (bigrams) co-occurrence network, as depicted in **Figure 14**, displayed one most significant, two next to significant, and many insignificant smaller word clusters. One cluster comprised phrases such as "rail transit", "urban rail", "transit ridership", and "property values"[7, 33]. The second cluster comprised phrases such as "built environment", "travel behaviour", "mode choice", "metro ridership", and "machine learning"[24, 25]. The next evident cluster comprises "air pollution", "climate change", "rapid transit", and " transit system". This network highlights the newer use of Machine Learning to understand travel behaviour, mode choice, and Transit Oriented Development (TOD). The image also shows the lack of interconnectedness between the subset of the networks; such as card data, smart data, urban form, etc not being directly connected to developing countries, urban transport, etc.

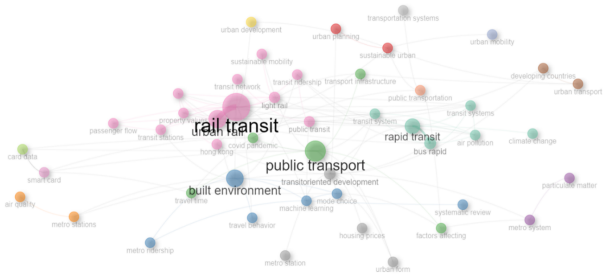

Figure 14. Co-occurrence network diagram of bigrams in titles.

Abstracts (Unigrams and Bigrams)

An analysis of co-occurrence networks in the abstracts of research publications, at both the unigram and bigram levels, has uncovered specific clusters of words. This provides a more comprehensive insight into the research themes, methodology, and focal areas that imply the plethora of knowledge in the field.

The co-occurrence network of individual words in the abstracts, depicted in **Figure 15**, revealed the presence of two separate clusters of words. The initial and most prominent complex cluster included elements such as "urban", "study", "results", "public", "analysis", "data", and "transit", along with significantly smaller nodes such as "transportation", "development", "data", "metropolitan", "spatial", "city", "planning", "system", "network" etc. These concepts are fundamental in transit research, encompassing the essential elements of investigations, such as data, analysis, factors, land, services, and planning-based networks as an important features in the metropolises. On the other hand, the second group consisted of fewer keywords that were significantly associated with the first cluster. The use of terms such as "stations", "ridership", "metro", and "subway" indicates that the studies in the first cluster are focused on these units of transportation as places of activity.

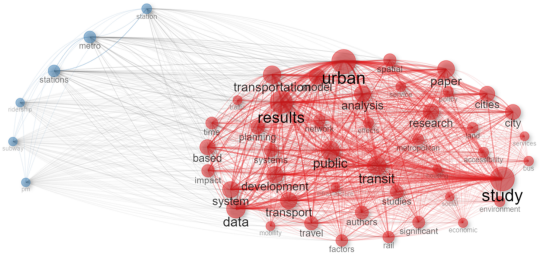

Figure 15. Co-occurrence network of unigrams in abstracts.

Similar to the Co-occurrence network diagram of bigrams in titles, **Figure 16** shows three prominent groups of abstract bigram co-occurrence networks. The rest of the elements in the network are not strong enough to make significant collaborations within the network. The first group emphasized the importance of public transportation in the context of "housing prices", "sustainable development", "urban development", "travel time", "rapid transit", "population density", "built environment", "metro stations"[4, 7, 34]. The second cluster is focused on allied services that are needed to strengthen public transport such as "infrastructure", "urban form", "traffic congestion issue", and "impact on climate change"[28, 35, 36]. The third group examined the "transit-oriented development", "light rail", "urban rail", "transit system", and "metro and transit network" and their impact on "real estate"[7, 37].

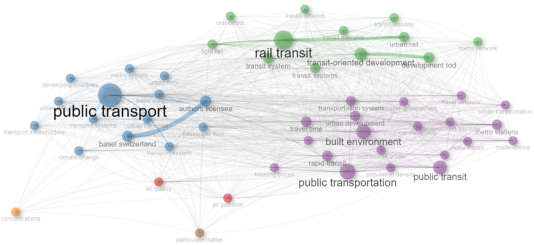

Figure 16. Co-occurrence network of bigrams in abstracts.

