

Exploring the Impacts of Highways in Urban Areas: A Comprehensive Bibliometric Analysis

Nishanthi.K¹ *, Rathnayake R.M.K² and Hettiarachchi H.A.N²

¹. Department of Geography, University of Kelaniya, Sri Lanka.

². Department of Geography, University of Sri Jayawardenapura, Sri Lanka.

Abstract

Highways are crucial to national development, economic growth, social connectivity, and regional development. In urban areas, highways are pivotal in shaping the built environment, influencing transportation efficiency, and impacting social and economic dynamics. To understand the whole discourse of academic knowledge on highways in urban areas, the study focused on providing a comprehensive global bibliometric analysis of the impacts of highways on urban areas over the past three decades. This was carried out by analyzing specific objectives, including publication trends, influential authors, international collaborations, and citation impacts. The study focuses on research publications on highways in urban areas from 1991 to 2024. The data includes publications sourced from the Web of Science database. It focuses on the impact of highways in urban areas using the three search terms: 'impact', 'highway', and 'urban'. Four hundred and thirty-eight research publications were used to conduct the study. The bibliometric analysis focuses on evaluating trends in publication volume over time using Biblioshiny, a software tool created by Massimo Aria. The analysis reveals that research on highways in urban areas has grown significantly over the last two decades, driven by increasing scholarly interest. Key themes identified include transportation efficiency and environmental sustainability, with emerging focus areas such as urban behavior and socio-economic impacts. Significant contributions from the USA and China underscore the global nature of this research.

Keywords: Bibliometric Analysis, Environment, Highway, Impact, Urban

1. Introduction

Road networks play a pivotal role in the development of a country, particularly in the developing world. It improves economic growth and social progress and enhances the quality of life through various paths. Firstly, by linking rural areas to urban centers, roads facilitate the movement of goods and services, thereby opening new markets for farmers and businesses to expand their reach and improve profitability (Rao, 2007). Furthermore, a well-developed road network promotes trade by simplifying the transportation of goods within and between regions, consequently fostering increased economic activity, job creation, and foreign exchange earnings (Mbaiwa, 2003).

Corresponding author.

E-mail address: chathurikaj@geo.ruh.ac.lk (Jayasinghe D. B. C)

Highways play a crucial role in advancing nations for many reasons. They serve as the fundamental framework for fostering economic growth, social ties, and regional progress (Abdul Quium, 2019). Extensive research has explored the difference between transportation and the economy. A strong transportation infrastructure is widely regarded as essential for stimulating local economic advancement (Weisbrod, 2008).

Numerous studies have delved into the intricate link between transportation and land use, focusing on how new transport infrastructure shapes land development. The conventional approach evaluates the socio-economic benefits of altering land use, justifying investments in infrastructure (Al-Shaar et al., 2021; Bacior & Prus, 2018; Button et al., 2004; Kasraian et al., 2016). Recent research also considers the economic dimension when analyzing accessibility and transport-land use interactions. Spatial accessibility, recognized as a crucial economic determinant, is intertwined with urban economics (Bertolini et al., 2005). However, purely economic perspectives may not fully grasp the spatial impacts of transport infrastructure, particularly concerning evolving territories. Moreover, these economic models often rely on equilibria and require data that may be lacking in many developing countries (Coenen et al., 2012).

Alternative viewpoints stress the need for a holistic approach to urban development management that incorporates geographic, geologic, and geomorphologic factors, as well as the potential for natural hazards. Urban sprawl, influenced by transport infrastructure, has emerged as a global concern amidst climate change and dwindling fossil fuels (Ganguly et al., 2018). Research illustrates that new highways can foster urban expansion, affecting population density and environmental conditions (Song et al., 2020).

Across diverse settings, studies reveal the intricate relationship between highways and shifts in environmental, demographic, and land-use conditions. Investigations in developing nations like Turkey, China, and India highlight the varied impacts of new highways on population distribution, land use alterations, and environmental repercussions (Yigitcanlar & Kamruzzaman, 2014). Furthermore, human activities such as infrastructure construction and urban expansion have the potential to disrupt the natural landscape, trigger natural disasters, and undermine the sustainability of urban and infrastructural development (Coates, 2022).

Constructing new highways represents a significant government investment aimed at bolstering economic growth in both rural and urban areas. A well-functioning transportation system, particularly highways, is pivotal at national, state, and local levels, enhancing connectivity, economic prosperity, and societal well-being. However, it's crucial to acknowledge the environmental repercussions of such development, which can entail varying degrees of harm to natural ecosystems (Zacharias & Tang, 2010).

Highway construction directly impacts and displaces existing ecosystems while altering local landscapes. Road expansion affects both living and non-living components of the environment, disrupting terrestrial and aquatic ecosystems. Construction activities emit particulate matter into the air, compromising air quality, primarily through land clearing, excavation, and facility construction (Trombulak & Frissell, 2000).

Furthermore, the construction of highways is a significant source of pollution to natural water bodies, as pollutants from soil erosion, fossil fuel use, and construction materials contaminate rivers and lakes, leading to water quality degradation. Residential areas near highways are particularly susceptible to pollution from increased traffic, including heavy metals emitted by vehicles (Duong & Lee, 2011). The health and quality of life of individuals residing and working near highways are also impacted, with proximity to major roadways linked to respiratory issues, cardiovascular disease, and other health concerns. Moreover, workers at construction sites may face higher mortality rates due to pulmonary diseases and chronic obstruction (Brugge et al., 2007).

