# Bibliometric Analysis of Renewable Energy and Climate Change Research

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**NATURALISTA CAMPANO**
**ISSN: 1827-7160**
**Volume 28 Issue 1, 2024**

# Bibliometric Analysis of Renewable Energy and Climate Change Research

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Abstract

Climate change poses an existential threat, necessitating urgent action to transition towards sustainable energy systems. This study presents a bibliometric analysis to map the intellectual structure of renewable energy and climate change research from 2000-2023. Publications were retrieved from Scopus using the search query "renewable energy" AND "climate change" restricted to English articles. Data were analyzed using bibliometric software tools to understand publication trends, research themes, collaboration patterns, and impact. The results revealed a substantial increase in publications over time, with key themes around policy, technology integration, public perceptions, and climate impacts on renewables. Developed countries lead in terms of output and impact, but emerging economies play an increasingly prominent role. International collaboration is steadily increasing, linking researchers across disciplines and geographical boundaries. These findings provide insights into the growth of this interdisciplinary field, pointing to policy frameworks, sustainable technologies, and public engagement as critical priorities. The limitations of the database coverage and English language bias are also acknowledged. Overall, this study highlights the crucial role of collaborative, solution-oriented research in accelerating the transition to renewable energy for effective climate change mitigation.

Keywords: bibliometric analysis, climate change, renewable energy, research trends, collaboration

## 1.Introduction

The escalating threat of climate change, primarily driven by anthropogenic greenhouse gas emissions, necessitates a paradigm shift towards sustainable energy sources (Rosa et.al., (2015)). Renewable energy, encompassing solar, wind, and geothermal alternatives, stands as a promising avenue for mitigating climate change, offering clean and sustainable alternatives to conventional fossil fuels (Quaschning, 2019). A comprehensive understanding of the current research landscape exploring the intricate relationship between renewable energy and climate change is crucial for informing future research directions and policy decisions.

This study employs a bibliometric analysis to explore research trends, thematic structures, and collaboration networks within the realm of renewable energy and climate change research. By analyzing publications indexed in the Scopus database spanning from 2000 to 2023this study aims to address the following key aspects:

1. Identify trends in research activity: Investigating the evolution of research on the connection between renewable energy and climate change over the past [number] years.

2. Examine thematic areas: Unveiling prominent research topics and their interrelationships within this interdisciplinary field.

3. Uncover influential scholars and institutions: Identifying the leading researchers and institutions shaping the landscape of renewable energy and climate change studies.

4. Analyze collaboration patterns: Investigating how researchers and institutions collaborate across geographical and disciplinary boundaries.

Through an exploration of these facets, this study aims to furnish valuable insights into the current state of knowledge and future directions within this critical field. This understanding of the research landscape can aid policymakers and researchers in prioritizing research efforts, fostering collaboration, and accelerating the transition towards a sustainable and climate-resilient future. The subsequent sections will delve into the intricacies of our methodology and present key findings, inviting the reader to join us in unraveling the complex tapestry of Renewable Energy and Climate Change.

**2.Literature Review**

Climate change remains a pressing global challenge that demands urgent action in various sectors. The energy sector has a significant influence on greenhouse gas emissions, necessitating the focus on renewable energy as a critical tool for mitigation efforts. This review explores the multifaceted relationship between renewable energy and climate change, drawing insights from current research.

First, the potential of renewable energy to mitigate climate change is well established (Owusu et.al., 2016). These sources, such as solar, wind, and geothermal, offer clean energy generation with minimal emissions, in contrast to fossil fuels. This shift towards renewable energy aligns with the pursuit of sustainable development goals and necessitates supportive policies and measures (Uğurlu, 2021).

However, achieving sustainable energy transitions requires a nuanced understanding of the interplay between the climate and energy. Incorporating potential climate impacts on renewable resources into energy models is crucial for informed decision making (Silva et al., 2021). This integration ensures that energy planning considers future climate scenarios and mitigates potential vulnerabilities.

Furthermore, public opinion on climate change and renewable energy demonstrates a complex intertwining with varying levels of understanding and support (Hamilton et al., 2019). Addressing these public perceptions and fostering knowledge transfer are essential for garnering public acceptance and facilitating successful implementation of green energy initiatives.

The impact of the energy mixes on vulnerability to climate change is another crucial consideration. Huang et al. (2023) highlighted the link between a renewable-heavy energy mix and increased societal resilience to climate risks. This underscores the potential of renewable energy to mitigate climate change, enhance adaptive capacity, and build a more resilient future.

However, the transition to Green Economy requires a broader perspective (Gasparatos et al. 2017). In addition to mitigating climate change, understanding the potential implications of different renewable energy pathways for biodiversity and ecosystems is crucial. Striking a balance between environmental sustainability and the advancement of renewable energy is vital to a truly sustainable future.