Themes

The author's keywords, titles, and abstracts reveal the complex relationship between mass transit and associated impact- research using word thematic maps. These maps divide terms into quadrants and show thematic clusters' importance and development, providing a comprehensive view of field research trends. The field's advancement is driven by *motor themes* in the first quadrant, which includes the driving forces behind the advancement of the field. These themes are crucial for understanding the core developments and innovations in mass transit research, In the second quadrant is niche themes, focusing on specialized or less mainstream investigations within the field. These topics often represent cutting-edge or highly specific areas of study. The third quadrant includes Emerging or Declining Themes that might be gaining traction or showing potential for future research. *basic themes* in the fourth quadrant explain mass transit or metro-related subjects. The fourth quadrant is Basic Themes, it includes fundamental topics related to mass transit or metro systems. These themes explain the foundational concepts and traditional subjects in the research. By analyzing the importance (centrality) and development (density) of these phrases, the inference identifies the aspects of research fields.

Figure 17 shows that In the first quadrant, known as motor themes, the focus is on central topics driving the advancement of mass transit research. This includes "Public Transport", which addresses core mechanisms and systems of public transportation; "Built Environment", which examines the interaction between transit systems and urban infrastructure; and "COVID", which explores the pandemic's impact on transit usage and policies. encompasses in the literature database. The second quadrant features niche themes that represent specialized or less mainstream areas of study. This quadrant highlights innovative topics such as "Geographically Weighted Regression", which analyzes spatial variations within transit data; "Housing Price", which investigates the influence of transit access on property values; and "Hedonic Price Model", which evaluates factors affecting property values related to transit. Other niche themes include Complex Networks, focusing on intricate transit system networks; "Vulnerability and Gentrification", addressing socio-economic impacts like community displacement; and "Shared Mobility", which looks at alternative transportation modes that complement traditional transit systems. In the "third quadrant", we find emerging or declining themes that indicate shifting research interests or evolving trends. For instance, "Particulate Matter" is highlighted here, focusing on environmental concerns related to pollution and air quality impacts of mass transit systems. The fourth quadrant contains basic themes, representing fundamental and traditional topics in mass transit research. This quadrant includes "Accessibility", which looks at how easily people can use transit systems; "Public Transportation", covering general aspects of transit systems; and "Transit Oriented Development, which examines urban planning strategies integrating transit with development. Other basic themes are "Land Use", studying how land is utilized in relation to transit systems; "China", focusing on specific research about transit systems in China; "Subway/Metro", investigating subway and metro systems; and "Air Quality", assessing the impact of transit systems on environmental air quality.

Figure 18 shows several quadrants in the thematic map of bigrams within titles. The first quadrant includes, in lowering centrality order, "smart card", "card data", "metro system", "public transport", "mode choice", "rail transit", "urban rail", and "light rail". These are major themes that exist in the literature and describe the broader themes. In the second quadrant, "sustainable mobility", "particulate matter", and "subway stations" are grouped. These are niche themes that show a progression in the insights of the broader themes. The third quadrant consists of "high-speed rail", "metro stations", "air quality", "built environment", and "metro ridership", signifying the emerging and declining themes in the subject. The basic themes, in the fourth quadrant, are somewhat similar to **Figure 14**, with "transit-oriented development", "covid pandemic", "housing prices", "bus rapid", "public transit" and "rapid transit" as the themes lower centrality and lower density implying towards a stagnant field.

