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A Bibliometric Analysis of Climate Change, Aviation, and Law: Research Trends and Thematic Evolution (2000–2025)

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ABSTRACT

Purpose: *Numerous studies, including conceptual and exploratory studies on climate change and aviation, have been pursued in the realms of environmental law, policy, and sustainability. However, a comprehensive study of how legal scholar actually treats the aviation and climate change nexus remains neglected. Under this conception, this research attempts to synthesize the structure of knowledge and reveal the research trends at the nexus of climate change, aviation, and law in order to bring out the developments in sustainability-related legal discourse.*

Methodology: *A bibliometric study was undertaken with a carefully curated dataset of scholarly works retrieved from the Scopus database. The dataset consisted of the literature spanning from 2000 to 2026 within the subject areas like Social Sciences and Environmental Science. Further, the search was narrowed down using carefully selected keywords such as climate change, sustainability, carbon emission, emission control, air transportation, and environmental policy. Analytical tools such as Rpackages and Biblioshiny were used for mapping and interpretation of bibliographic data.*

Findings: *The analysis followed a thematic evolution from discussions on carbon emissions and environmental regulation in aviation toward broader areas of sustainable development, international legal frameworks, and policy instruments. Important areas of interest are air transportation policies, carbon offset mechanisms, international law relating to aviation, and legal issues regarding the Paris Agreement and ICAO Regulations. The analysis also brings to light clusters of intellectual influence and networks of collaboration between authors, institutions, and countries, thus illustrating the social and intellectual landscape of the field.*

Practical Implications: *The study offers a panoramic overview of the current academic inquiry at the interface of climate law and aviation. It draws attention to key policy debates and research/ implementation projects and informs academics, legal practitioners, and policymakers about a set of priorities and knowledge gaps emerging in the effort to address environmental challenges posed by aviation.*

Originality: *The study makes a unique contribution by integrating scattered knowledge in the field and presenting a systematic overview of the scholarly output. In quick succession, it identifies key sources, influential authors, major documents, and emerging themes, thereby enhancing our understanding of legal responses to climate change in the aviation sector.*

Keywords*: Climate Change, Aviation Law, Carbon Emissions, Environmental Policy, Sustainability, Emission Control, Air Transportation, Sustainable Development Goals.*

Introduction

Climate change, aviation, and law are all interconnected through a complex process, affecting and being affected by each other. Climate change, as a worldwide phenomenon, has aspects of temperature rise, extreme events, variation in climatic pattern, etc., that influence various sectors, including aviation. It is a matter of concern that the aviation industry increases climate change through emission of greenhouse gases and deposition of particulates high in the atmosphere, thereby furthering the process of global warming (Y. et al., 2024), (L. & T., 2012), (D.I.A., 2017). While changes in climate transform flying conditions, turbulence levels, and aircraft performance and increase extreme weather events more often, these factors adversely affect aviation operation and safety (Y. et al., 2024), (L. & T., 2012), (M. & M., 2022). On the one hand, aviation has to look into minimizing its environmental impacts, and on the other hand, it needs to adapt itself to a climate that is changing. Emphasis on mitigation strategies suggests reducing emissions from aircraft through advanced technology and the design of aircraft as well as through carbon offsetting schemes, but for the environmental challenge in the skies, such actions may not suffice (L. & T., 2012), (D.I.A., 2017). Adaptation is necessary for safe and efficient aviation operations in the changing climate, requiring wider ownership of the problem, additional regulation, and fiscal measures (L. & T., 2012), (D.I.A., 2017). Law is thus crucial in combating climate change and its tandem impact on aviation. The legal framework endeavors to restrict emissions, impose mitigation measures, and ensure compliance with international conventions. Climate change gave rise to climate law as a new branch of law, comprising the international, regional, national, and local means in response to the environment throughout the world (E.J. et al., 2013), (S.M. et al., 2025). Legal instruments are frequently invoked to restrict property rights in the public interest and to lay down on persons and legal entities the positive obligation to act in order to abate climate change (E.J. et al., 2013).

The paper discusses the following research questions using bibliometric analysis and systematic review:

- **Which are the most influential authors, journals, Countries based on citation?**
- **How the concept of climate climate change, aviation, and law evolved over the years?**
- **What is the research gap and future scope of research on the topic climate change, aviation, and law?**

Network analysis and descriptive analysis have been used by the authors, each aiming at fulfilling the objectives of the study. The second half of the study paper is a review of the literature; sections three and four deal with research methodology and data analysis. Finally, the findings and resultant outcomes are drawn up into conclusions.

Literature Review

An important dimension to the project of the study is the literature review that examines existing research on the subject and creates a framework within which the study problem is defined and analyzed. It also gives us a wider and narrower understanding of past studies and provides information on areas wherein previous researchers were unaware of Ideas, The intersection of climate change, aviation, and law is a complex and evolving zone of inquiry. Through the emission of GHGs, predominantly CO_2 and other non-CO_2 factors involving contrail-cirrus and ozone creation (Y. et al., 2024), (V. et al., 2021), aviation significantly contributes to climate change. Aviation activities together form 2.5 percent with growing trends of GHG emissions in the world (F.A. et al., 2021). Emissions from these sectors also prove difficult to reduce for technical reasons-lacking a low-carbon substitute-and for legal reasons, especially for those pertaining to international aviation, which is not under the control of any single State (B. & Z., 2023). Not only does the aviation industry result in climate change; it is also affected by the same phenomenon. Climate warming changes flight conditions, aggravating turbulence, flight times, and incidences of extreme weather events, thereby negatively impacting aviation operations and safety (Y. et al., 2024). Some mitigation strategies suggested include the use of Sustainable Aviation Fuels (SAF) and market-based mechanisms such as the International Civil Aviation Organization (ICAO) carbon offsetting scheme (B. & Z., 2023), (W. et al., 2023). Following these methods, the wanted targets of the Paris Accord had not been realized; hence, more advanced technologies and policies are necessary (V. et al. 2021), (D.I.A. 2017). Climate change legislate the environment, including the regulation of aviation emissions. Legislative instruments are promulgated at the international, regional, and national levels to counter the adverse effects of climate change. Within this framework, ICAO has

developed technical standards and market-based measures to limit emissions from international civil aviation (B. and Z., 2023). At the national level, tax policies, technical standards, and infrastructure development are put in place to cut emissions (B. and Z., 2023). However, their performance differs and calls for more effective legal frameworks to coordinate (A. and L., 2024). The intricate relationship between law and climate change is multifaceted. Legal regulations must weigh in on the side of property rights and, conversely, deals with the public and existential interests, often leading to granting the owners higher positive obligations to act in the public interest (D., 2017). Climate law may be viewed as a distinct field of law, incorporating all varieties of laws and accepting new instruments that somehow soften the traditional distinction between formal and informal, public and private, substantive and procedural law (E.J. et al., 2013). This is vital for the coherence of the legal approach to climate change. Major challenges still go into mitigating aviation impacts on climate change. The self-regulatory nature of the aviation sector and the fragmented nature of climate mitigation interventions have been a barrier to substantial progress (W. et al., 2023), (A. & L., 2024). A holistic approach encompassing voluntary measures and enforceable regulatory mechanisms is necessary to put the issue of emissions reductions on air most on the table (J. et al., 2016). Another development that is needed in the legal arena is to cater to the dynamic and interconnected nature of climate change, aviation, and law so the regulations become aligned toward ethical norms and needs of societies (D., 2017) (E.J. et al., 2013).

Research Objectives

- To identify the leading journals and most influential authors contributing to the field at the intersection of climate change, aviation, and law.
- To assess the intellectual and social structures shaping scholarly discourse in the domain of climate change and aviation-related legal studies.
- To identify patterns of research collaboration among authors, institutions, and countries working on climate change, aviation, and legal frameworks.