Similarly, highways significantly influence the environment, society, and economy. Consequently, numerous researchers worldwide have conducted studies to discern the multifaceted roles of highways (Haleem et al., 2016). While past literature reviews have examined the impact of highways, researchers have employed diverse analytical methods to assess these impacts.

This study encompasses various geographical regions worldwide to provide a comprehensive overview spanning three decades of research on the effects of highways. No studies have been conducted on this basis; thus, it will be helpful to understand the importance of highway construction, its impact on urban areas, and the global research trend on this topic. At present, there is a lack of a comprehensive global bibliometric analysis that systematically maps the evolution, research trends, influential publications, and thematic development of highway-related research in urban contexts. Thus, the primary objective of this study is to provide a comprehensive global bibliometric analysis of research on the impacts of highways on urban areas over the past three decades. To achieve the primary objective the study structured to analyze the following specific objective such as—Trends in Research Publications and Yearly Trends in Average Citations, Top Journals Contribution, Top Locally Cited Authors, Evolution of Research Output by Source, Emerging and Evolving Research Topics, Thematic Mapping of Research, Global Research Collaboration Network and Citation Analysis of Countries in Highway Impact Research: Total and Average Citations (1991-2024). The study provides a valuable foundation for research and evidence for future urban planning and policy development.

02. Materials and Methods

The paper uses bibliometric analysis to provide a comprehensive overview of current research on the impact of highways in urban areas. The practice of bibliometric analysis has experienced substantial growth from 1998 to 2017 and beyond. The method employs a diverse collection of mathematical tools and statistical techniques to examine and map out published research articles.

Statistical methodologies reveal the rationales behind scientific research and disciplinary trends (Öztürk et al., 2024). Bibliometric analyses offer researchers insights into the historical trajectory of a field, explain its current state, and identify novel opportunities for further investigation. This particular study delves into bibliometric analysis within the realm of the impact of highways in urban areas (Lepora et al., 2024). The methodology followed for the study is shown in Figure 1.

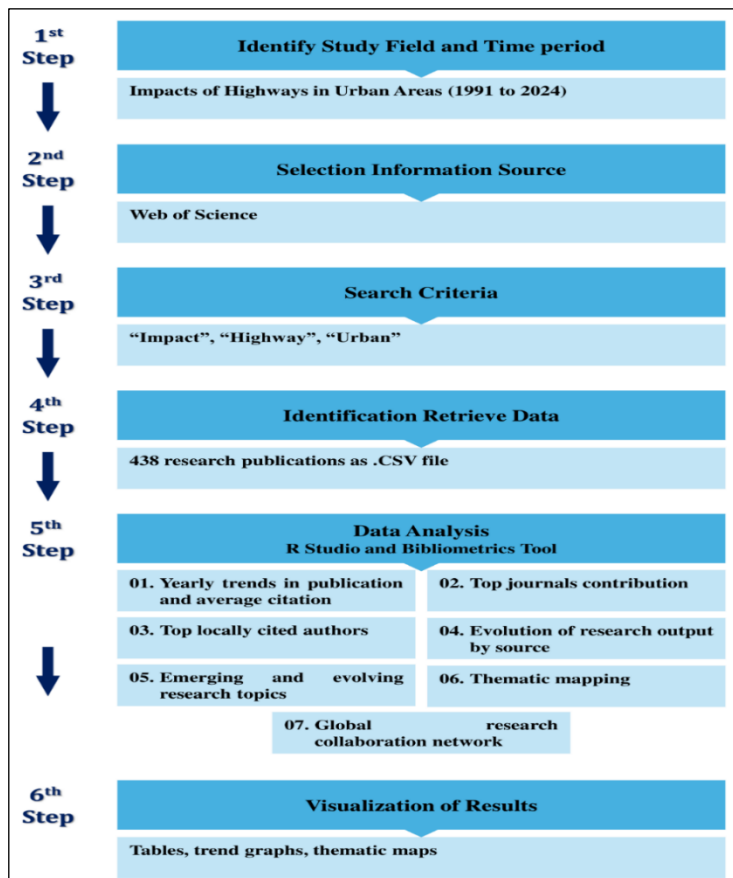


Figure 1: Workflow of the Study

The study exclusively encompasses empirical and review articles. Non-English studies were excluded from the analysis. Moreover, the analysis did not include other forms of literature, such as books, book chapters, or conference proceedings.

The Web of Science stands out as the most extensive database for scientific literature, encompassing over 11,000 peer-reviewed journals across various disciplines, and is distinguished by its rigorous journal selection criteria, high-quality indexing standards, and comprehensive citation metadata. Thus, the study used the Web of Science database to examine the impact of highways in urban areas, using the three search terms: 'impact', 'highway', and 'urban'. Four hundred and thirty-eight research publications were used to conduct the study.

The data analysis employed Biblioshiny, a software created by Massimo Aria, to explore the current state of research on the impact of highways in urban areas (Nica, 2025; Oribia et al., 2024; Sharma et al., 2025). Bibliometric analysis techniques were applied to study the Yearly Trends in Average Citations, Top Journals Contribution, Top Locally Cited Authors, Evolution of Research Output by Source, Emerging and Evolving Research Topics, Thematic Mapping, and Global Research Collaboration Network on Highway Impacts in Urban Areas (1991-2024)(Aria & Cuccurullo, 2017). The paper presents data visualization through tables and graphs, including trend graphs, top authors' production, corresponding author countries, country maps, and thematic maps. These visual aids are interpreted to draw meaningful conclusions.