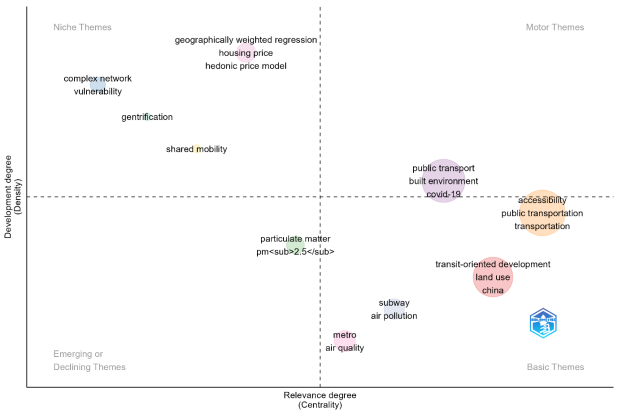

Figure 17. Thematic map of words from author's keywords.

The thematic map of bigram terms within abstracts displayed a dynamic landscape, as depicted in **Figure 19**. In the first quadrant, terms such as "public transport", "travel time", "rail transit", "transit-oriented development", and "built environment" were highly pertinent, highlighting their pivotal role in the current research genre. Additionally, terms like "public transit" and "rapid transit" also contributed to this theme, albeit with lesser relevance. The second quadrant encompassed "transportation research", "national academy", "research board", and "particulate matter", concentrations as niche themes. The third quadrant comprised terms like "air pollution", "air quality", "subway stations", "subway systems", "carbon dioxide", and "underground space" which were highly relevant, suggesting emerging trends. Finally, the fourth quadrant which shows basic themes includes "metro system", "climate change", and "passenger flow" as the broad themes around which the other quadrant themes revolved.

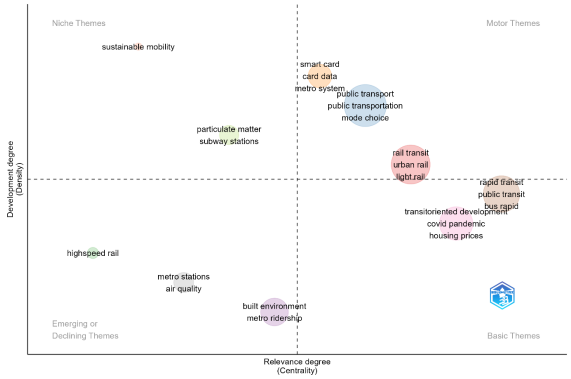

Figure 18. Thematic map of bigrams from titles.

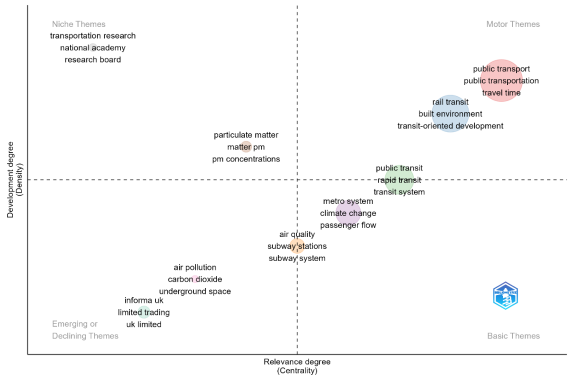

Figure 19. Thematic map of bigrams from abstracts.

4. Discussion

The bibliometric analysis conducted in this study provides a thorough examination of the changing research environment regarding the effects of Metro Rail Transit (MRT) systems in metropolitan cities. The study conducts a thorough examination of the changing publication scene, identifying intricate transformations, making predictions about future scholarly contributions, and revealing significant contributors on a worldwide scale. Examining keywords, titles, and abstracts enhances our comprehensive understanding of MRT implications, revealing subject groupings and emergent patterns. The study effectively examines current research issues, providing significant insights for urban planning decisions. The findings have ramifications for policymakers and academics, guiding future studies and informed decision-making in the dynamic field of metropolitan transit systems.

Identification of Key Themes: The analysis highlights numerous crucial themes in the MRT research environment. Transit-oriented development, land use, air quality, and smart card data are identified as key factors in mass transit research, representing the fundamental principles of this field. These issues are in line with worldwide phenomena including the New Urban Agenda, Sustainable Development Goals, and Smart City Projects, which connect MRT systems with broader global priorities.

