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Modal Shift in the Context of Sustainable Development: A Bibliometric Exploration of Scientific Trends.

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Abstract

This article presents a bibliometric analysis of the scientific literature on modal shift within the framework of sustainable development, covering the period from 2015 to 2025. Modal shift referring to the transition from private motorized transport modes to more sustainable alternatives such as public transit, walking, and cycling has become a central issue in strategies aimed at ecological transition and urban resilience.

The study is based on a final sample of 119 peer-reviewed articles, selected from the **Web of Science** database using the PRISMA method. The data were analyzed with Biblioshiny**,** part of the Bibliometrix package in RStudio**.** The objective is to map scientific trends, identify the most influential authors, institutions, countries, and journals, and to explore the conceptual structure of the field.

The results reveal a continuous increase in publication volume, with a notable peak in 2022. European countries particularly Germany, the United Kingdom, and Belgium stand out for their high research output, while China and the United States are showing growing engagement. At the institutional level, universities such as Vrije Universiteit Brussel and TU Berlin emerge as key knowledge hubs. The keyword co-occurrence analysis highlights several thematic clusters focused on sustainable mobility, user behavior, emission reduction, and public policy. Modal shift is positioned as a pivotal concept that links these various research areas.

The article concludes by advocating for stronger international collaboration and the integration of qualitative and interdisciplinary approaches to enrich the understanding of territorial and behavioral dynamics related to sustainable mobility.

Keywords: Modal shift; Sustainable mobility; Bibliometric analysis; Urban transport

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Introduction

The transition toward sustainable mobility has become one of the most pressing challenges of the 21st century, both for researchers and policymakers. In the face of climate change, automobile dependency, and urban fragmentation, modal shif*t* defined as the transition from private motorized transport modes to more sustainable alternatives such as public transit, cycling, and walking has emerged as a key strategic lever to reduce greenhouse gas emissions, promote social inclusion, and reshape urban mobility systems.

Over the past decade, scientific interest in this topic has grown considerably, mobilizing disciplines such as urban planning, transport economics, geography, behavioral sciences, and environmental policy. However, the existing literature remains fragmented across various themes, regions, and methodological approaches. This dispersion limits our ability to identify conceptual advances, collaborative patterns, and key contributors in a coherent manner.

In this context, the present study undertakes a bibliometric analysis of scientific publications related to modal shift within the broader framework of sustainable development, covering the period from 2015 to 2025. The main objective is to map the intellectual, thematic, and collaborative landscape of the field in order to provide a clearer understanding of its scientific trajectory, identify influential research actors, and uncover emerging research trends.

To this end, the research is guided by four main questions:

• RQ1: What are the dominant scientific trends regarding modal shift and sustainable mobility from 2015 to 2025?

• RQ2: Who are the most influential authors, institutions, journals, and countries in this research area?

• RQ3: What are the main conceptual and thematic structures organizing the academic discourse on modal shift?

• RQ4: What emerging directions can inform future research and public policy in the field of sustainable mobility?

Methodologically, the article combines descriptive bibliometric techniques and science mapping analysis using the Bibliometrix R package (v5.0.1) and its interactive Biblioshiny interface. **The structure of the article follows a logical progression: after presenting the methodology, the results are analyzed and discussed, followed by practical recommendations and a reflection on the study's limitations and research prospects.**

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1. Research methodology :

This section outlines the methodology adopted for conducting our bibliometric study on modal shift within the broader context of sustainable development. It presents the rationale behind the methodological choices and the key steps followed throughout the analysis.

1.1.Data collection method:

Bibliometric analysis is a robust quantitative method that enables the systematic assessment of scientific research trends through statistical techniques. It encompasses various tools such as co-authorship analysis, co-citation mapping, and keyword co-occurrence, providing a comprehensive overview of the intellectual and thematic landscape of a research domain (De Bakker et al., 2005).

This approach was deemed particularly relevant to our topic, as it allows for the exploration of a large volume of academic literature in a structured, reproducible, and objective manner. In contrast to qualitative approaches, which may be subject to researcher bias and interpretive subjectivity (MacCoun, 1998), bibliometric methods rely on measurable data, thus enhancing the validity and neutrality of the findings.

This bibliometric approach is increasingly applied in sustainability and transport studies. Similar studies have used it to examine trends in smart mobility, urban resilience, and low carbon transport strategies. In the context of **modal shift**, this method enables a retrospective and prospective analysis of how the field has evolved, highlighting the emergence of new research clusters, the role of key authors and institutions, and the evolution of conceptual frameworks over time.

So, the bibliometric analysis conducted in this study was based on data extracted from the Web of Science Core Collection, recognized for its scientific rigor and multidisciplinary coverage of peer-reviewed journals. This database was chosen due to its compatibility with advanced bibliometric tools and its strong citation tracking capacity, making it an ideal source for quantitative research evaluation.