03. Results and Discussion

The bibliometric analysis of the impacts of highways in urban areas is shown in Figure 2, which comprises research papers from Web of Science-indexed journals. The dataset encompasses contributions from 273 journals, reflecting a wide array of publications. With a total of 437 documents, each representing an individual research paper, the dataset demonstrates a notable annual growth rate of 9.15%, signifying ongoing scholarly interest. The average age of documents is 7.62 years, indicating the publication timeline. Notably, each document averages 21.16 citations, underscoring its impact on the academic community. Drawing from 18,325 collective references, the dataset is rooted in a rich array of literature. Content-wise, it includes 1,194 unique Keywords Plus (ID) terms and 1,484 unique Author's Keywords (DE), enriching the understanding of research topics. Across the documents, 1,608 authors have contributed, including 42 single-authored documents, reflecting individual research endeavors. Collaboration is evident, with an average of 3.85 co-authors per document and approximately 17.62% of documents involving international co-authorships, fostering global scholarly exchange.

Document types vary, encompassing articles, proceedings papers, reviews, letters, editorial materials, and retracted publications, illustrating the dataset's diversity. Overall, these details offer a comprehensive glimpse into the dataset's breadth, composition, and scholarly impact.

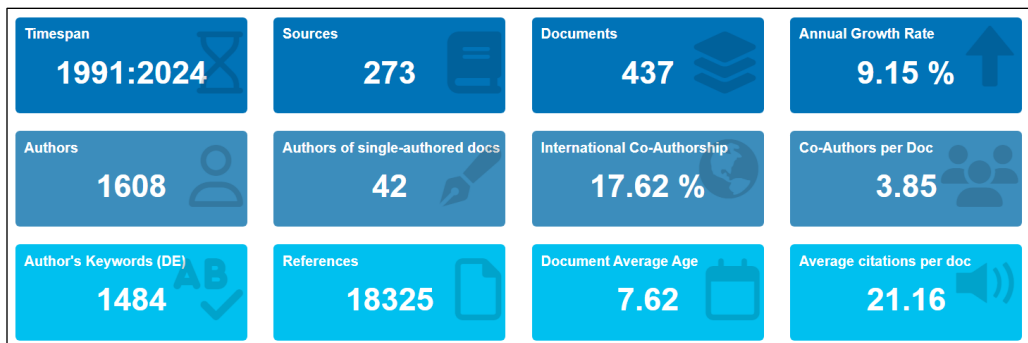


Figure 2: Summary of Main Information of the Dataset on the Impact of Highways in Urban Areas: A Web of Science Bibliometric Analysis

In this research, time series analysis was conducted to explain the evolution of trends in the impact of highways on urban areas. The study uses annual science production and annual citations to illustrate these trends effectively.

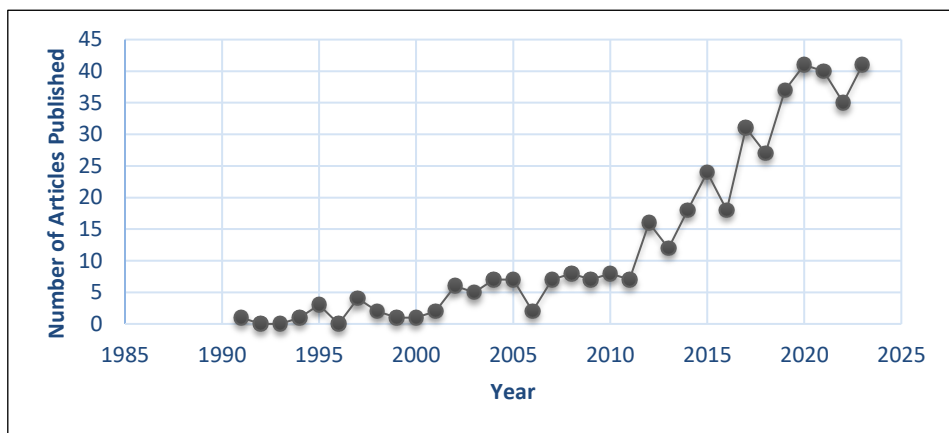


Figure 3: Trends in Research Publications on the Impact of Highways in Urban Areas (1991-2024): A Time Series Analysis

The data indicates the path of research articles published in Web of Science-indexed journals concerning the impact of highways in urban areas spanning from 1991 to 2024, as shown in Figure 3. Analyzing the fluctuations reveals distinct patterns: Between 1991 and 1996, minimal interest was evident, with only one article in 1991 and sporadic publications after that. From 1997 to 2001, a modest increase occurred, with publications ranging from 2 to 4 annually, signaling a growing interest in the topic. The years 2002 to 2006 witnessed a significant flow in publications, peaking at seven articles in 2004 and 2005, likely in response to escalating urbanization and transportation challenges. From 2007 to 2011, publication rates remained relatively stable, fluctuating between 2 and 8 articles per year, without significant deviation from the prior period. From 2012 to 2016, a notable rise was observed, with publications increasing steadily from 16 in 2012 to 24 in 2015, possibly indicating renewed interest or methodological advancements. The most substantial progress in publications occurred between 2017 and 2024,

peaking at 41 articles in 2020 and 2023. In 2024, 18 research papers were published in the first quarter of the year. It shows an increased interest in the research area.