Comprehension of Fundamental and Motor Subjects: The systematic analysis of keywords, titles, and abstracts yields a comprehension of fundamental and motor subjects. The terms transit-oriented development and air quality refer to well-established places that are characterized by their high level of centrality and density, which signifies their ongoing importance. On the other hand, the terms high-speed rail and COVID-19 are prominent topics that suggest the development of new areas of research and significant changes in thinking due to world events.

Identification of Niche Themes: The acknowledgment of specialized topics, such as sustainable mobility and particulate matter, implies a more thorough investigation of subtle issues within the wider MRT field. These themes indicate an increasing recognition of the environmental effects and health concerns, highlighting the necessity for interconnected and sustainable transportation solutions.

When examining the bibliometric analysis of Metro Rail Transit (MRT) systems, it becomes evident that several important themes are missing. Surprisingly, the discovered clusters do not give much importance to public health, quality of life, and last-mile connection, even though they are essential aspects of urban living in the scientific database. This insight raises the need to carefully examine any research gaps that may indicate topics that have not been adequately investigated in the current discussion. Having said that, we recognize that including Google Scholar in future research could enhance the scope of our analysis. Future studies could

integrate data from multiple databases to provide a more comprehensive review of the literature, encompassing a wider range of publications and perspectives. This approach would allow for a broader understanding of the impact of MRT on public health, quality of life, and last-mile connection, drawing from a diverse array of sources.

The concurrent emergence of high-speed rail and the fall of specific trends indicate a dynamic transformation in global goals or technological advancements. This prompts inquiries on the changing importance of academic disciplines within the framework of MRT systems. How do these shifts indicate the changing priorities in metropolitan cities, and how can they impact the direction of research in urban planning and sustainable development? Upon careful examination of these issues, it becomes clear that the consequences of urban planning are significant. The emphasis on Transit-Oriented Development and environmental sustainability highlights the capacity of MRT systems to enhance resilient, easily reachable, and eco-friendly urban environments. Nevertheless, a thorough analysis is required to determine whether existing urban planning policies are in accordance with these discoveries. If they are not, there could be significant repercussions for the attainment of wider global objectives.

The analysis offers readers a comprehensive perspective that furnishes them with insights into the subject of MRT research. An analysis of major topics, contributors who engage significantly, and evolving patterns is a valuable contribution to the current body of literature. Nevertheless, this raises the need for a thorough examination of whether the work adequately covers the extent of the highlighted limitations, guaranteeing that the direction for future research is specified and can be acted upon. Moreover, the viability of the study depends on its capacity to provide innovative viewpoints and stimulate a transformation in the discussion surrounding MRT systems. Do the identified themes and collaboration networks represent significant innovations, or do they just reinforce existing ideas? This critical assessment urges academics to surpass the limitations of current information, promoting a detailed discussion on the effects of MRT systems. The analysis identifies potential areas for further research, and the critical perspective emphasizes the importance of considering these suggested directions in a practical manner. Do these possibilities stem from the current issues encountered by urban cities, or do they exist solely as theoretical frameworks? Policymakers and scholars are encouraged to consider the identified gaps not just as abstract ideas, but as practical strategies that might effectively tackle real-world difficulties in metropolitan areas influenced by MRT systems.

To summarise, although the bibliometric study provides valuable insights, the lack of some themes, the changing global objectives, and the discovered gaps in the literature all highlight the necessity for a more detailed understanding. Other studies may use the same analysis with different datasets to understand the development in the field and draw inferences. Also, the keyword in conjunction with a specific region or timeframe will also be able to give different results. Researchers are encouraged to actively challenge the existing state of affairs and explore uncharted areas. This will ensure that future studies not only coincide with developing trends but also have the potential to bring about significant changes in urban areas affected by MRT systems. The ever-changing nature of the MRT environment necessitates a research program that is equally flexible, responsive, and intentional.