The PRISMA flow diagram illustrates the article selection process adopted in this bibliometric review on modal shift and sustainable development. An initial pool of **284 records** was identified through systematic searches conducted in the **Web of Science** database, using keywords related to “modal shift,” “sustainable mobility,” and “sustainable development.” In the screening phase, 81 records were excluded for one or more of the following reasons: the publication date was outside the selected range of 2015 **to** 2025, the documents were not

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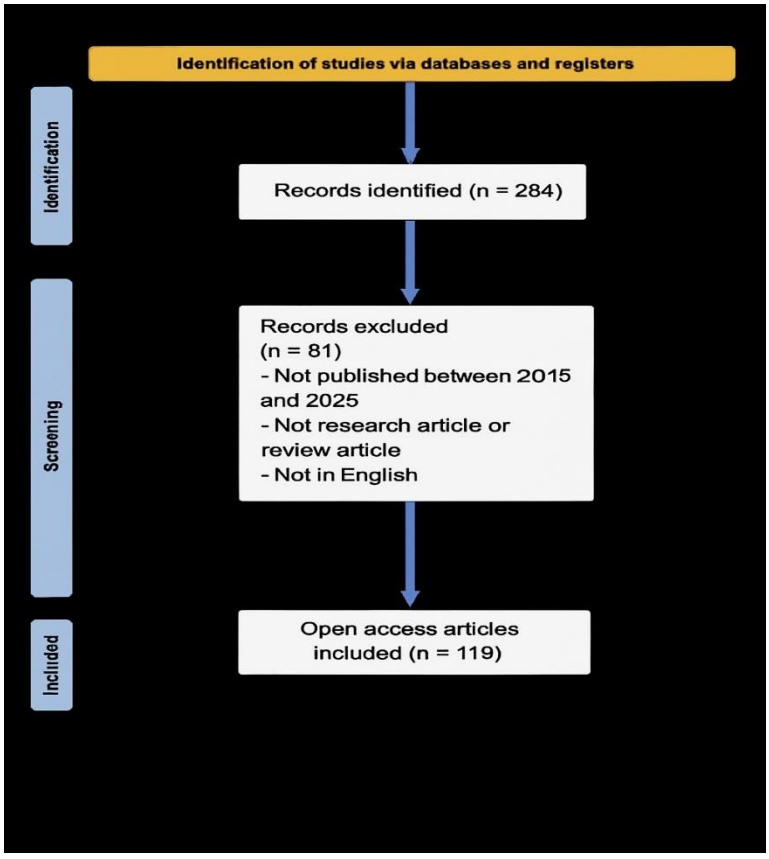
categorized as research articles or review articles, or they were not written in English. After applying these inclusion criteria, a final dataset of 119 open access articles was selected for bibliometric analysis using the **Biblioshiny** tool. So, the final dataset, refined for consistency and relevance, was exported in **BibTeX format** and processed using **RStudio** with the **Bibliometrix R package**, through its **Biblioshiny web interface** (Lim et al., 2021). This rigorous filtering process ensured the relevance, quality, and consistency of the data, providing a solid foundation for exploring scientific production, collaboration networks, and thematic evolutions in the field of sustainable modal shift. (Figure 1)

Figure N°1 : Research Design.



Source: The PRISMA (Author)

1.2.Data Analysis Method:

The analytical approach combined both descriptive bibliometric techniques and science mapping analysis**.** Using the **Bibliometrix (v5.0.1)** and **Biblioshiny** tools, the first phase involved a descriptive analysis to identify trends in publication output, most productive authors, contributing countries, leading journals, and institutional affiliations. This provided a macrolevel overview of research productivity and impact in the field of modal shift and sustainable development.

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Subsequently, network analysis methods were employed to investigate the structural dimensions of the scientific domain. These included:

- **Co-authorship analysis**, to understand collaboration patterns among authors and countries.
- **Keyword co-occurrence analysis**, to explore emerging topics and thematic clusters.
- **Co-citation analysis**, to identify core references and intellectual foundations.

The networks generated were visualized using clustering algorithms and centrality metrics such as betweenness**,** closeness**,** and PageRank, offering insights into the strategic positioning of entities within the knowledge structure. These analyses helped uncover the intellectual**,** social, and conceptual structures shaping the scientific discourse on modal shift and its integration into sustainable urban transport systems.

By applying this method, our study not only maps the intellectual and collaborative structure of the research landscape but also provides insights into how modal shift is framed within sustainable development discourse, revealing strategic directions for future research and policy debates.

1.3.Epistemological and Methodological Foundations :

This research is anchored in a **positivist epistemological paradigm**, which assumes that scientific knowledge can be objectively measured and analyzed through observable patterns in empirical data. The study adopts a **quantitative and deductive reasoning approach**, aiming to identify and interpret the structural characteristics of the scientific literature on modal shift and sustainable development. The use of bibliometric analysis is particularly justified in this context, as it allows for the systematic mapping of research outputs, authorship networks, and thematic trends based on verifiable and reproducible data. This method enables the researchers to uncover not only the intellectual foundations of the field but also emerging scientific directions, while minimizing subjective biases. The choice of this approach reflects a commitment to analytical rigor, transparency, and comprehensive coverage of the academic landscape.