Research Methodology

In this work bibliometric analysis is done over the literature taken from Scopus database following the systematic procedure. Research technique used is structure and discussed in figure no. 1 below:

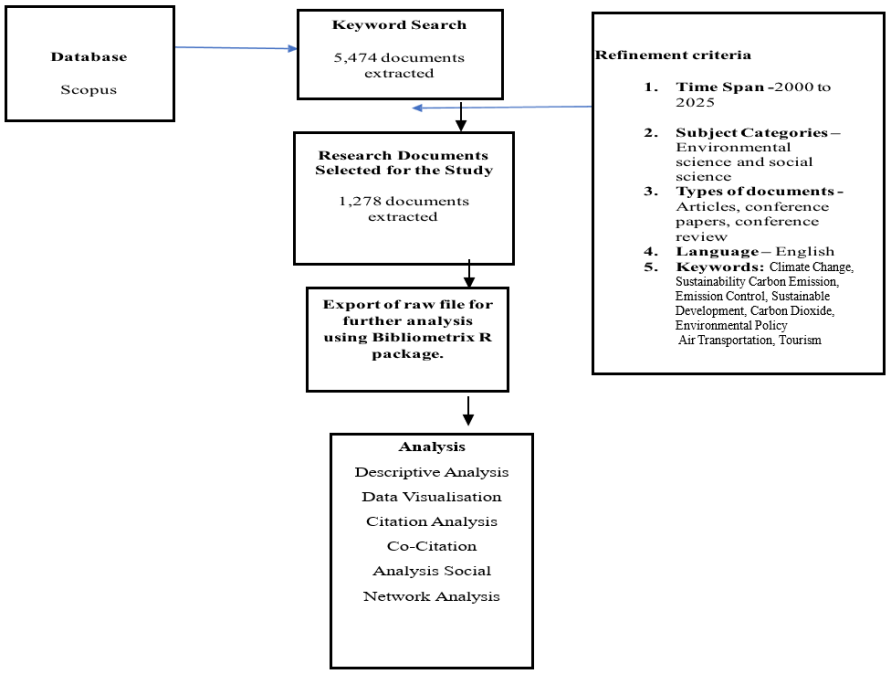


Figure 1: Flowchart for Research Methodology

Primary Database Collection

There are many globally reputable databases such as Scopus, Web of Science, Google Scholar, and Dimensions, all containing a wide spectrum of academic publications. Among these, Scopus is definitely one of the biggest and widely used databases, hence I preferred working with it. A total of 1,278 results of publications were retrieved by using a list of combinations of pre-specified keywords. When doing worldwide database searches, several sets of keywords were used. No filters were applied, relating to country or otherwise. Every record of a publication has useful information such as the name of the author, country of origin, number of citations, type of document, and source. This metadata was well exploited to carry out analyses.

Fundamental Keywords

Table 1: List of Primary and Secondary Keywords

Fundamental Keyword	**Exploring Trends in Green Infrastructure Planning**
Primary Keywords using (AND)	**climate change" AND aviation AND law**
Secondary Keywords using (OR)	**EXACTKEYWORD , "Climate Change") OR LIMIT-TO (EXACTKEYWORD , "Sustainability") OR LIMIT-TO (EXACTKEYWORD , "Carbon Emission") OR LIMIT-TO (EXACTKEYWORD , "Emission Control") OR LIMIT-TO (EXACTKEYWORD , "Carbon Dioxide") OR LIMIT-TO (EXACTKEYWORD , "Air Transportation") OR LIMIT-TO (EXACTKEYWORD , "Tourism") OR LIMIT-TO (EXACTKEYWORD , "Sustainable Development") OR LIMIT-TO (EXACTKEYWORD , "Environmental Policy"**

Source: Authors' Calculation

Thus, the query for searching the documents in Scopus is:

"ALL ("climate change" AND aviation AND law) AND PUBYEAR > 1999 AND PUBYEAR < 2027 AND (LIMIT-TO (EXACTKEYWORD , "Climate Change") OR LIMIT-TO (EXACTKEYWORD , "Sustainability") OR LIMIT-TO (EXACTKEYWORD , "Carbon Emission") OR LIMIT-TO (EXACTKEYWORD , "Emission Control") OR LIMIT-TO (EXACTKEYWORD , "Carbon Dioxide") OR LIMIT-TO (EXACTKEYWORD , "Air Transportation") OR LIMIT-TO (EXACTKEYWORD , "Tourism") OR LIMIT-TO (EXACTKEYWORD , "Sustainable Development") OR LIMIT-TO (EXACTKEYWORD , "Environmental Policy")) AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ENVI")) AND (LIMIT-TO (LANGUAGE , "English"))Initial Search Outcomes

The Scopus database is searched using a variety of keywords relevant to our study to locate publications. Language-based analysis is used to investigate them. With 1,667 publications, English is the most widely used language, followed by chineses.

Data analysis and findings

As shown in Figure 2, the data analysis was divided into two main parts: a descriptive analysis and scientific mapping. Descriptive analysis, the first component, examines bibliometric data to identify key features of the dataset, such as authors, documents, and sources/journals. The second is scientific mapping, which uses visualization techniques including factorial analysis, network analysis, three-field plots, and theme maps.

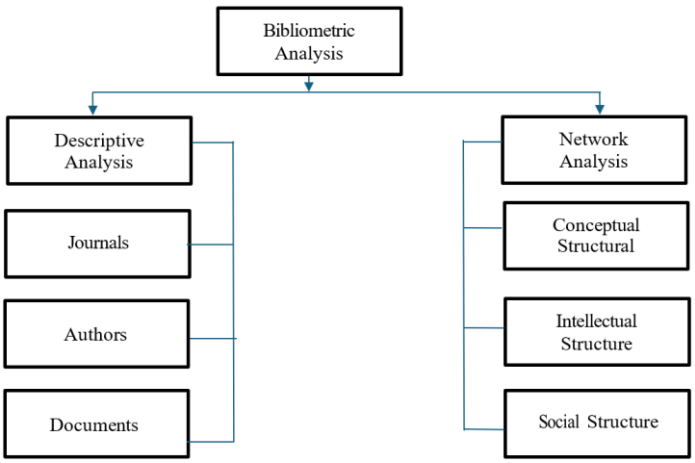


Figure 2: Bibliometric Analysis

Descriptive Analysis

Data Set

Table 2 shows the final dataset of 1,278 documents for this bibliometric study on climate change, aviation, and law, covering the period from 2000 to 2025. These documents are disseminated through 463 sources, indicating a fine breadth of scholarly dissemination. It shows that the documents have registered a publication growth rate of 21.23% per annum, proving that academic interest in this interdisciplinary area is intensifying rapidly. The documents are on average 5.37 years old and have average citations of 39.74 per document, depicting strong scholarly impact. The collaboration index (Co-authors per document) is 3.54, while 33.18% of the documents feature co-authorship on an international level, which means a high degree of international collaboration. The distribution encompasses 976 journal articles, 52 book chapters, and 166 review articles, pointing toward a varied amalgamation of document types present in the environmental law and aviation discourse.

Table 2: Description

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2000:2025
Sources (Journals, Books, etc)	463
Documents	1278
Annual Growth Rate %	21.23
Document Average Age	5.37
Average citations per doc	39.74
References	108279
DOCUMENT CONTENTS	
Keywords Plus (ID)	5845
Author's Keywords (DE)	3670
AUTHORS	
Authors	3726
Authors of single-authored docs	234
AUTHORS COLLABORATION	
Single-authored docs	254
Co-Authors per Doc	3.54
International co-authorships %	33.18
DOCUMENT TYPES	
article	976
book	45
book chapter	52
conference paper	25
data paper	1
editorial	3
letter	2
note	7
retracted	1
review	166

Three Field Plots

Presented in Figure 3 is a three-field plot drawn through a Sankey diagram that shows the relationships between authors (AU), author keywords (DE), and author countries (AU_CO) for climate change, aviation, and law. On the left, among the key contributing authors, Zhang Y, Li J, Wang Y, Sun Y, Zhou D, and Gössling S are some of the most prolific in this interdisciplinary domain. The center column presents keywords used most commonly, including climate change, sustainability, aviation, emissions, carbon emissions, climate policy, mitigation, and environmental law, showing conceptual focus within the literature. On the right lie the dominant contributing countries of the USA, United Kingdom, Germany, China, and Australia, implying that research work in this field is led mainly by the developed nations. A noticeable contribution is also witnessed at the research level from countries such as India, Italy, Netherlands, Canada, and Sweden, portraying a globally distributed research interest. The visualization furthers by highlighting the strong integration among authors, thematic keywords, and international collaboration led by advanced and emerging economies on aviation environmental and legal implications.