As per the publications, research on the effects of urban roadways amid increasing global urbanization is becoming more prevalent. Infrastructure is strained by the increasing number of cars and cities, leading to problems with traffic, pollution, and quality of life. With the world's population growth, human needs have recently driven the development of transportation facilities, with significant impacts. Assessing these impacts and resolving congestion are top priorities for researchers. Environmental concerns, including greenhouse gases and air pollution, prompt mitigation measures. Additionally, highways affect social and economic dynamics, leading to research on equitable development. Planning for urban transportation requires assessing policies such as road pricing and public transit improvements, as well as understanding the effects of highways. Academics, decision-makers, and practitioners promote evidence-based solutions that support sustainable and equitable urban development objectives.

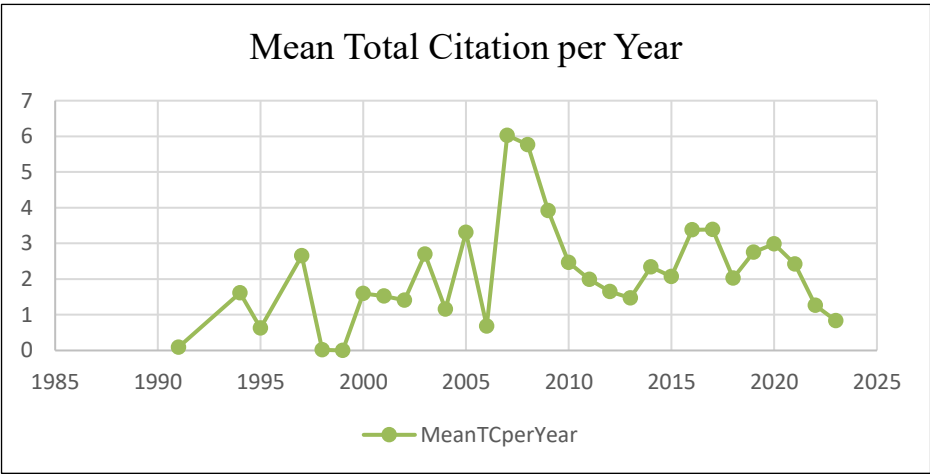


Figure 4: Yearly Trends in Average Citations of Research on Highway Impact in Urban Areas (1991-2024)

This analysis offers valuable insights into the yearly average citations of research articles concentrating on the influence of highways in urban areas, as featured in Web of Science-indexed journals. Analyzing the trends: Between 1991 and 2001, as shown in Figure 4, there were notable fluctuations in average citations, indicating varying degrees of recognition and impact within the academic sphere. From 2002 to 2009, a generally upward trajectory is observed, with citations steadily increasing, particularly peaking around 2007, indicating heightened recognition by the academic community. From 2010 to 2016, average citations remained moderate, suggesting a stable research impact. However, from 2016 to 2020, there was a significant surge in average citations, culminating in a peak. Yet, a sharp decline is noted in 2024,

indicative of potentially diminished relevance or impact within academic discourse for research on this topic that year. Overall, the data underscores fluctuations in the recognition and impact of research on the impact of highways in urban areas over time, with spikes in citation rates reflecting heightened visibility and influence within academia.

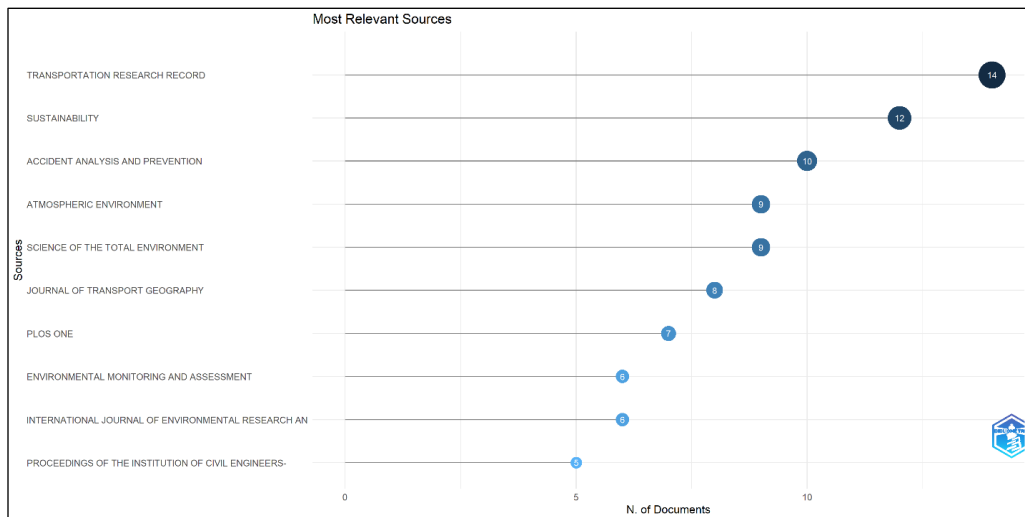


Figure 5: Top Journals Contributing to Research on Highway Impacts in Urban Areas

Figure 5 reveals that the Transportation Research Record is the most prolific source, contributing 14 documents, making it the leading journal for research on the impacts of highways in urban areas. This is expected, given its focus on transportation topics, including traffic management, urban planning, and infrastructure impacts. Sustainability is the second most relevant source, with 12 documents demonstrating its alignment with the environmental and social aspects of highway impacts, including pollution, urban sprawl, and community well-being. Accident Analysis and Prevention (10 documents) and Atmospheric Environment (9 papers) are also key sources, underscoring the importance of traffic safety and environmental pollution studies related to highways.