5. Conclusion

Through this extensive bibliometric study, authors have examined several aspects of the impact of Metro Rail Transit (MRT) systems on metropolitan regions. An in-depth analysis of evolving publication patterns revealed the ever-changing nature of academic contributions, enabling researchers to identify trends and predict the future direction of research connected to MRT. By examining the key characters that are affecting the conversation, authors have discovered the pioneering researchers, organizations, and countries that are driving creative research. This research provides vital insights into the forces that are guiding the discussion on the impacts of MRT systems. The study revealed the detailed relationships within the intricate network of keywords, titles, and abstracts, improving our nuanced understanding of the ramifications of MRT systems. Through understanding the embedded coding in the literature, we have not only clarified present study themes and trends but also established a basis for future studies, guiding well-informed assessments in the field of urban planning. Transit-oriented development, environmental sustainability, and socio-economic ramifications have become important areas of focus, in line with global objectives such as sustainable development goals and smart city programs. While this research offers valuable insights, it is important to acknowledge its limitations. Different datasets and keywords might yield different results, and this study represents one of many possible perspectives on the topic. The findings presented here are intended to offer a general understanding of the field's development and

to identify potential areas for future research.

This work serves as a foundation for future studies by outlining key themes and contributors, but it is just one piece of the broader research landscape. Future investigations could expand on these findings to provide a more comprehensive view of MRT systems and their implications, ultimately guiding urban planning and transit system innovations. The identification of key contributors, whether they be persons, institutions, or countries, provided a comprehensive understanding of the factors that drive groundbreaking research in this field. Examining the intricate network of keywords, titles, and abstracts not only provides insight into the present discussion but also establishes a foundation for future inquiries. An analysis of important topics and developing patterns not only provides a current overview but also offers a flexible structure for understanding the changing field of MRT research. The study's future significance lies in its ability to lead and encourage MRT system research. The research reveals patterns, prominent contributors, and key subjects to guide future research. The suggested potential includes investigating real-world effects, ethical issues, and equitable access to emerging technologies. This study informs urban planning decisions and lays the groundwork for metropolitan transit system innovation and enhancement as urban mobility evolves.

Author Contributions

Vikash Ranjan conducted the bibliometric analysis. Shailendra Kumar Mandal elaborated on the results highlighted in the result of the analysis, with the narration of the themes, their evolution, and their relation to other themes. Writing and editing are done by both authors.

Conflict of Interest

The authors state that there are no conflicts of interest to declare.

Data Availability Statement

The data that support the findings of this study are the bibliometric data and it is available on request from the corresponding author.

Acknowledgements

The authors wish to thank the colleagues from the Department of Architecture and Planning, NIT Patna who helped in reviewing and discussing the manuscript.

References

[1] Mohan, D., 2008. Mythologies, metro rail systems and future urban transport. Economic and Political Weekly. 43(4), pp. 41–53.

[2] Carrigan, A., King, R., Velasquez, J.M., et al., 2013. Social, nvironmental and Economic Impacts of BRT Systems. Available from: www.embarq.org (cited 10 July 2024)

[3] Lu, K., Han, B., Zhou, X., 2018. Smart Urban Transit Systems: From integrated framework to interdisciplinary perspective. Urban Rail Transit. 4(2), 49–67. DOI: https://doi.org/10.1007/s40864-018-0080-x

[4] Lin, D., Zhou, Z., Weng, M., et al., 2024. Metro systems: Construction, operation and impacts. Tunnelling and Underground Space Technology. 143(March 2023), 105373. DOI: https://doi.org/10.1016/j.tust.2023.105373

[5] Iqbal Raj, S., Julker Naem, A.S., 2022. Socioeconomic impact of the first Mass Rapid Transit (MRT) in Dhaka. Seminario Internacional de Investigación en Urbanismo. DOI: https://doi.org/10.5821/siiu.11977

[6] Ahasan, R., Hoda, M.N., Alam, M.S., et al., 2023. Changing institutional landscape and transportation development in Dhaka, Bangladesh. Heliyon. 9(7), e17887. DOI: https://doi.org/10.1016/j.heliyon.2023.e17887