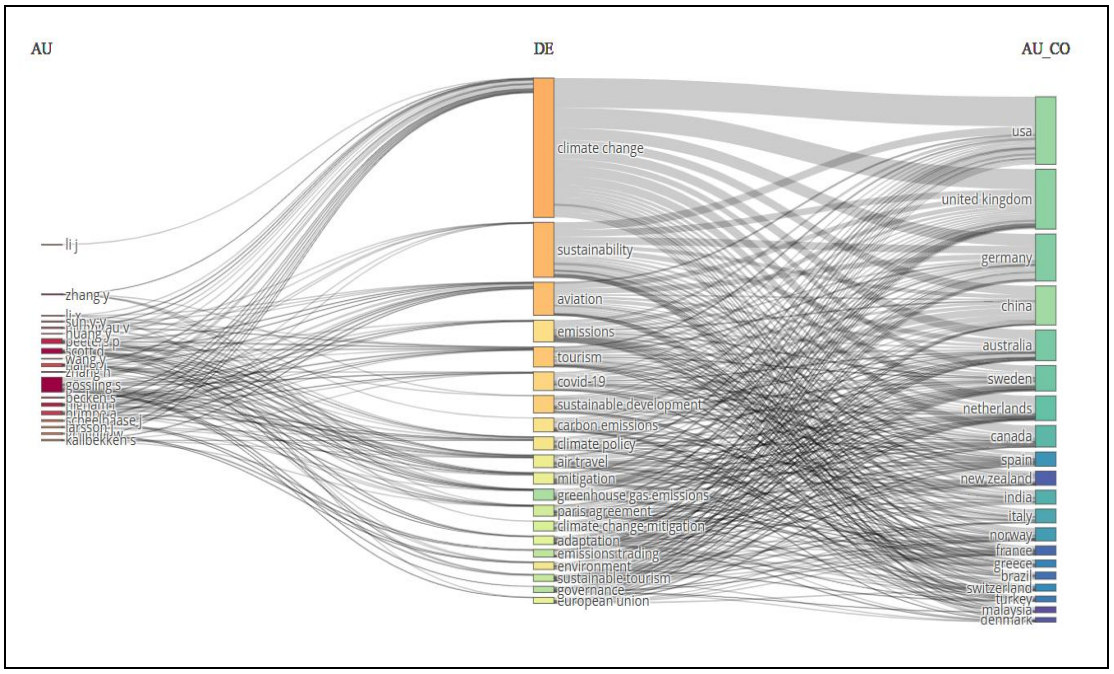


Figure 3: Three Field Plots

Periodic Trend

Figure 4 shows the periodic trends in the research domain of climate change, aviation, and law using two indicators: annual scientific production and average citations per year. The first graph shows that the number of articles representing research quantities steadily increased from 2000 onwards, with a surge after 2018, culminating in a peak in 2023 with over 150 articles. This, therefore, means that there has been a growing academic interest in the aviation-environmental nexus, especially given the resurgent global discussions and policy development on climate change in recent times. The second graph, which measures average citations per year, is much more turbulent. It reached two sharp peaks: one in late 2007 and the other in 2020, bearing witness to highly influential, cited works in those years respectively. However, from 2021, there has set in an apparent decline with the average citations hitting its low in 2024. This recent setback has to do with the newness of the publications, which are thus yet to accumulate citations. All in all, this view suggests that the recent intensification of scholarly output notwithstanding, newer research in the field is still gathering academic momentum.

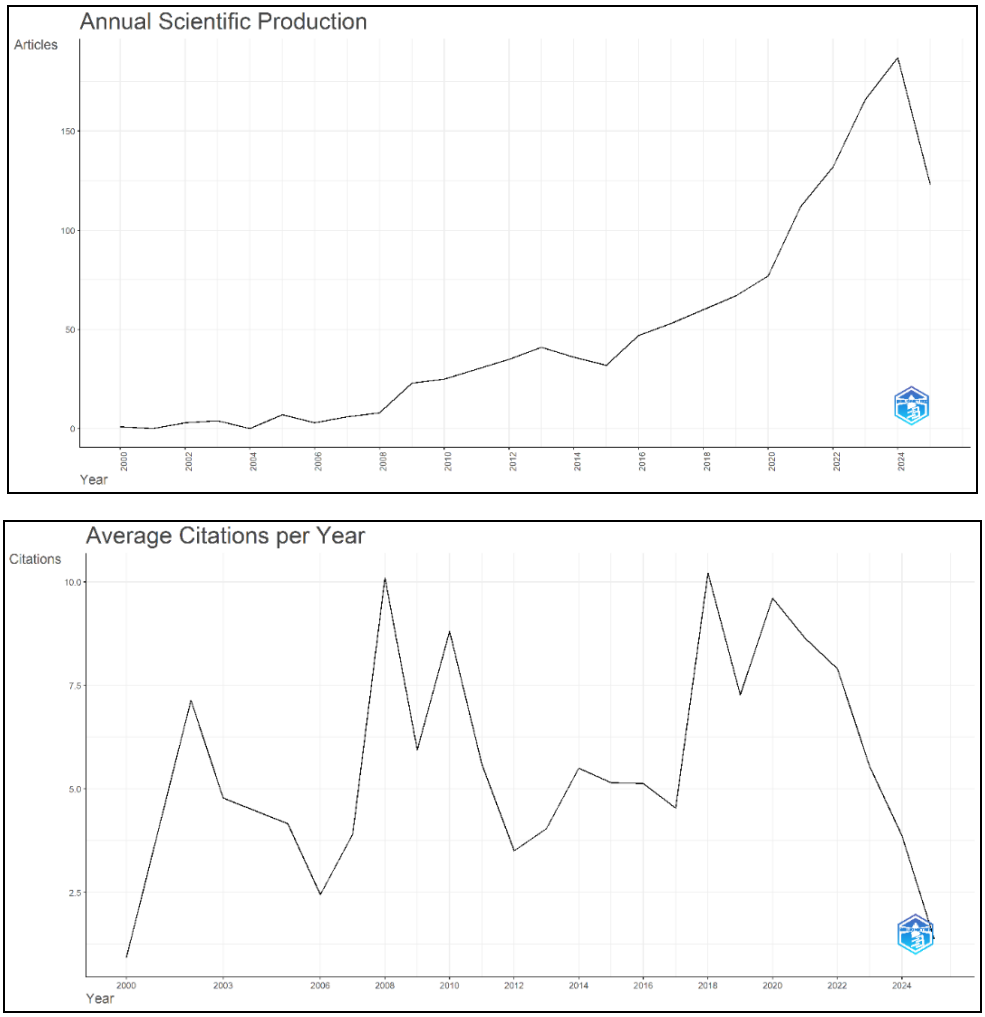


Figure 4: Periodic Trend

Journal Analysis

A journal-level analysis was implemented to bring out key sources for climate change, aviation, and law, with two metrics attached: (a) number of documents published (Figure 5), and (b) H-index (Figure 6). While publications directly point to the research activity, the H-index furnishes a more thorough influence measure by accounting for productivity plus citation impact. It may be perceived from Figure 5 that Sustainability (Switzerland), Journal of Sustainable Tourism, and Journal of Cleaner Production sit on the top as sources with great productivity toward the topic considered in this interdisciplinary review. These are all ranked above Science of the Total Environment, Environmental Science and Pollution Research, and Journal of Air Transport Management, suggesting that there is impassioned dialogue on environmental and aviation issues in the respective journals. Figure 6 presents the ranking of journals in order of local H-index, showing that the Journal of Sustainable Tourism and the Journal of Cleaner Production enjoy the highest citations and hence influence on the dataset, followed by Sustainability (Switzerland) and Science of the Total Environment. The publications in these journals are not only frequently produced on the subject but also earn powerful attention in the scholarly world, thereby cementing their role as central venues in debates over the environmental impact of aviation and attendant legal problems. The visibility of journals from the environment and sustainability realm also reveals the interdisciplinarity of the research, oriented strongly at regulatory, policy, and operational challenges concerning aviation in climate change terms.