The chart also highlights the interdisciplinary nature of the research, with sources such as the Journal of Transport Geography and Science of the Total Environment (each with 9 documents) focusing on the geographical and environmental aspects of highway impacts. Environmental Monitoring and Assessment and the International Journal of Environmental Research and Public Health (each with six documents) emphasize environmental and public health monitoring. On the other hand, sources such as the Proceedings of the Institution of Civil Engineers, which contribute fewer documents (5), may focus on specific or more specialized aspects of the topic. Overall, this chart visually demonstrates the most relevant and prolific sources for studying the impacts of highways on urban areas, with journals such as Transportation Research Record and Sustainability being particularly valuable for researchers

seeking to understand the broader effects of highways on transportation efficiency and environmental and social sustainability.

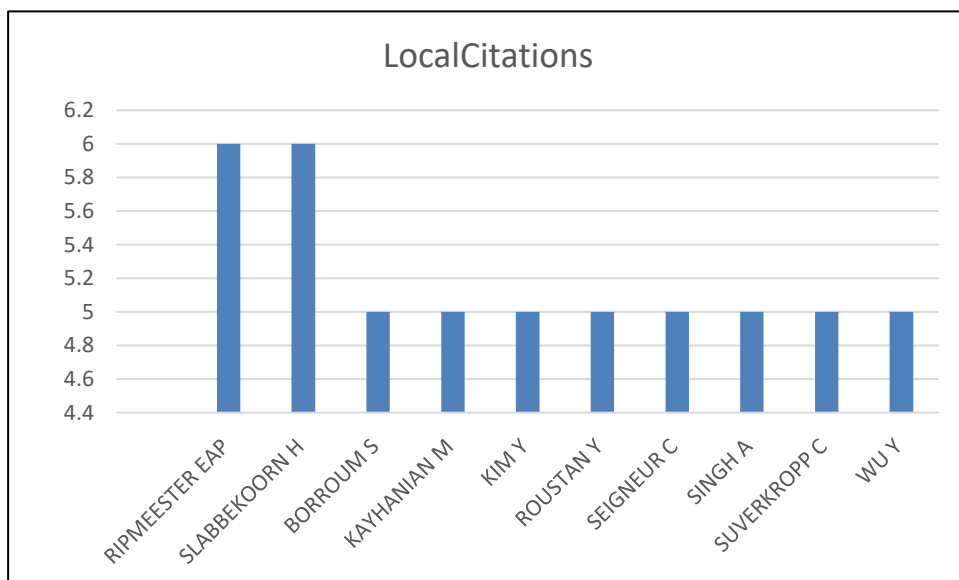


Figure 6: Top Locally Cited Authors in Research on Highway Impacts in Urban Areas

The most locally cited authors list is shown in Figure 6, featuring scholars who have received the highest number of citations in the examined dataset. These authors are distinguished by the frequency with which other researchers reference their work in the same collection of documents. Ripmeester EAP and Slabbekoorn H lead the list, each with 6 local citations, highlighting their research's significant influence and frequent citation. Additionally, Borroum S, Kayhanian M, Kim Y, Roustan Y, Seigneur C, Singh A, Suverkropp C, and Wu Y each have five local citations, indicating their considerable impact and frequent citation by peers. The high citation counts for these authors underscore the value and relevance of their contributions to this study.

Figure 7 illustrates the publication trends related to the study over time. There is a clear trend of increasing publication output across various sources, with a notable rise in the last two decades. For example, the Transportation Research Record has shown a steady rise, from just 1 document in 2008 to 14 in 2024, making it the most prolific source. Similarly, the focus on sustainability has grown significantly, particularly from 2015 onwards, with the number of documents reaching 12 by 2024. Environmental and safety aspects have also gained prominence, as evidenced by the gradual increase in publications in Science of the Total Environment and Atmospheric Environment since around 2005 and the notable rise in Accident Analysis and Prevention in the past decade. The period from 1991 to 2000 saw minimal publication activity, suggesting limited research during that time. However, there has been a notable expansion in interdisciplinary research, with a growing inclusion of environmental and sustainability journals. This reflects an

increasing recognition of the need to address diverse perspectives, including environmental, social, and safety concerns.

Overall, the analysis highlights a growing interest in the impacts of highways on urban areas, with significant contributions from transportation, environmental, and safety research, aligning with global concerns about sustainable urban development and the balance between infrastructure growth and ecological and social well-being.