2. Results and discussions:

2.1.Descriptive analysis:

In this study, a bibliometric analysis was conducted using the Biblioshiny tool (within RStudio) to explore scientific trends related to modal shift in the context of sustainable development over the period 2015–2025. The extracted table presents key descriptive statistics derived from a curated dataset of 119 scientific documents, sourced from 60 academic journals and outlets.

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Among these, 7 were single-authored publications, and 12 were literature reviews, highlighting a growing academic interest in synthesizing and structuring knowledge around sustainable mobility practices. The share of international co-authorship reached 31.09%, reflecting a notable level of cross-border research collaboration. On average, each publication involved 3.71 co-authors, contributing to a total of 425 distinct authors, further emphasizing the collaborative nature of research in this field. The dataset includes 7484 references, indicating strong scholarly engagement and citation depth. With an average document age of 3.98 years, the corpus demonstrates a relatively recent and dynamic development of the topic. The observed annual growth rate of 5.76% confirms a steady increase in scientific production in this area. Furthermore, the final selection includes 106 full research articles and 1 early access publication, reinforcing the predominance of empirical contributions in the study of modal shift and sustainable development. (Table 1)

Table N°1: Descriptive Overview of the Bibliometric Corpus (2015–2025)

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2015:2025
Sources (Journals, Books, etc)	60
Documents	119
Annual Growth Rate %	5,76
Document Average Age	3,98
Average citations per doc	22,69
References	7484
DOCUMENT CONTENTS	
Keywords Plus (ID)	445
Author's Keywords (DE)	498
AUTHORS	
Authors	425
Authors of single-authored docs	6
AUTHORS COLLABORATION	
Single-authored docs	7
Co-Authors per Doc	3,71
International co-authorships %	31,09

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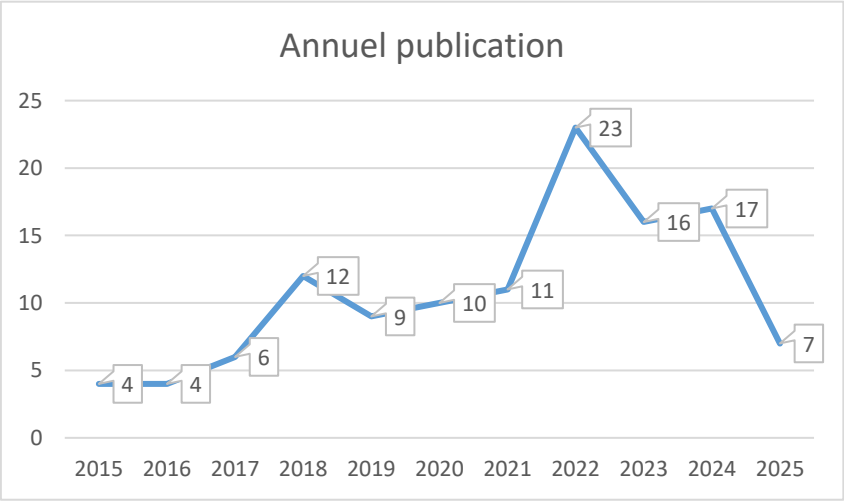
DOCUMENT TYPES	
article	106
article; early access	1
review	12

Source: Author (Web of Science Database)

The annual scientific production chart illustrates the evolution of research output related to modal shift and sustainable development between 2015 and 2025. The analysis reveals a general upward trend in the number of publications, with notable fluctuations across the years.

From 2015 to 2017, scientific output remained relatively modest and stable, with 4 to 6 publications per year, indicating an emerging interest in the topic. A significant increase occurred in 2018**,** reaching 12 publications, likely reflecting growing global concern for sustainable transport policies following international climate agendas. After a slight decline in 2019 (9) and a gradual recovery between 2020 and 2021 (10 and 11)**,** a sharp rise is observed in 2022, peaking at 23 publications, the highest in the entire period. This surge may be attributed to post-pandemic recovery policies and increased research on low-carbon mobility transitions. However, the trend declined again in 2023 (16) and remained relatively stable in 2024 (17)**,** before experiencing a steep drop to 7 publications in 2025 possibly due to incomplete data for the final year or delays in indexing recent publications. Overall, the dataset shows a growth dynamic over the decade, confirming that modal shift is an increasingly relevant research topic in the context of sustainability transitions. (figure 2)

Figure N°2: Annuel publication



Source: Author (Web of Science Database)

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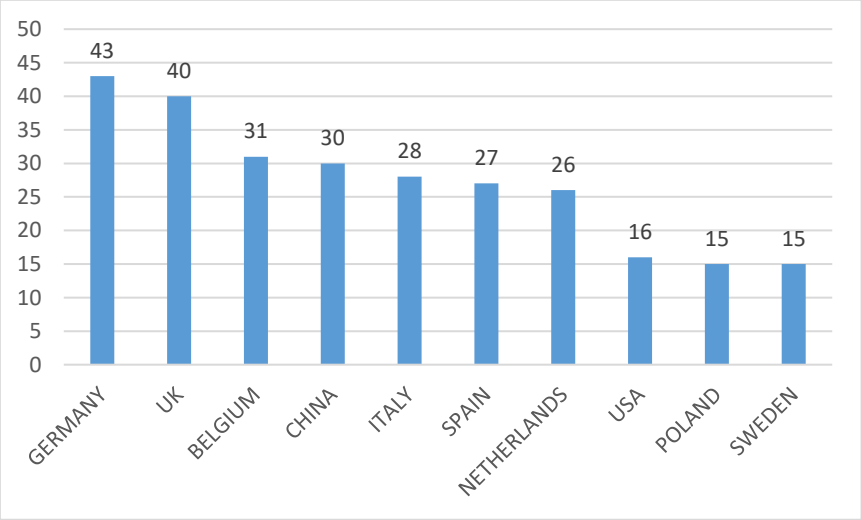
2.1.1. Contributing country:

The analysis of contributing countries reveals that the majority of publications originate from Europe, with Germany (43), the United Kingdom (40), and Belgium (31) leading the output. This highlights the key role these countries play in advancing research on modal shift and sustainable mobility. China (30) also emerges as a significant contributor, reflecting a growing international engagement with these issues beyond the European context.

This geographical distribution likely reflects a combination of factors, including national transport policies**,** the maturity of mobility systems, and the density of academic research networks in these countries. The presence of countries like Italy, Spain, and the Netherlands further underscores the diversity of approaches within Europe, while contributions **from** the United States (16), Poland (15), and Sweden (15**)** suggest a broader, albeit uneven, global interest in the field.

Figure N°3: Top Contributing Countries by Number of Publications



Source: Author (Web of Science Database)

The following table presents the top ten countries based on total citations and average citations per article in the field of modal shift and sustainable development. The United Kingdom and Italy recorded the highest total citation counts (387 and 379, respectively), while the United States achieved the highest average citations per article (69.5), reflecting a strong scholarly impact despite a lower number of publications. Notably, countries such as Greece and Sweden also demonstrated high citation averages, underscoring the growing academic influence of smaller research systems. These findings highlight the global relevance and intellectual depth of research focused on sustainable mobility transitions.

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Table N°2: Top Cited Countries

Country	TC	Average Article Citations
UNITED KINGDOM	387	29.8
ITALY	379	42.1
GERMANY	300	21.4
USA	278	69.5
CHINA	242	26.9
SWEDEN	168	33.6
GREECE	163	40.8
NETHERLANDS	129	14.3
BELGIUM	122	15.2
SPAIN	84	14.0

Source: Author (Web of Science Database

2.1.2. Contributing affiliations:

The analysis of institutional affiliations highlights the leading academic contributors to the research field. At the top of the list is Vrije Universiteit Brussel, with 9 articles, followed by Delft University of Technology and Technische Universität Berlin, each contributing 8 publications**.** These figures underscore the prominent role of European institutions**,** particularly from Belgium, the Netherlands, and Germany, in advancing research on modal shift, sustainable mobility, and transport policy.

Other key contributors include Chalmers University of Technology (Sweden), University of Antwerp**,** University of Ghent**,** and Eindhoven University of Technology, suggesting a wellestablished European academic network actively engaged in this domain.

Beyond Europe, institutions such as Southeast University and Beijing Jiaotong University (China), along with Universidad Autónoma de Madrid (Spain), also appear among the most productive. This indicates a growing internationalization of the research landscape, with notable engagement from both Asian and Southern European institutions.

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Table N°3: Most Productive Affiliations

Affiliation	Articles
VRIJE UNIV BRUSSEL	9
DELFT UNIV TECHNOL	8
TECH UNIV BERLIN	8
CHALMERS UNIV TECHNOL	7
UNIV ANTWERP	6
UNIV GHENT	6
EINDHOVEN UNIV TECHNOL	5
SOUTHEAST UNIV	5
UNIV AUTONOMA MADRID	5
BEIJING JIAOTONG UNIV	4

Source: Author (Web of Science Database)

2.1.3. Contributing authors:

This bar chart compares the number of articles authored by key contributors with their corresponding fractionalized article count. The fractionalized count adjusts for co-authorship by dividing each article's contribution proportionally among the authors, offering a more accurate reflection of individual author contribution.

Mostofi H. emerges as the most prolific author with 3 articles and a fractionalized count of 2.5, indicating a strong personal contribution across their co-authored publications. Other notable contributors include **Nikitas A.**, whose fractionalized score (1.33) is relatively high despite having only 2 publications, suggesting a leading role in those studies.

In contrast, authors such as **Gautama S.** (0.45), **Gleser M.** (0.39), and **Krstic M.** (0.27) show lower fractionalized contributions, which may imply that they were secondary contributors **or** part of larger author teams**.** Overall, this chart highlights the importance of considering both raw publication counts and individual author contribution when evaluating scholarly productivity.