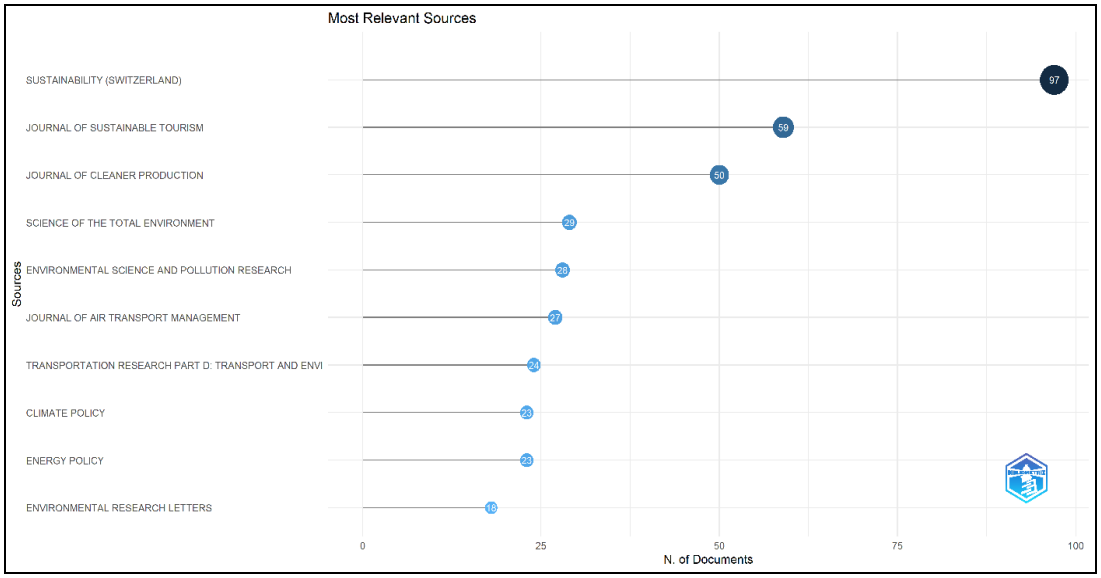


Figure 5: Most Relevant Sources

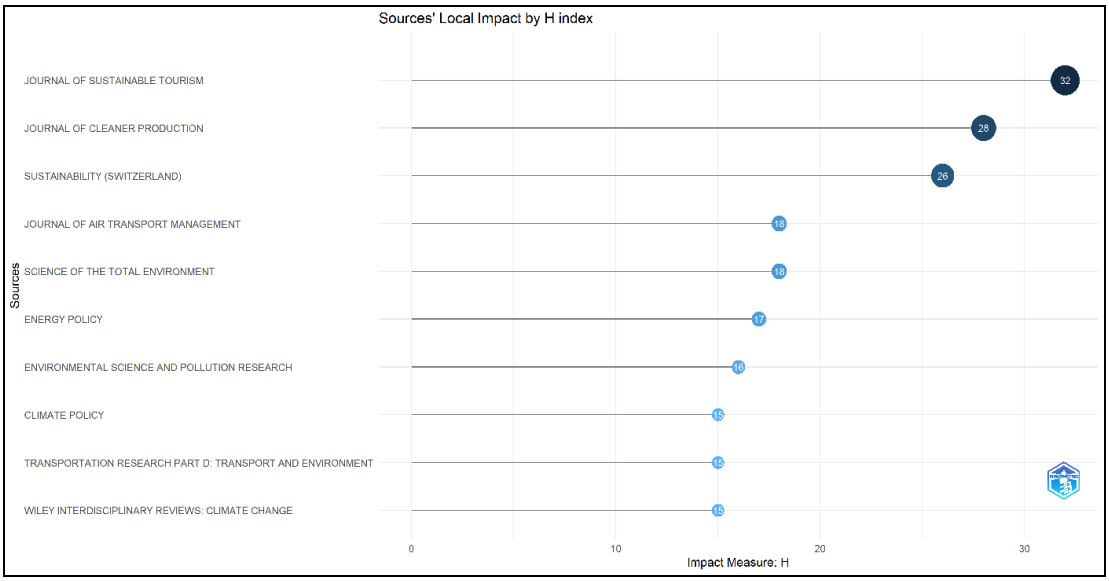


Figure 6: Local sources impacted by H index

Figure 7 illustrates the source dynamics of top five journals contributing to research on climate change, aviation, and law, with emphasis on cumulative publication trends over time. These journals Sustainability (Switzerland), Journal of Cleaner Production, Journal of Sustainable Tourism, Science of the Total Environment, and Environmental Science and Pollution Research have entered a steady growth period since 2015, with acceleration occurring near 2020. Of these, Sustainability (Switzerland) is at the front, growing at a faster pace and crossing 100 cumulative publications by 2025, indicating leading dissemination channels for interdisciplinary research in this domain. Likewise, the Journal of Cleaner Production and Journal of Sustainable Tourism are on strong upward trajectories, signaling increasing scholarly interest in environmental, legal, and policy aspects of aviation within the context of climate change. This overall upward volume in publication also shows the increased attention within academia on sustainable aviation practices, carbon emissions regulation, the environmental impact of tourism, and evolving legal formulations facing climate challenges.

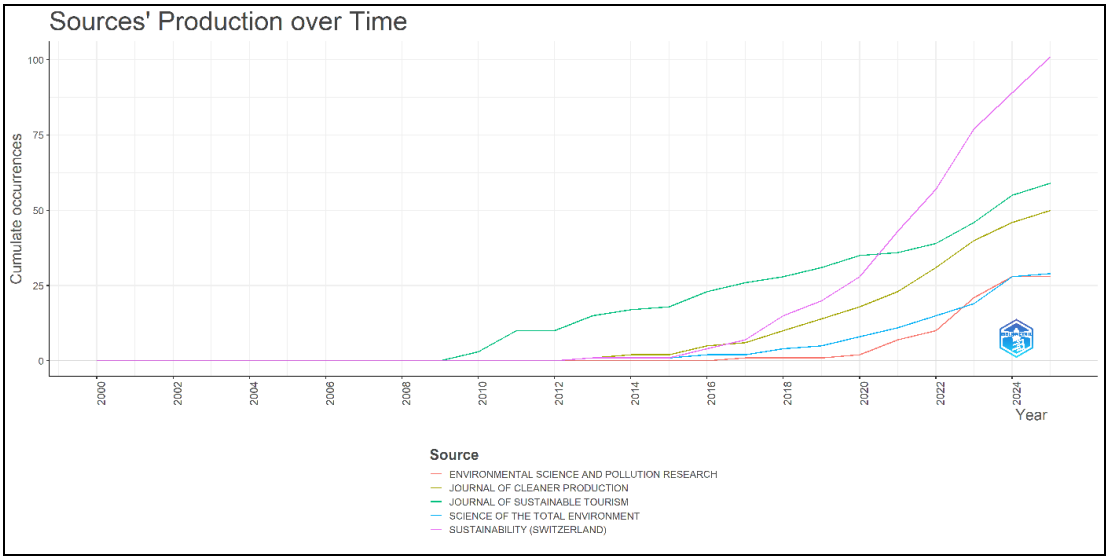


Figure 7: Source Growth

Authors

Author analysis was conducted to ascertain the most influential and productive researchers in the nexus of climate change, aviation, and legal studies. It thus opens more pathways for further exploration by scholars and institutions in this inter-disciplinary field. The analysis was carried out on three parameters - the total number of documents produced (Figure 8a); the gradual productivity of an author in a timeline (Figure 8b), and H-index impact (Figure 9). Per Figure 8(a), Gössling S., Scott D., and Zhang Y. come out as the top three authors with the highest amount of publications, placing them at a key juncture in the progressing scientific discourse on climate policy and aviation sustainability. Figure 8(b) shows continuous engagement of these authors in scholastic pursuits throughout the years, with Gössling S. having steadier output and citation frequencies indicating a wider acceptance of his contributions. Regarding academic impact as measured by H-index from Figure 9, Gössling S., Petersen P., and Scott D. were the most influential authors on the twins of productivity and citation. The development of the literature at the crossroads of environmental law, air transport, and climate governance has been influenced greatly by their work.