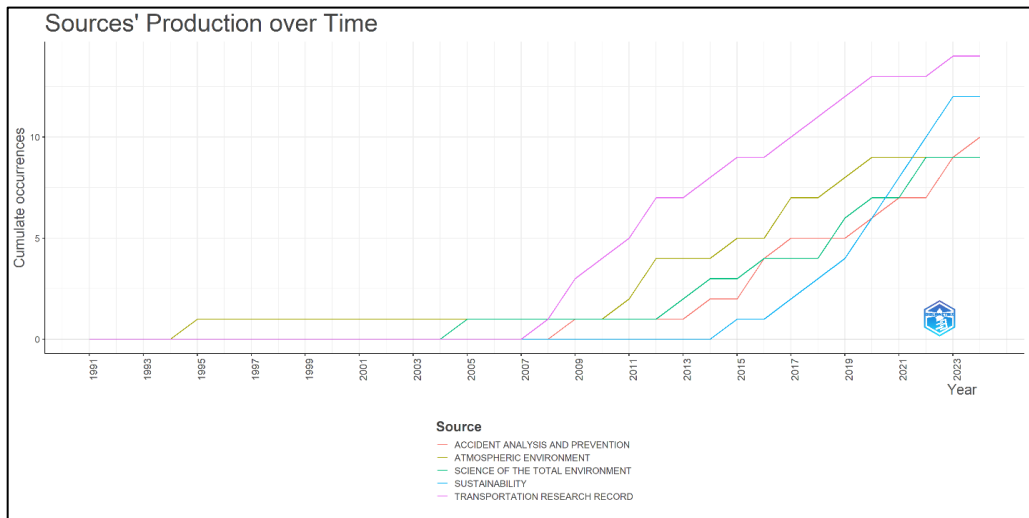


Figure 7: Evolution of Research Output by Source on Highway Impacts in Urban Areas (1991-2024)

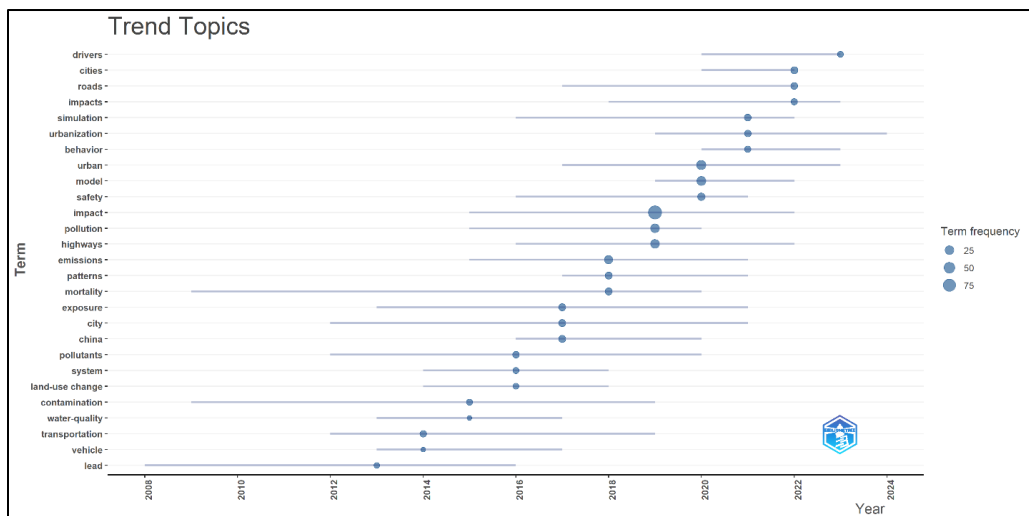


Figure 8: Emerging and Evolving Research Topics on Highway Impacts and Urban Issues (1991-2024)

The bibliometric analysis of trend topics in Figure 8 reveals several key patterns in the research landscape over time. Notably, Impact (93 occurrences) and Highways (25 occurrences) are prominent, indicating a substantial and

increasing interest in understanding the effects of highways and their broader impacts, particularly since 2015. Similarly, research on Urban (32 occurrences) and Cities (13 occurrences) has surged, especially in recent years (2020-2023), reflecting a growing focus on urban environments and the challenges of urbanization. Concerns about Pollution (25 occurrences) and Emissions (21 occurrences) have been consistent, aligning with global efforts to address environmental and health impacts.

The use of Model (28 occurrences) and Simulation (11 occurrences) techniques has also increased in recent years (2019-2022), highlighting advancements in computational tools for impact prediction. Emerging topics such as Urbanization (10 occurrences) and Behavior (9 occurrences) since 2019 suggest a growing interest in the interplay between urban growth and human behavior. Specific interests, such as China (12 occurrences) and water quality (5 occurrences), point to targeted research in particular regions and environmental contexts. Trends in topics such as Lead and Contamination reveal shifts in research focus over time, reflecting evolving priorities and emerging concerns. Overall, the analysis underscores a growing and diversified interest in highway impacts, urban issues, and environmental problems, particularly in recent years.