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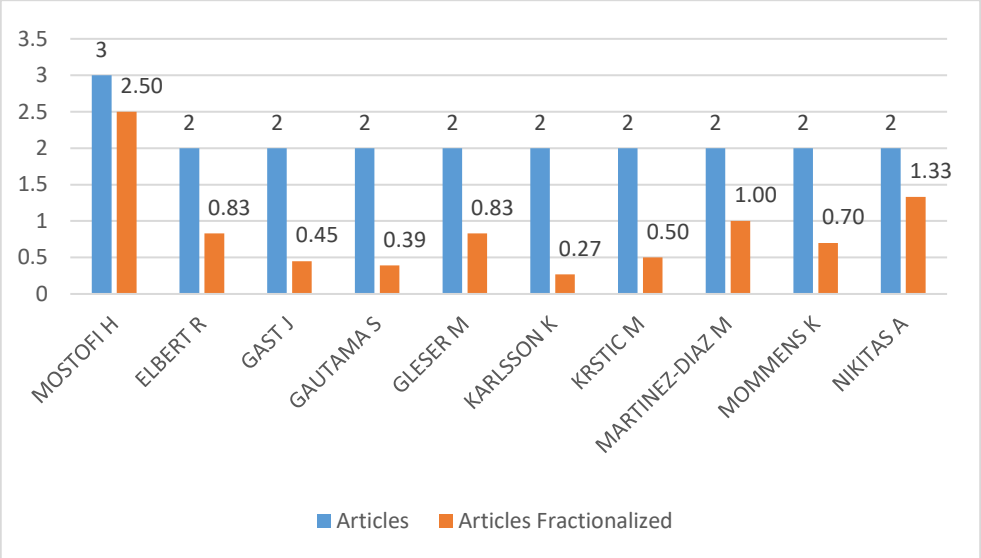
Figure N°4: Top Authors by Article Count and Fractional Contribution



Source: Author (Web of Science Database

2.2.Citation Analysis:

2.2.1. Most Productive Journals:

The table highlights the most frequently used publication sources within the analyzed corpus. The journal ***Sustainability*** clearly dominates the landscape, with 28 published articles, reflecting its central role in disseminating research on sustainable mobility**,** modal shift, and transport policy. Its open-access nature and interdisciplinary focus may contribute to its high representation. Following this, ***Energies*** appears with 6 articles, suggesting a growing interest in the energy dimension of transportation and sustainability. Journals such as the ***Journal of Transport & Health*** and ***Transportation Research Part A: Policy and Practice*** each contribute 4 publications, highlighting the relevance of public health and policy-oriented approaches in current transport research.

Several other journals, including ***Cities***, ***Journal of Advanced Transportation***, and ***Sustainable Cities and Society***, contribute with 3 articles each. This distribution reflects the multidisciplinary nature of the field, spanning urban studies**,** transport systems, and sustainability science**.**

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Table N°4: Most productive journals based on number of articles published.

Sources	Articles
SUSTAINABILITY	28
ENERGIES	6
JOURNAL OF TRANSPORT \& HEALTH	4
TRANSPORTATION RESEARCH PART A-POLICY AND PRACTICE	4
CITIES	3
JOURNAL OF ADVANCED TRANSPORTATION	3
RESEARCH IN TRANSPORTATION BUSINESS AND MANAGEMENT	3
SUSTAINABLE CITIES AND SOCIETY	3
TRANSPORTATION RESEARCH PART D-TRANSPORT AND ENVIRONMENT	3
APPLIED SCIENCES-BASEL	2

Source: Author (Web of Science Database

2.2.2. Citation Impact of the Most Relevant Sources

This table highlights the bibliometric performance of the most relevant journals in the field. *Sustainability* stands out with the highest h-index (12) and total citations (614)**,** reflecting its strong influence and consistent output since 2017. *Energies* and *Environmental Research Letters* also show significant citation impact. Newer journals such as *Research in Transportation Business and Management* and *Cities*, despite their recent entry (2022), display high m-index values, indicating a growing influence in a short time.

The data illustrates a mix of long-established and emerging sources, both contributing to the development of knowledge in sustainable and modal-shift-related research.

Table N°5: Impact of sources based on total number of citations (TC)

Source	h_index	g_index	m_index	TC	NP	PY_start
SUSTAINABILITY	12	24	1,333	614	28	2017
ENERGIES	6	6	0,667	89	6	2017
JOURNAL OF ADVANCED TRANSPORTATION	3	3	0,375	60	3	2018

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RESEARCH IN TRANSPORTATION BUSINESS AND MANAGEMENT	3	3	0,75	27	3	2022
TRANSPORTATION RESEARCH PART A-POLICY AND PRACTICE	3	4	0,3	41	4	2016
TRANSPORTATION RESEARCH PART D-TRANSPORT AND ENVIRONMENT	3	3	0,273	249	3	2015
APPLIED SCIENCES-BASEL	2	2	0,4	48	2	2021
CASE STUDIES ON TRANSPORT POLICY	2	2	0,5	30	2	2022
CITIES	2	3	0,5	19	3	2022
ENVIRONMENTAL RESEARCH LETTERS	2	2	0,333	117	2	2020

Source: Author (Web of Science Database

2.2.3. Author Impact Analysis

This table presents key bibliometric indicators for the top contributing authors in the field. **Mostofi H.** ranks highest with an h-index of 3, and 65 total citations across 3 publications since 2021, reflecting strong and consistent contributions.