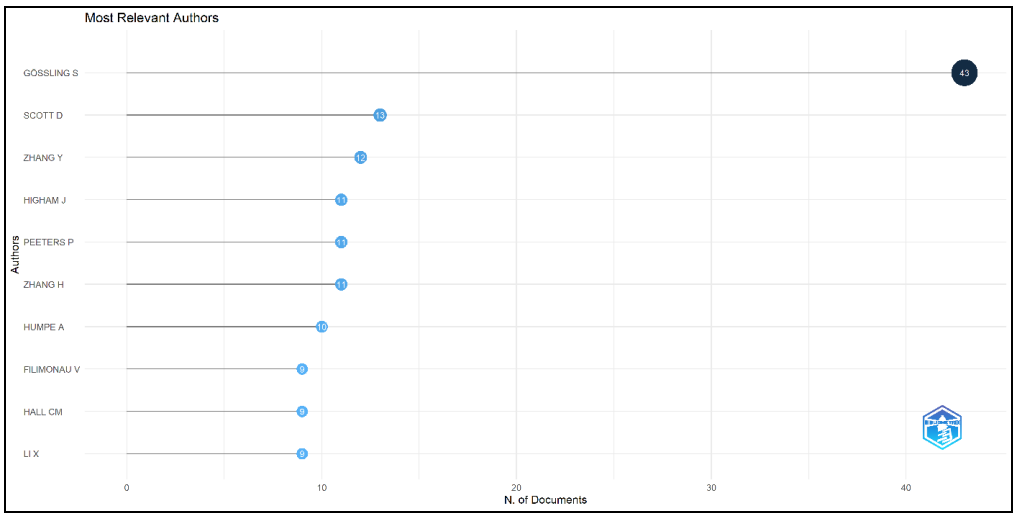


Figure 8 (a): Most Relevant Authors

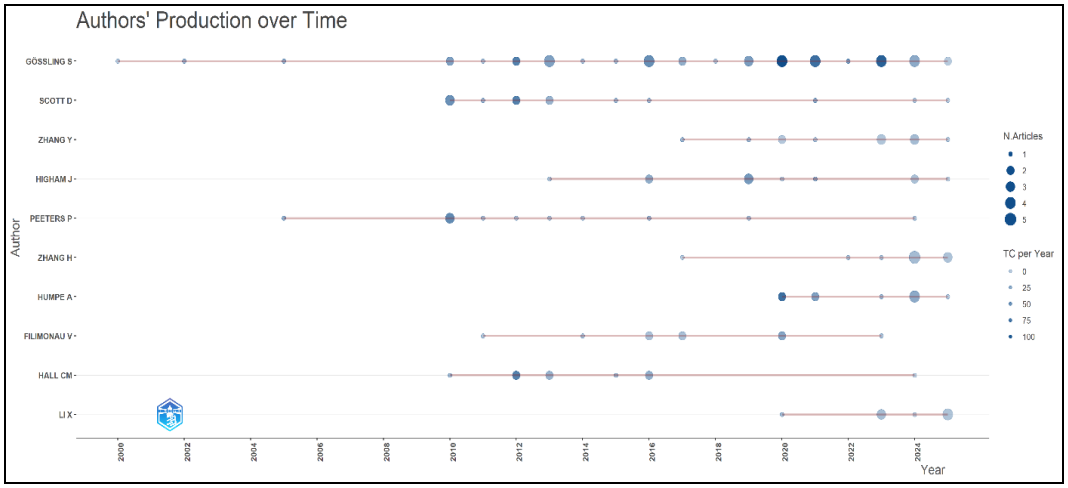


Figure 8 (b): Authors Production Over Time

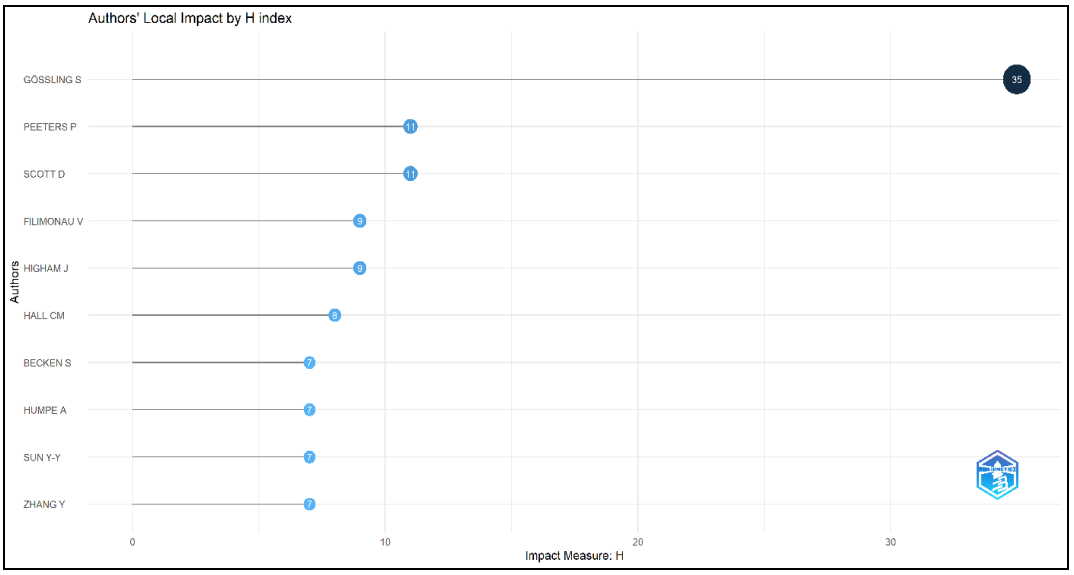


Figure 9: Authors' Local Impact by H Index

Country-Wise Analysis

A prospective study of the national scientific output created to identify countries actively involved in research related to climate change with aviation and legal focus was administered. China leads the publication figure with 672 articles, and the USA follows with 606 publications and then the UK with 417, indicating strong activities of the domain in China, the USA, and the UK (see Figure 10 and Table 3). India finds a place within the first ten, further pointing at its increased interest in investigating the environmental and legal concerns of aviation. According to Table 4, Italy, the UK, and Australia are those countries standing out in the research impact, measured by total citations and average citations per article, with Italy leading the pack in average citations per article (93.6), followed by the UK (87.6) and Australia (77.7), meaning that these countries have a strong scholarly output with major research influence. Even though the emerging countries Malaysia and Brazil are in the top 20 for scientific output, the relatively lower citation parameters indicate a need to improve the quality, international relevance, and impact of their contributions to the literature on climate change and aviation.

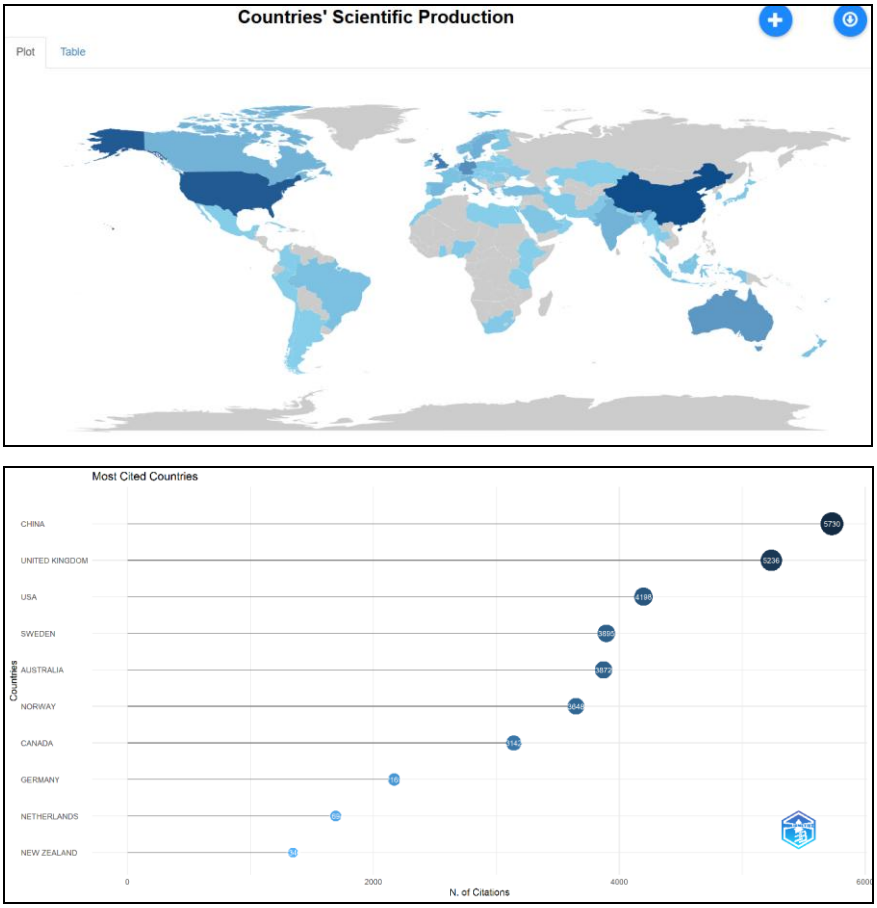


Figure 10: Countries' Scientific Production

Table 3

CHINA	672
USA	606
UK	417
GERMANY	316
AUSTRALIA	269
SWEDEN	147
NETHERLANDS	139
CANADA	136
INDIA	133
ITALY	122
NORWAY	107
SPAIN	103
SWITZERLAND	88
GREECE	86
TURKEY	80
BRAZIL	64
FRANCE	60
NEW ZEALAND	58
DENMARK	56
MALAYSIA	56

Table 4

Country	Total Citations	Average Article Citations
CHINA	10352	31.2
UK	9198	87.6
ITALY	6737	93.6
AUSTRALIA	6370	77.7
USA	3892	46.9
INDIA	2908	22.5
BRAZIL	1899	45.2
CANADA	1626	60.2
FINLAND	1407	74.1
KOREA	1350	79.4
CHINA	10352	31.2
UK	9198	87.6
ITALY	6737	93.6
AUSTRALIA	6370	77.7
USA	3892	46.9
MALAYSIA	1329	40.3
PORTUGAL	1253	54.5
HONG KONG	1196	46
NETHERLANDS	1089	36.3

Documents Citation

A study of the most cited global texts allows pinpointing the foundational works that most influenced discourse on climate change, particularly in the domain of aviation and environmental law. Figure 11 shows a list of books that received over 400 citations worldwide, further attesting to their importance in the scholarly milieu. Ranking first in citation for the field is a work by Lenzhen J. (2014) appearing in Nature Climate Change: it has 1116 citations and is at the heart of the issue of climate policy and science. Next is Peters GP (2008) in Ecological Economics and Monks PS (2009) in Atmospheric Environment, with 945 and 819 citations, addressing issues on carbon footprints, economic implications of emissions, and atmospheric changes. Other key studies are those of Gössling S. (2012, 2002) and Lee DS (2010), published in Atmospheric Environment and Ecological Economics, who have been instrumental in quantifying the environmental impact of air travel, thereby underlining the significance of regulatory frameworks for aviation emissions. Together, this literature creates the intellectual structure required for contemporary efforts in the research and policymaking of environmental sustainability, legal accountability, and carbon governance in aviation.