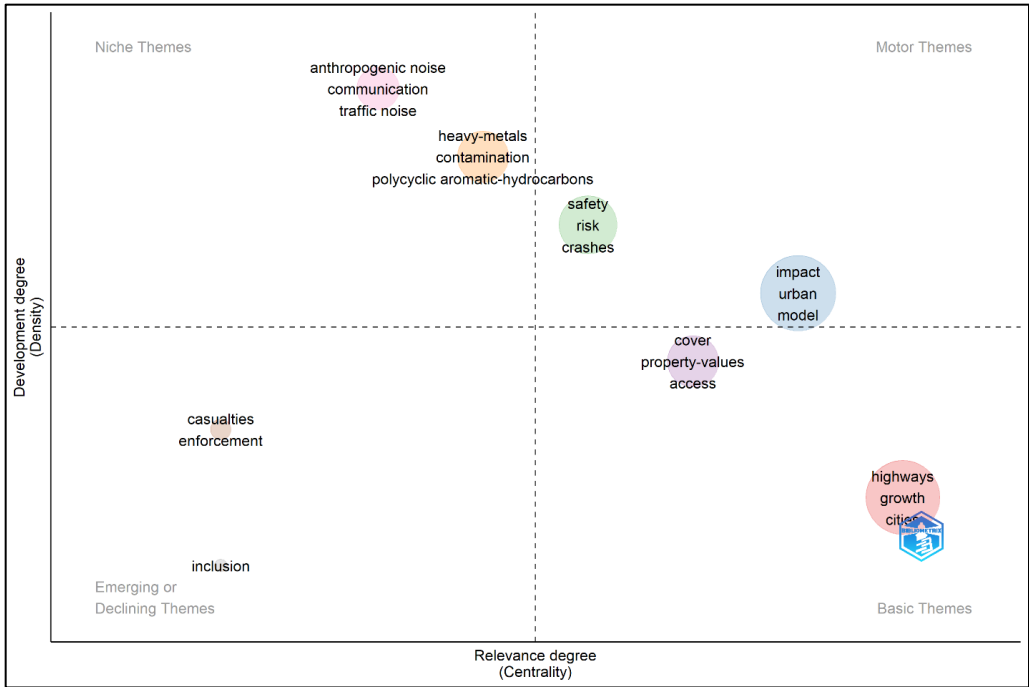


Figure 9: Thematic Mapping of Research on Highway Impacts in Urban Areas: Development and Relevance (1991-2024)

The thematic map, Figure 9, categorizes research themes into four distinct quadrants based on two dimensions: Development Degree (Density), which indicates how well developed and internally cohesive a theme is, and Relevance Degree (Centrality), which reflects the importance or centrality of a

theme within the broader research field. In the upper right quadrant, known as Motor Themes, we find themes such as "impact," "urban," and "model." These are both highly relevant and well-developed, suggesting that topics related to the impact of highways, urban development, and modeling are crucial and have been extensively explored in literature. The upper left quadrant contains Niche Themes like "anthropogenic noise," "communication," "traffic noise," "heavy metals," "contamination," and "polycyclic aromatic hydrocarbons." These themes are well developed but less central, indicating specialized research areas with significant internal coherence but limited connection to the core topics of the broader field. The lower left quadrant represents Emerging or Declining Themes, such as "casualties," "enforcement," and "inclusion," which are underdeveloped and less relevant. These themes may represent developing areas of interest that have not yet gained significant traction or could decline in importance. Lastly, the lower right quadrant, labeled "Basic Themes," includes "highways," "growth," "cities," "cover," "property values," and "access." These themes are central to the field but not yet fully developed, indicating they are crucial for understanding the impact of highways in urban areas but require further exploration. The thematic map offers a comprehensive overview of the research landscape on the impacts of highways in urban areas, highlighting which themes are well-established, niche, and emerging or underdeveloped. Understanding these dynamics will help identify gaps, focus on relevant themes, and contribute meaningfully to the ongoing discourse.

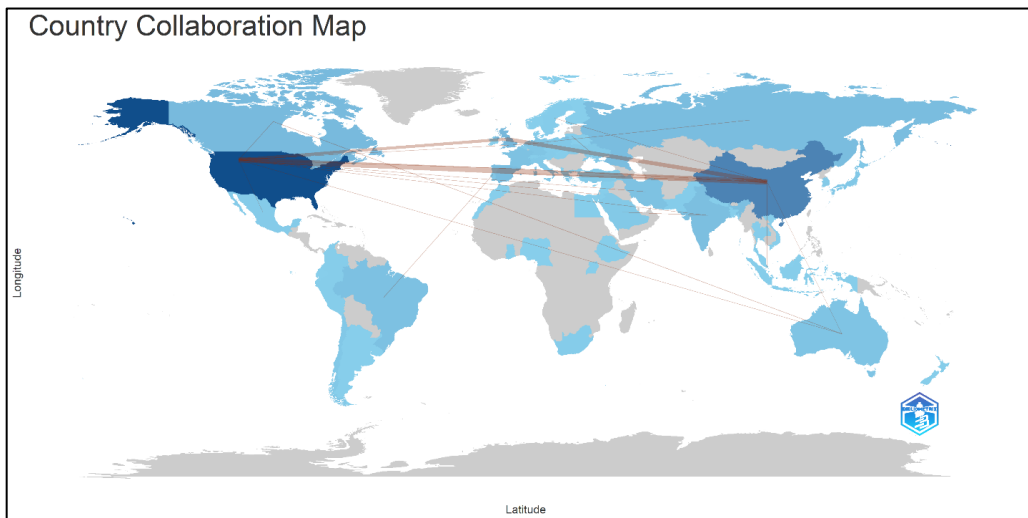


Figure 10: Global Research Collaboration Network on Highway Impacts in Urban Areas (1991-2024)

The bibliometric analysis of the country collaboration map in Figure 10 reveals key patterns in international research partnerships. The USA emerges as a central hub in the network, demonstrating frequent collaborations with a variety of countries, including China (6), Canada (2), India (2), and the United Kingdom (3), underscoring its significant role in global research. China also plays a prominent role, with substantial collaborations, particularly with the

USA (6), and notable partnerships with countries like Singapore, Spain, and Sweden (2 each). European countries exhibit strong connections both among themselves and with non-European nations; for example, the Netherlands has notable collaborations with Russia (2) and maintains connections with China, Sweden, and Singapore (1 each), while France and Spain engage actively with both the USA and other European countries. Brazil and Chile have established significant connections in South America, partnering with Spain, Portugal, and other South American nations such as Argentina and Colombia, indicating a growing regional research network.