Authors such as **Nikitas A.** (114 citations) and **Sallis JF** (266 citations) show high overall impact, despite a lower **m-index**, indicating influence spread over a longer time. In contrast, recent contributors like **Elbert R., Gast J., and Gleser M.** (all starting in 2023) show promising m-index scores (0.667)**,** reflecting rapid academic recognition. These results highlight both established scholars and emerging voices in the literature on sustainable transport and modal shift.

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Table N°6: Bibliometric performance of the most influential authors

Author	h_index	g_index	m_index	TC	NP	PY_start
MOSTOFI H	3	3	0,6	65	3	2021
ELBERT R	2	2	0,667	10	2	2023
GAST J	2	2	0,667	7	2	2023
GAUTAMA S	2	2	0,2	72	2	2016
GLESER M	2	2	0,667	10	2	2023
KARLSSON K	2	2	0,25	55	2	2018
KRSTIC M	2	2	0,333	60	2	2020
NIKITAS A	2	2	0,25	114	2	2018
OVIEDO D	2	2	0,333	35	2	2020
SALLIS JF	2	2	0,2	266	2	2016

Source: Author (Web of Science Database)

2.3.Network analysis

The network analysis employs a relational approach to examine and categorize bibliographic data such as Co-word, Citation, Co-authorship, bibliographic coupling, and Co-citation.

2.3.1. Co-word analysis:

This table summarizes the centrality metrics of the most relevant keywords in the co-occurrence network. The term “modal shift” clearly dominates the conceptual structure, with the highest betweenness (372.6), closeness (0.016), and PageRank (0.108) scores. This indicates that it plays a pivotal role in connecting different clusters and bridging key research themes.

Keywords such as “transport” and “sustainable mobility” also show strong centrality values, confirming their foundational importance in the scientific discourse. In contrast, terms like “public transport”, “travel behavior”, and “mode choice” have lower betweenness and PageRank, suggesting a more thematic or supporting role within the overall structure.

Concepts such as “systems” and “policy” exhibit the lowest centrality indicators, indicating a peripheral position in the keyword network either due to lower co-occurrence or weaker connections with core themes. Overall, the results highlight the strategic importance of modal shift as a central node in the literature, closely linked to the broader themes of transport systems and sustainable mobility.

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Table N°7: Co-Occurrence of Keyword.

Node	Cluster	Betweenness	Closeness	PageRank
modal shift	1	372,6	0,016	0,108
transport	1	166,59	0,015	0,074
sustainable mobility	1	103,139	0,014	0,069
public transport	1	12,983	0,013	0,037
travel	1	36,788	0,013	0,038
travel behavior	1	16,493	0,012	0,034
choice	1	1,302	0,011	0,018
systems	1	0	0,01	0,013
mode choice	1	1,728	0,012	0,02
policy	1	0,224	0,01	0,013

Source: Author (Web of Science Database)

So Figure 5 presents a tree map of the most frequently used keywords in the scientific literature on modal shift and sustainable mobility between 2015 and 2025. The largest areas are occupied by terms such as “modal shift,” “transport,” “sustainability,” and “sustainable mobility,” highlighting their central role in the field. Other significant terms like “mobility,” “public transport,” “emissions,” and “travel behavior” reflect the multidimensional nature of research, ranging from environmental impacts to user behavior. This visualization illustrates the thematic richness and interdisciplinary character of the current academic discourse.

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Figure N°5: Tree Map of the Most Frequent Keywords in Scientific Publications (2015–2025)

Source: Author (Web of Science Database)

2.3.2. Keyword Co-Occurrence Network:

Findings from the co-occurrence network (Figure 7) highlight that the theme of modal shift forms the central cluster in the scientific discourse, closely linked to core concepts such as sustainable mobility, public transport, and sustainability. This cluster represents the primary research focus on strategies that promote a transition from private vehicle use to more sustainable transport modes.

Five additional thematic clusters are identified in the network, each representing a distinct yet interconnected aspect of the broader topic.

First, the sustainability cluster connects modal shift with keywords such as emissions, climate change, environmental impact, and transport strategies. This indicates that many studies situate modal shift within a climate policy framework, focusing on reducing emissions through improved public transport and active mobility solutions. Modal shift is thus not only a transport planning issue but also a core strategy for achieving broader environmental goals.

Second, a mobility systems cluster (purple) encompasses terms like land use, dynamics, and urban form, suggesting research linking urban planning and mobility behavior. This cluster

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emphasizes the structural and spatial determinants of modal shift, particularly in relation to infrastructure, density, and accessibility.