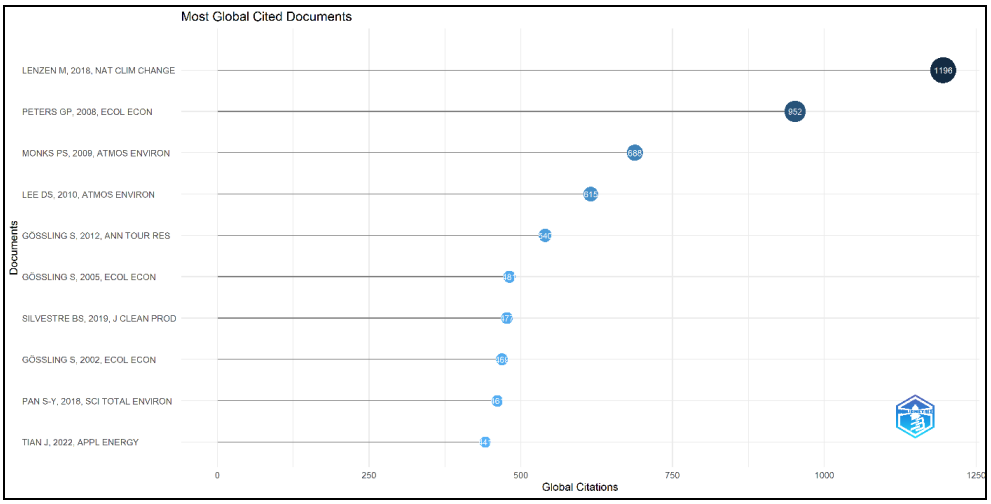


Figure 11: Most Global Cited Documents

Keyword

Keywords are core descriptors that encapsulate the thematic focus of research literature, and their analysis is vital to unraveling the knowledge structure, emerging trends, and the interdisciplinary scope of a research field. Going by Figure 12, the word cloud and frequency-based chart show the most relevant terms associated with climate change, aviation, and legal studies. The keyword with the highest frequency is 'climate change' itself, followed by sustainability, carbon emission, emission control, and sustainable development, illustrating the major themes of environmental impact, sustainable aviation practices, and legal frame-building for emissions and climate responsibilities. Additional major terms such as “carbon dioxide,” “environmental policy,” and “air transportation,” showcase how much the legal and policy aspects are crucial when balancing the environmental footprint of aviation. In the word cloud, the size of each word is a visualization of its frequency of occurrence and its conceptual importance in the literature. It is becoming evident by this analysis that the field is, by nature, an interdisciplinary one, intersecting the avenues of environmental law, public policy, aviation management, and sustainability; thus, it provides a complex environment-changing arena for exploration by future research.

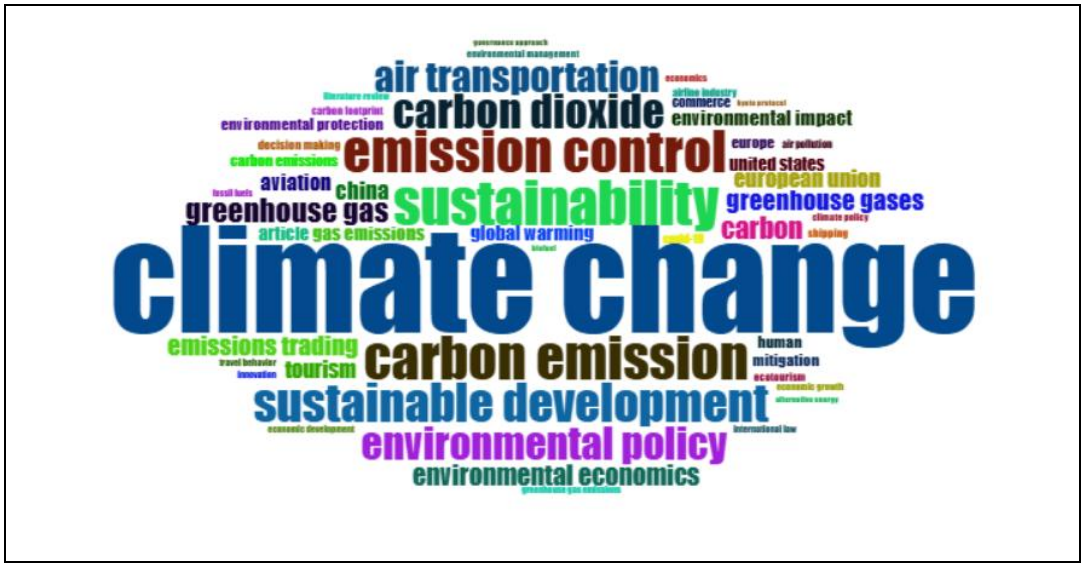


Figure 12: Word Cloud

Trend Topics

Figure 13 gives an overview of ever-changing research trends within climate change and aviation law, showing indisputable evidence of the growth in academic interest post-2010 and shadowed by an even bigger number of publications after 2015. Initial works (2005–2012) were more technically oriented, dealing with issues such as atmospheric chemistry and air transport policy. Between 2013 and 2018, however, the interest moved toward larger environmental policy issues, carbon emission levels, and climate change. In the recent years (2019–2025), applied and policy-forming research seems to be on the rise with sustainability, emission regulation, green financing, and legal frameworks-concerning UNFCCC-taken seriously into consideration. This shift, therefore, observes the metamorphosis of the field into a multidisciplinary solution-driven interface necessary for global environmental governance.

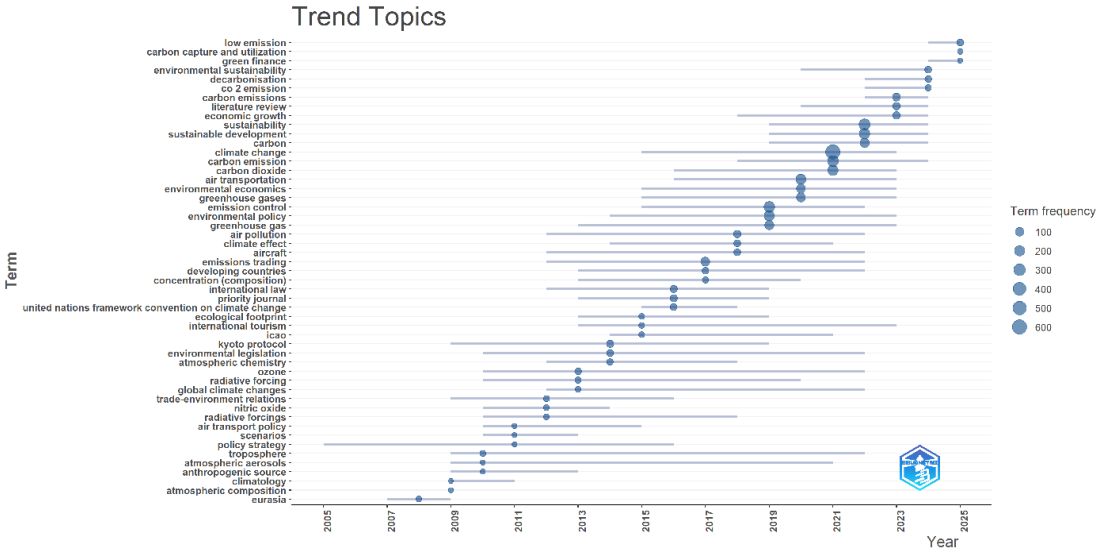


Figure 13: Trend Topics

Data Visualisation

A data visualisation of the current literature is designed to objectively map the existing knowledge base on climate change in aviation and law. Such visualisation further aids in reviewing the thematic evolution in research within this niche, enabling researchers to build keyword-based networks to study conceptual clusters. In this study, literature mapping using network analysis was done for three knowledge structures: (a) conceptual structure, (b) intellectual structure, and (c) social structure (Ingale & Paluri, 2020).

Conceptual Structure

In this study, the conceptual structure network is generated through co-word analysis (Figure 14) alongside co-occurrence analysis of keywords (Figure 15). A co-occurrence network shows how often variables appear together in order to reveal their conceptual interrelationships from the literature. Thematic mapping (Figure 14) was applied to highlight core themes in climate change in aviation and law based on keyword analysis. The thematic map is a two-dimensional plot with density on the Y-axis and centrality (relevance) on the X-axis, whereas each bubble represents a theme with a particular positioning.