[7] Wan, T., Lu, W., Sun, P., 2023. Equity impacts of the built environment in urban rail transit station areas from a transit-oriented development perspective: A systematic review. Environmental Research Communications. 5(9). DOI: https://doi.org/10.1088/2515-7620/acf8b2

[8] Birkle, C., Pendlebury, D.A., Schnell, J., et al., 2020. Web of science as a data source for research on scientific and scholarly activity. Quantitative Science Studies. 1(1), 363–376. DOI: https://doi.org/10.1162/qss_a_00018

[9] Harzing, A.W., Alakangas, S., 2016. Google Scholar, Scopus and the Web of Science: A longitudinal and cross-disciplinary comparison. Scientometrics. 106(2), 787–804. DOI: https://doi.org/10.1007/s11192-015-1798-9

[10] Büyükkidik, S. A bibliometric analysis: A tutorial for the bibliometrix package in R using IRT literature. Journal of Measurement and Evaluation in Education and Psychology. 13(3), 164–193. DOI: https://doi.org/10.21031/epod.1069307

[11] de D. Ortúzar, J., Willumsen, L.G., 2011. Modelling Transport. John Wiley & Sons, Ltd.: Chichester. DOI: https://doi.org/10.1002/9781119993308

[12] Tzeng, G.-H., Huang, J.-J., 1981. Methods for Multiple Attribute Decision Making. Springer: Berlin, Heidelberg.

[13] Bozeman, B., 2007. Public values and public interest: Counterbalancing economic individualism. Acta Polit.

44, 1–214. DOI: https://doi.org/10.1057/ap.2009.14

[14] Small, K.A., Verhoef, E.T., Lindsey, R., 2007. The Economics of Urban Transportation. Routledge: London. DOI: https://doi.org/10.4324/9780203642306

[15] Molina, M.J., Molina, L.T., 2004. Megacities and atmospheric pollution. Journal of the Air & Waste Management Association. 54(6), 644–680. DOI: https://doi.org/10.1080/10473289.2004.10470936

[16] Ewing, R., Cervero, R., 2010. Travel and the built environment. Journal of the American Planning Association. 76(3), 265–294. DOI: https://doi.org/10.1080/01944361003766766

[17] Geurs, K.T., Van Wee, B., 2004. Accessibility evaluation of land-use and transport strategies: Review and research directions. 12, 127–140. DOI: https://doi.org/10.1016/j.jtrangeo.2003.10.005

[18] Bowes, D.R., Ihlanfeldt, K.R., 2001. Identifying the impacts of rail transit stations on residential property values. Journal of Urban Economics. 50(1), 1–25. DOI: https://doi.org/10.1006/juec.2001.2214

[19] Lei, T.L., Church, R.L., 2010. Mapping transit-based access: Integrating GIS, routes and schedules. International Journal of Geographical Information Science. 24(2), 283–304. DOI: https://doi.org/10.1080/13658810902835404

[20] Debrezion, G., Pels, E., Rietveld, P., 2011. The impact of rail transport on real estate prices: An empirical analysis of the Dutch housing market. Urban Studies. 48(5), 997–1015. DOI: https://doi.org/10.1177/0042098010371395

[21] Iamtrakul, P., Padon, A., Klaylee, J., 2022. The study on association between urban factors and walkability of transit oriented development TOD. GMSARN International Journal. 16(4), 388–398.

[22] Budiati, W., Grigolon, A.B., Brussel, M.J.G., et al., 2018. Determining the potential for Transit Oriented Development along the MRT Jakarta corridor. IOP Conference Series: Earth and Environmental Science. 158(1). DOI: https://doi.org/10.1088/1755-1315/158/1/012020

[23] Bachtiar, F., Rahardjo, A.H., Olii. A., 2020. Picking Up People: Defining Walkable Ride-Hailing Transit Points Around MRT Stations in Jakarta. In Proceedings of the EduARCHsia & Senvar 2019 International Conference (EduARCHsia 2019). Atlantis Press: Paris. DOI: https://doi.org/10.2991/aer.k.200214.005