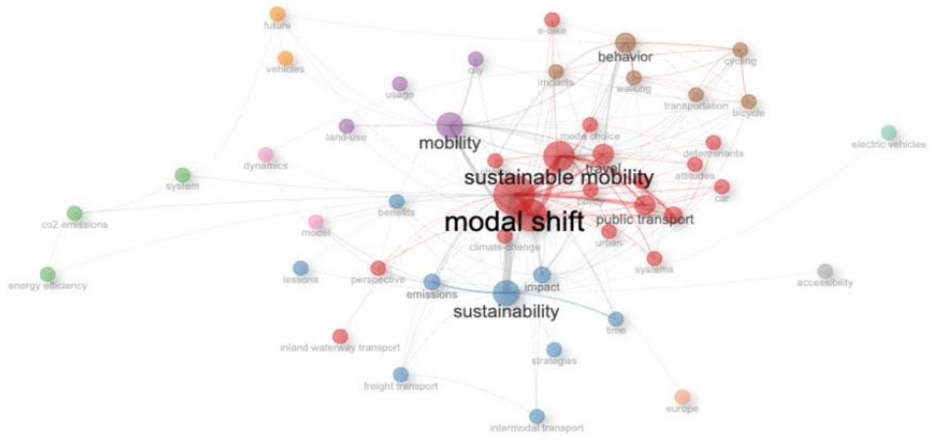
Third, the behavioral cluster (orange) groups terms such as travel behavior, attitudes, choice, and decision-making. This reflects the growing attention to individual-level determinants of mobility choices, including psychological, social, and cultural factors. It aligns with the increasing use of behavioral theories (e.g., Theory of Planned Behavior) in transport studies.

Fourth, a technological innovation cluster includes keywords such as electric vehicles, smart mobility, and ICT. While less central in the network, this cluster represents emerging research that explores how technology adoption and innovation can facilitate modal shift, either by enhancing the attractiveness of alternative modes or integrating systems.

Fifth, a policy and governance cluster are visible, with keywords like accessibility, equity, and policy frameworks. This reflects the role of public policy, transport justice, and regulatory mechanisms in shaping mobility patterns. It suggests that modal shift requires not only behavioral and technical solutions but also institutional support and inclusive planning.

Overall, the conceptual structure reveals a multidisciplinary and interconnected research landscape, where modal shift acts as a central pivot linking environmental sustainability, urban design, behavioral sciences, and public policy. The figure confirms that the transition toward sustainable mobility is a complex, system-based challenge, requiring integration across domains.

Figure N°6: Keyword Co-Occurrence Network in Modal Shift Research



Source: Author (Web of Science Database)

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2.3.3. Co-authorship analysis

The co-authorship analysis provides a detailed view of collaborative dynamics among countries engaged in research on sustainable mobility and modal shift. Through bibliometric techniques, this analysis uncovers the structure of international research networks and identifies the most influential countries in terms of scientific collaboration. The table below presents the top ten countries ranked by centrality indicators such as PageRank, betweenness, and closeness, reflecting their connectivity and strategic position within the co-authorship network.

The results show that the United Kingdom holds a central position with the highest betweenness value (145.910) and PageRank score (0.091), indicating its strong bridging role between different research clusters. The United States, Denmark, Netherlands, and Sweden also stand out with high centrality scores, suggesting their significant role in shaping international research on transport and sustainability. These countries act as hubs, linking various institutions and fostering multidisciplinary collaboration.

Table N°8: Top Countries by Network Centrality Indicators

Node	Cluster	Betweenness	Closeness	PageRank
united kingdom	2	145,91	0,021	0,091
usa	1	81,632	0,021	0,084
denmark	1	33,756	0,018	0,069
netherlands	1	70,016	0,019	0,06
sweden	1	70,404	0,019	0,058
italy	1	32,258	0,019	0,045
belgium	2	31,693	0,018	0,041
germany	4	27,233	0,017	0,038
canada	2	1,167	0,016	0,034
france	4	14,707	0,015	0,032

Source: Author (Web of Science Database)

The network visualization highlights clear regional and linguistic clusters. Notable links are observed between the UK, Belgium, and Canada, as well as among Nordic countries such as Sweden, Denmark, and the Netherlands. **France**, although present in the network, appears more peripheral, with a lower *PageRank* (0.032), indicating relatively fewer high-impact collaborations compared to its European counterparts.

This analysis reveals the pivotal role of cross-national partnerships in advancing research on modal shift strategies and sustainable transport systems. Countries with higher centrality

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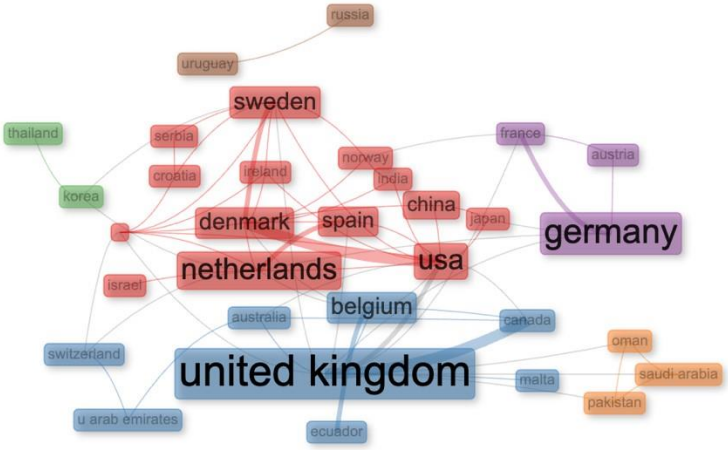
typically benefit from strong research infrastructures, national policies promoting sustainable mobility, and established collaborations between universities, local governments, and transport agencies. Their academic outputs contribute significantly to the global discourse on public transportation, low-emission urban mobility, and behavioral transition toward greener transport modes. (Figure 7)