As Figure 14 depicts, "climate change," "sustainability," and "carbon emission" arise as basic themes that find themselves in the lower-right quadrant, denoting the great relevance of topics yet an underdeveloped status with more research and policy development needed in aviation law. Disposed in the upper-left quadrant of this grid are niche themes of "carbon dioxide," "greenhouse gas," and "carbon," which are well internally developed but with looser connection into the larger discussion of aviation law.

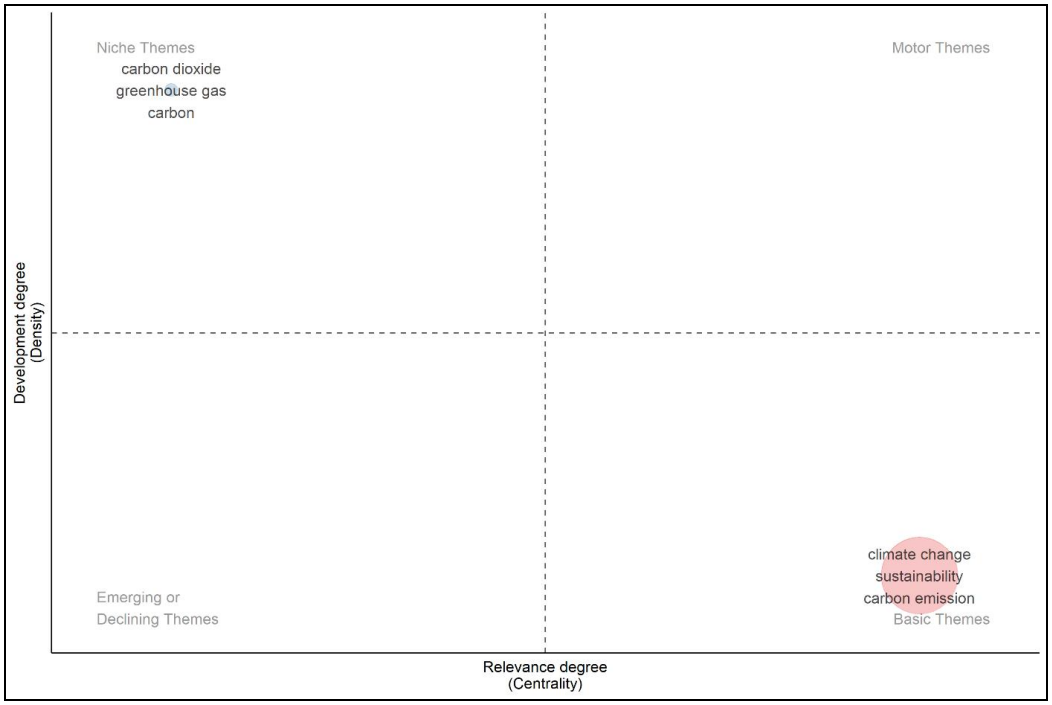
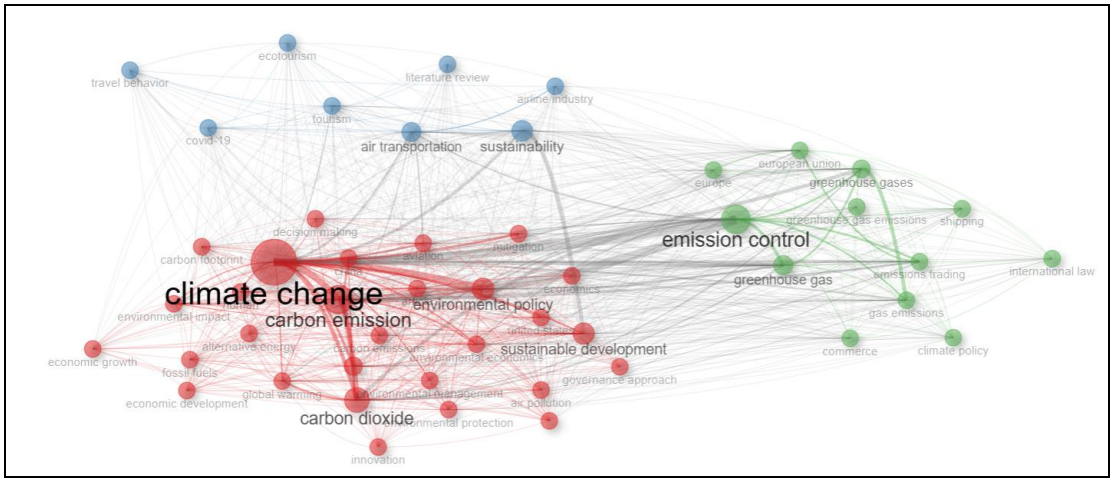


Figure 14: Thematic Map

Multiple Correspondence Analysis (MCA) with the help of Biblioshiny was employed to develop the conceptual structure network using unit keywords as depicted in Figure 15. The analysis shines a light on three different clusters of themes within the literature on the environment and aviation law. The green cluster concerns emission control and greenhouse gas management issues, which legally and operationally address methods to reduce aviation-related emissions; meanwhile, the blue cluster leads toward general sustainability concepts that have indirect linkages to climate change in an aviation law context. The sizes of the nodes denote the frequency of keyword occurrences, and nodes' closeness denotes a high degree of conceptual relatedness. These results visualize that climate change and carbon emissions remain the main issues of concern, requiring the formulation of adequate regulatory frameworks and well-integrated operational strategies to resolve these pressing environmental challenges within the aviation domain.

Figure 15: Conceptual Structure Network



Intellectual Structure

To identify the prominent authors and assess their influence within the discourse of climate change in aviation and law, a co-citation analysis of unit authors was carried out. Co-citation analysis helps researchers in understanding related studies of one issue and mapping the intellectual structure of the field. Essentially, co-citation is the number of times that two authors are cited together, indicating a conceptual and thematic similarity between them. A co-citation network analysis will shed light on the different streams of research appearing within the domain.

The below co-citation network visualization depicts the various thematic clusters that currently define the field of climate change in aviation and law. The network apparently shows five clusters, colored green, blue, purple, pink, and orange; each cluster represents a research direction with an interconnection among themselves.

The green cluster, having McKercher B. (2010) as the most central node, represents a very robust foundation in climate change impacts on aviation and tourism with pertinent work by authors such as Becken S. (2012) and Hall C.M. (2016) on climate change mitigation in aviation.

The blue cluster features authors such as Gössling S. (2005, 2006) or Peeters P. (2016) working on topics like aviation emissions, climate policy implications, and environmental strategies within aviation law.

The purple cluster is linked with the central cluster, emphasizing environmental governance and perspectives on sustainable development applicable to climate change in aviation, linking to Becken S. (2002) and Gössling S. (2020).

The pink cluster stretches toward major environmental policy works of Ostrom E. (1990) and Giddens A. (2009), suggestive of theoretical underpinnings on collective action and climate governance within aviation legal frameworks.

The orange cluster located to the bottom right, encompassing "directive (eu)" and "regulation (eu)," informs about the perspectives governing law and regulations imposed by the EU aviation law and general environmental directives, emphasizing substantially the privileged position of law in climate change mitigation in the aviation world.

There lies the position of McKercher B. (2010) at the center, speaking much of its pivotal influence in this sector of research in touch with the vicinity of nodes that speak of high conceptual relatedness, an indication of the integrated yet diversified research backdrop linking climate change, aviation operations, and environmental law.

In combination with co-citation analysis and systematic review, climate change in aviation and law research constitutes diversified but interlinked domains such as emission control, sustainable aviation policies, regulatory frameworks, and climate governance in aviation law; all geared toward cross-disciplinary approaches in operationalization and policy development.