[24] Abdullah, M., Dias, C., Muley, D., et al., 2020. Exploring the impacts of COVID-19 on travel behavior and mode preferences. Transportation Research Interdisciplinary Perspectives. 8, 100255. DOI: https://doi.org/10.1016/j.trip.2020.100255

[25] Parker, M.E.G., Li, M., Bouzaghrane, M.A., et al., 2021. Public transit use in the United States in the era of COVID-19: Transit riders' travel behavior in the COVID-19 impact and recovery period. Transport Policy. 111, 53–62. DOI: https://doi.org/10.1016/j.tranpol.2021.07.005

[26] Awad-Núñez, S., Julio, R., Gomez, J., et al. 2021. Post-COVID-19 travel behaviour patterns: impact on the willingness to pay of users of public transport and shared mobility services in Spain. European Transport Research Review. 13(1). DOI: https://doi.org/10.1186/s12544-021-00476-4

[27] Griffith, S.M., Huang, W.-S., Lin, C.-C., et al., 2020. Long-range air pollution transport in East Asia during the first week of the COVID-19 lockdown in China. Science of the Total Environment. 741, 140214. DOI: https://doi.org/10.1016/j.scitotenv.2020.140214

[28] Ratnawati, E., 2021. MRT as an Alternative Transportation Solution which is environmentally friendly and traffic jam free in Jakarta. IOP Conference Series: Earth and Environmental Science. 819(1), 012040. DOI: https://doi.org/10.1088/1755-1315/819/1/012040

[29] Ahmed, S., Nahiduzzaman, K.M., Hasan, M.M.U., 2018. Dhaka, Bangladesh: unpacking challenges and reflecting on unjust transitions. Cities. 77, 142–157. DOI: https://doi.org/10.1016/j.cities.2017.11.012

[30] Boisjoly, G., El-Geneidy, A.M., 2017. How to get there? A critical assessment of accessibility objectives and indicators in metropolitan transportation plans. Transport Policy. 55, 38–50. DOI: https://doi.org/10.1016/j.tranpol.2016.12.011

[31] Cheshmehzangi, A., Thomas, S.M., 2016. Prioritizing accessible transit systems for sustainable urban development: Understanding and evaluating the parameters of a transportation system in mumbai. Journal of Urban Planning and Development. 142(4), 1–12. DOI: https://doi.org/10.1061/(ASCE)UP.1943-5444.0000338

[32] Zhu, X., Liu, S., 2004. Analysis of the impact of the MRT system on accessibility in Singapore using an integrated GIS tool. Journal of Transport Geography. 12(2), 89–101. DOI: https://doi.org/10.1016/j.jtrangeo.2003.10.003

[33] Mehr, H.S., Rahnama, M.R., Shokouhi, M.A., et al., 2016. Optimization of main public transport paths based on accessibility-Case study: Mashhad, Iran. Journal of Public Transportation. 19(1), 114–128. DOI: https://doi.org/10.5038/2375-0901.19.1.8

[34] Hasibuan, H.S., Mulyani, M., 2022. Transit-oriented development: Towards achieving sustainable transport and urban development in Jakarta metropolitan, Indonesia. Sustainability. 14(9), 5244. DOI: https://doi.org/10.3390/su14095244

[35] Chapman, L., 2007. Transport and climate change: A review. Journal of Transport Geography. 15(5), 354–367. DOI: https://doi.org/10.1016/j.jtrangeo.2006.11.008

[36] Bhandari, M., Kumar Mishra, A., Rana Magar, B., 2017. Implementability of municipal transport master plan of Bandipur inner ring road, Tanahun, Nepal. Nepal Article in International Journal of Scientific & Technology Research. 6(8), 306–313. Available from: www.ijstr.org (cited 10 July 2024).

[37] Joshi, R., Joseph, Y., Patel, K., et al., 2017. Transit-oriented development: Lessons from international experiences. 1–38.