Figure N°7: International Co-Authorship Network



Source: Author (Web of Science Database)

2.3.4. Co citation:

The co-citation network (Figure 8) illustrates the intellectual foundation of research on sustainable mobility and modal shift. Central references such as *Fishman (2016)*, *Pucher (2008)*, and *Banister (2008)* form the backbone of the field, often co-cited in studies related to urban cycling, transport policies, and behavioral change. Distinct clusters reflect thematic subfields: for instance, *Ajzen (1991)* anchors work on behavioral theories, while other nodes represent environmental concerns or technological innovations. This intellectual structure underscores the multidisciplinary nature of the research domain, connecting planning, psychology, sustainability, and public policy.

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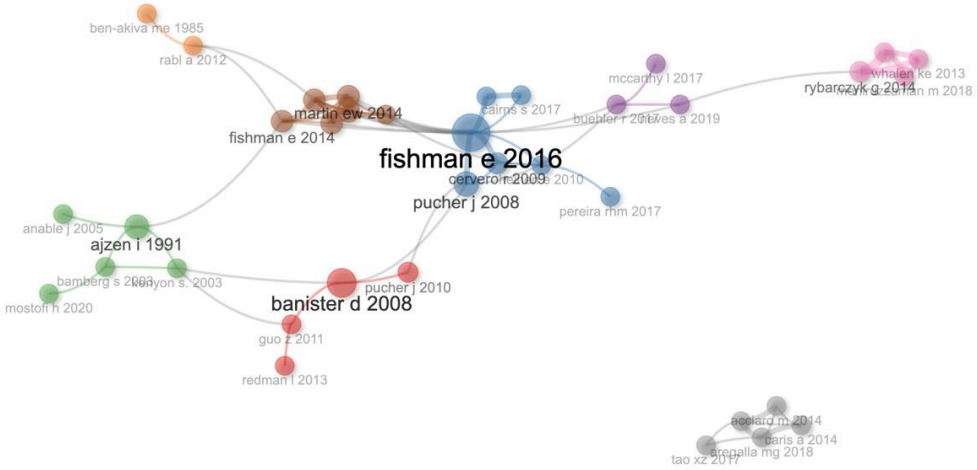
Figure N°8: Co-Citation Network



Source: Author (Web of Science Database)

3. **Practical Recommendations:**

- Promote international research collaboration to strengthen cross-border knowledge on sustainable mobility.
- Translate research into policy by engaging with decision-makers and urban planners.
- Encourage open access and multilingual publishing to broaden global reach and inclusion.
- Support behavioral studies and awareness campaigns to foster modal shift adoption.
- Invest in smart and green transport technologies to enhance sustainable mobility systems.

4. **Limitations and future research directions:**

This study presents several limitations that may impact the generalizability of its findings

- **Database Scope**: Using only Web of Science may exclude relevant studies from other databases like Scopus or Google Scholar. A multi-source approach is recommended.
- **Language Bias:** The focus on English-language publications limits global representativeness. Future work should include multilingual sources.
- **Methodological Limits:** Bibliometric methods reveal trends but overlook real-world dynamics. Qualitative research (e.g., case studies, interviews) is needed.
- **Restricted Document Types:** Excluding books and grey literature may reduce conceptual depth. Future studies should diversify source types.
- **Incomplete 2025 Data:** Publications from 2025 may be underrepresented due to indexing delays. Results for this year should be interpreted cautiously.

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Conclusion

This bibliometric study has offered a structured and comprehensive overview of the scientific landscape surrounding modal shift within the broader framework of sustainable development from 2015 to 2025. By analyzing 119 peer-reviewed publications sourced from the Web of Science database, the research identified prevailing trends, influential contributors, and the thematic progression of this field. The growing academic focus on modal shift reflects its increasing importance as a strategic lever to address global challenges such as climate change, urban congestion, and social inequalities in mobility.

The results reveal a progressive and dynamic expansion of the literature, especially after key international climate and sustainability milestones. European countries most notably Germany, the United Kingdom, and Belgium emerge as dominant contributors to the academic debate, while the involvement of China, the United States, and several countries from Southern and Eastern Europe points to a broader global engagement in sustainable mobility research.

Thematic mapping and keyword co-occurrence analyses demonstrate the richness and multidisciplinarity of the field. “Modal shift” lies at the heart of an interconnected web of concepts linking sustainable mobility, behavioral change, emissions reduction, and transport policy. These insights confirm the convergence of multiple disciplines such as environmental sciences, urban planning, transport economics, and behavioral studies around the issue of mobility transitions.

In conclusion, this bibliometric analysis not only charts the intellectual and collaborative landscape of modal shift research but also highlights strategic directions for academia, policymakers, and practitioners. By identifying thematic gaps, influential actors, and emerging trends, it invites a more integrated, inclusive, and action-oriented approach to advancing sustainable urban mobility globally.

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