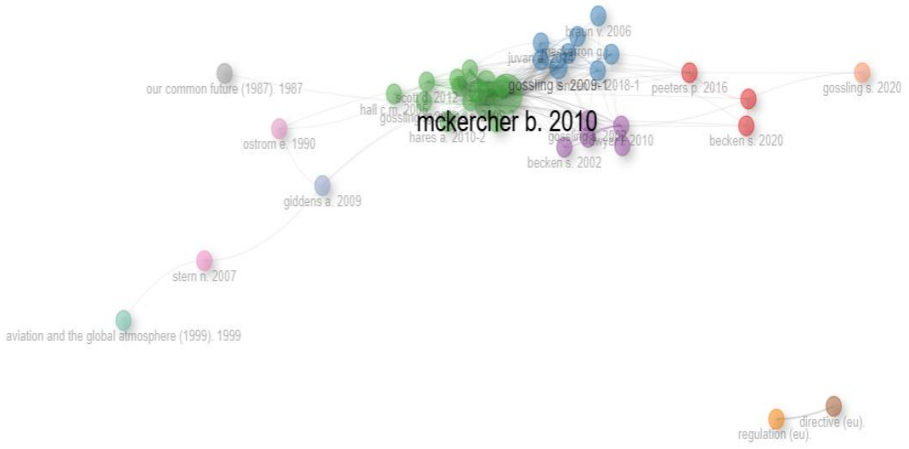


Figure 16: Collaborative Network Co-Citation Analysis

Social Structure

An author collaboration network analysis was undertaken in an attempt to understand existing avenues for collaboration among authors originating from different nations related to climate change in aviation and law. This type of analysis allows for visualizing patterns of co-authorship and uncovering thematic clusters and intellectual linkages in the area. The collaboration network (Figure 17) illustrates five primary clusters, graphically represented in green, blue, red, purple, and orange. The green cluster, with Gössling S. as the anchor, accounts for a highly interconnected network concentrated on aviation emissions, tourism's environmental impacts, and climate change policy within aviation law, truly reflecting his central role in the area. The blue cluster thus consists of authors collaborating on aviation sustainability and emissions management, with an emphasis on empirical assessment and operational strategies for the reduction of emissions from aviation. The red cluster shows groups working on aviation policy frameworks and law focusing on governance, regulatory measures, and stakeholder participation in airline-related activities of climate change mitigation. The purple cluster includes collaborations in sustainable aviation fuels, climate policy integration into aviation regulation, and passenger behavior under newly formed climate governance frameworks. The orange cluster, while smaller, constitutes highly specialized networks on the legal frameworks and operationalization of climate objectives in aviation law, thus providing a small but significant contribution toward the discourse. Together, these clusters represent multidisciplinary and collaborative research in climate change in aviation law, broadly linking legal, sustainability, and operational perspectives in emission management. The Country Collaboration Map (Figure 18) shows the global setting and interrelations on climate change in aviation and law research, with dominant strong patterns of international collaboration. The United Kingdom, the United States, and Australia emerge as major hubs, vigorously involved in collaborations with countries in Asia, Europe, and Oceania, thereby marking their high research output and prominence in climate change and aviation law. Europe, alongside the UK, Germany, and the Netherlands, forms a strong collaborative framework with the USA and Australia. Connection to Asian countries like China and India, on the other hand, shows reinvigorated research synergies in this domain. This distribution establishes the global character of research on climate change in aviation law, with multi-regional collaboration having especially become a must for climate and emission governance within aviation.

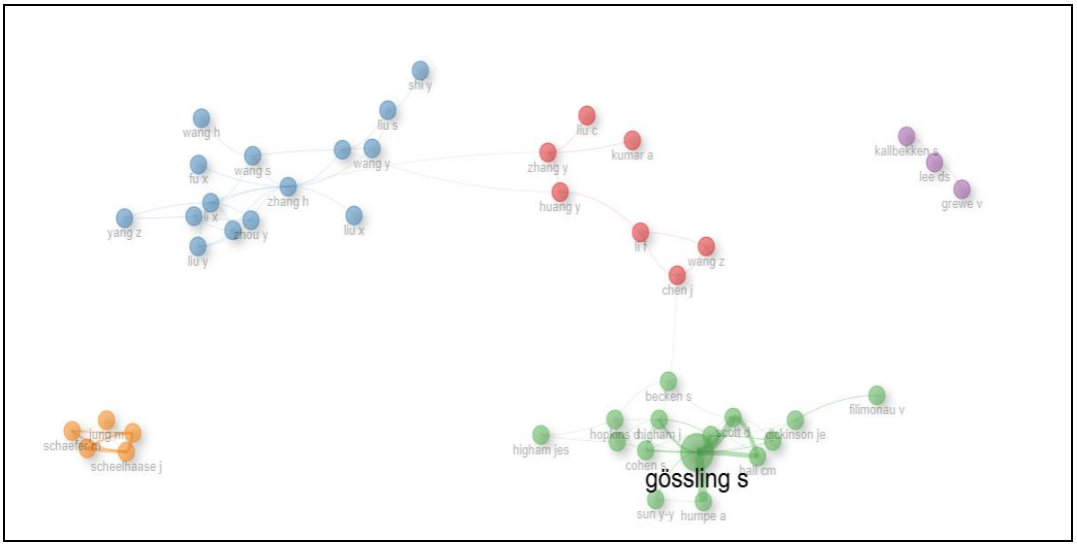


Figure 17: Collaboration Network

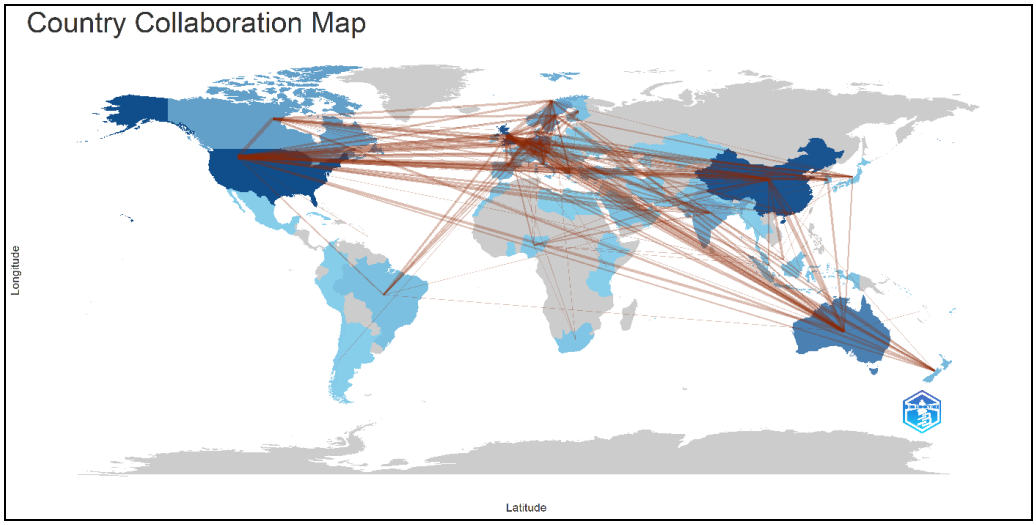


Figure 18: Country Collaboration Map

Conclusion

The bibliometric evaluation of the study title "A Bibliometric Analysis of Climate Change, Aviation, and Law" has been carried out under Scopus, the most used and respected global database. The analysis entails publications registered between the years 2000 and 2025. A systematic keyword search consisting of the operators "AND" and "OR" was used to extract documents deemed relevant, totaling 1,278 documents. Several parameters were considered to assess the present scope and trends within the dataset. Interestingly, almost all publications in the sample 1,278 are registered in English, followed by Chinese as the next most typical language. From keyword analysis, it becomes prominent that "climate change" is the most frequent term, confirming its centrality in literature on the topic. The year 2024 marks the highest peak of publication activity, trailed closely by 2025, hinting at the recent thrust on the interdisciplinary nature of the field. Roughly 30.2% of the research falls under the Environmental Science category. In terms of document type, journal articles come first, with review articles following. In the country-wise distribution, the United States occupies the apex position, trailed by the United Kingdom. From the author-level analyses, it becomes evident that the highest average number of publications per author stands at eight. The Linnaeus University, Kalmar emerges at the forefront in output, while the China National Natural Science Foundation takes the upper hand as the top funding agency. To derive further bibliometric insight, both descriptive and network analyses have been performed employing Biblioshiny software and R packages. To study the structure and evolution of the field, several analyses have been considered, such as temporal trend analyses, three-field plot analyses, co-authorship analyses, keyword co-occurrence analyses, and citation analyses. The relevances from these analyses, when unitedly considered, provide a deep insight into the evolution and dynamics of research on climate change and aviation law. According to the findings, 2024 and 2025 become the research-making years in the domain, and the trend suggests that in the coming years, the research activities are going to have a continued and strong growth.

Recommendation for Future Study

Future studies, as dictated by the results from the bibliometric investigation in this study, should concentrate on bridging gaps in regulatory coherence and fostering the expanded interdisciplinary collaboration that exists between climate change, aviation, and law. The scholars are thus suggested to explore areas underdeveloped yet thematically relevant, like legal issues concerning sustainable aviation fuels, green finance integration into aviation policy, or the emerging economies' role in setting up climate-resilient frameworks for aviation. Additionally, there remains an urgent need for comparative legal analyses that study the variable success of international-level agreements, such as the Paris Agreement and ICAO mechanisms, if any, in their implementation from national jurisdictions. Future studies are perhaps better off projecting ahead by looking into how technological evolutions, a change in passenger behavior, and modifications in geopolitical dynamics will affect climate law and aviation policy. An

expansion of data sources outside of English-preferred literature and boosting collaboration between jurists, environmentalists, and aviation technologists will further compound debate and pave the way for creating robust, globally aligned regulatory models.

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