The map showcases a diverse global network with collaborations spanning continents, such as Egypt with Greece and Saudi Arabia, and Pakistan with Ethiopia and Syria. Additionally, some collaborations are more specialized and isolated, such as Australia's with Bangladesh and Israel, or Greece's with Egypt and Saudi Arabia. Overall, the analysis highlights a complex web of international research collaborations, with the USA and China serving as major hubs and a broad range of countries participating in global research efforts.

Table 1: Citation Analysis of Countries in Highway Impact Research: Total and Average Citations (1991-2024)

Country	TC	Average Article Citation
USA	3610	30.10
Netherlands	1058	117.60
China	959	13.10
France	394	49.20
Canada	343	18.10
Iran	289	24.10
Turkey	183	30.50
Germany	174	19.30
Italy	169	33.80
Brazil	163	12.50

The bibliometric analysis of the most cited countries highlights notable differences in both total citations (TC) and average article citations, as shown in Figure 10. The USA, leading with 3,610 total citations and an average of 30.10 citations per article, demonstrates a substantial volume of impactful research.

However, its average citation count per article is moderate compared to some other countries. The Netherlands, with 1,058 total citations and an

impressive average of 117.60 citations per article, shows that despite a lower overall volume, its research is highly influential and frequently cited. In contrast, China has 959 total citations but an average of 13.10 citations per article, indicating significant research output with lower impact per article. France, with 394 total citations and an average of 49.20 citations per article, exhibits a strong impact relative to its research output. Canada, with 343 total citations and an average of 18.10 citations per article, has a lower total citation count but a relatively high average citation rate. Iran's 289 total citations and an average of 24.10 citations per article reflect moderate impact and high quality of research. Turkey, with 183 total citations and an average of 30.50 citations per article, shows that its research, while less in volume, is relatively well-cited. Germany has 174 total citations and an average of 19.30 citations per article, indicating a modest output with moderate impact. Italy, with 169 total citations and a higher average of 33.80 citations per article, suggests that its research is highly influential, though less in quantity. Brazil, with 163 total citations and an average of 12.50 citations per article, has significant research output but a lower average impact. While the USA leads in total citations, countries like the Netherlands and France are notable for their high average citations per article, reflecting varying levels of research impact and volume across different nations.

4. Conclusion

In conclusion, the bibliometric analysis of research on the impacts of highways in urban areas from 1991 to 2024 highlights a dynamic and evolving field marked by growing scholarly interest, interdisciplinary integration, and significant contributions from diverse sources and authors. As per the study, the trend in research publication from 1991 to 1996 was minimal, but the research interest grew gradually from 1997 to 2012. After 2012, there was a notable peak, and from 2020 to 2023, 41 articles were published. In 2024, 18 articles were already published in the first quarter, indicating sustained and growing interest in the field. The yearly trend in average citations shows fluctuations in scholars' interest in the field from 1991 to 2024. The citations in the field show a steady rise from 2002 to 2016. After 2016, there is a high scholarly recognition for the field of research on Highway Impacts in Urban Areas. As per the Top Journals Contribution highlights, the research in highway impacts in urban areas were published in diverse range of journals. The journals of Transportation Research Record and Sustainability are the leading journals for the field. According to the top locally cited authors in the research field, the scholars with the highest citations identified in the study are Ripmeester E.A.P. and Slabbekoorn. Following them, the most cited scholars include Borroum S., Kayhanian M., Kim Y., Roustan Y., Seigneur C., Singh A., Suverkropp C., and Wu Y. Evolution of Research Output by Source shows a significant upward trend over the two decades. Transportation Research Record and sustainability sources are significantly grown with the number of documents. However, the field has a notable improvement in interdisciplinary

research. The emerging and evolving research topics reveal key patterns in the study, with a primary focus on terms such as "impact," "urban," "pollution," and "model," which are commonly used to explore highway-related issues. After 2019, the use of models, simulations and techniques has increased in the research field. The thematic map analysis shows that motor themes such as impact, urban, and model are well-developed and play an important role in highway studies. Basic themes such as highways, growth, cities, and property values are core topics but remain underdeveloped. Therefore, researchers can focus on these areas as potential research gaps in the field. The analysis of global collaboration shows broad connections between countries. The USA and China serve as key hubs, maintaining partnerships with multiple nations. Similarly, European, South American, and Asian countries contribute actively, indicating both global and regional research integration. The bibliometric analysis of the most cited countries reveals that the USA has the highest total citations. The Netherlands and France have the highest average citations per article. Finally, the analysis highlights the expansion and growing interconnection of the field of study, marked by rising publication rates, evolving research themes, and strong global collaborations. The findings are important for future urban planning and infrastructure policy recommendations, as they consider the key themes of the study. Furthermore, most studies are concentrated in developed countries, indicating a knowledge gap in rapidly urbanizing developing countries. Thus, the study highlights the potential for future interdisciplinary research on the impacts of highways in urban areas, including developing countries.

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