The broader literature emphasizes the interconnectedness of climate change and energy, highlighting the crucial role of the energy sector in tackling this global challenge (Altiparmak & Wang, 2021). A two-pronged approach is crucial for integrating renewable energy sources and optimizing energy use across various sectors. This comprehensive strategy, as emphasized by Motlagh et al. (2020), is essential for achieving sustainable energy transitions and effectively mitigating climate change.

Additionally, it is imperative to acknowledge that climate change can significantly affect renewable energy generation (Yang et al., 2022). Long-term impact assessments that consider climate uncertainty are necessary to ensure the continued efficacy and reliability of renewable energy sources.

The dynamic nature of the energy sector and climate policy further necessitate continuous research and knowledge updates. Øverland et al. (2017) highlighted the importance of understanding the evolving geopolitics of renewable energy to inform effective decision-making. This ensures that policy frameworks remain adaptable and address the ever-changing landscape of energy production and climate change.

Finally, public acceptance and support for the transition to renewable energy are crucial factors that influence the success of green energy reforms (Jijie et al., 2021). Public education on climate change and the benefit of renewable energy plays a pivotal role in fostering understanding and garnering support for the transition.

This review highlights the critical role of renewable energy in mitigating climate change. However, a multifaceted approach is required to achieve effective and sustainable solutions. Understanding the impact of climate change on renewable energy generation, public perceptions, and policy frameworks is crucial for designing and implementing successful climate-change mitigation strategies. Moving forward, interdisciplinary research and collaboration across various sectors remains essential, as we strive to build a more sustainable and climate-resilient future.

While the existing literature extensively explores the multifaceted connections between renewable energy and climate change mitigation, a gap remains in understanding the trends and patterns within this research domain through bibliometric analysis.

Identifying the most actively researched areas: This involves analyzing keywords, author affiliations, and publication trends to understand which aspects of the relationship between renewable energy and climate change receive the most attention.

Mapping intellectual structure: Bibliometric analysis can visualize the intellectual structure of the field by identifying key research clusters and exploring how different concepts and themes are interconnected.

Identifying emerging research areas: By analyzing recent publications and citation patterns, it is possible to identify emerging areas of research within the field that may hold potential for future exploration.

Based on these gaps, the following research questions aim to utilize a bibliometric approach.

RQ1: What are the predominant research themes and trends in the scholarly literature on renewable energy and climate change mitigation, as evidenced by the bibliometric data?

RQ2: How has the intellectual structure of research on renewable energy and climate change mitigation evolved over time and what are the emerging research areas based on recent publications?

## 3.Methodology

This section outlines the methodology employed for the bibliometric analysis of the relationship between renewable energy research and climate change.

### Data Sources and Search Strategy

The data for this study was sourced from the Scopus Bibliographic Database. Scopus was chosen because of its comprehensive coverage of peer-reviewed scientific literature across various disciplines, making it suitable for large-scale bibliometric analysis.

The search strategy utilized the following Boolean logic string:

("Renewable energy" AND "climate change")

This string aims to identify publications that explicitly address both concepts in their titles, abstracts, or keywords. The search was further restricted to include only English-written articles to ensure consistency and facilitate analysis.

### Inclusion and Exclusion Criteria

Articles were included in the analysis if they met the following criteria.

Published in peer-reviewed journals indexed in Scopus.

Written in English.

Published between 2000 and2023 (Specify the desired period for analysis).

The title, abstract, or keywords explicitly mention both "renewable energy" and "climate change."

Articles were excluded if they were as follows:

Are not peer-reviewed publications (e.g., conference proceedings and book chapters).

They have not been written in English.

Fall outside the specified publication period.

Data Extraction and Analysis

The search results were downloaded from Scopus in a format suitable for further analysis, such as CSV or tab-delimited text.

The bibliographic data extracted from each article included publication year, title, authors, author affiliations, keywords, abstracts, and citation counts.

Extracted data will be managed and analyzed using relevant software tools, such as bibliometric analysis software (e.g., Vosviewer and Bibliometric) or spreadsheet software with data analysis capabilities (e.g., Microsoft Excel with appropriate add-ins) (Moral-Muñoz et al., 2020; Van Eck et al., 2010)

Statistical and Analytical Techniques

The following statistical and analytical techniques were employed to analyze the extracted data.

Publication trends: The total number of publications per year was visualized to identify trends in research activity over the chosen period.

Keyword co-occurrence analysis: This technique was used to identify frequently used keywords and their co-occurrence patterns within the retrieved publications. This helps us to understand the thematic structure and emerging research topics within the field.

Citation analysis: Citation data will be used to identify highly cited publications and authors, which can reveal influential research articles and prominent scholars in the field.

## 4.Results and Discussion

### 4.1 Overall Information

This dataset in Table 1 encompasses a 23-year period ranging from 2000 to 2023. It comprises 13,516 documents derived from 4,252 sources including journals, books, and other publication types. The dataset exhibits an annual growth rate of approximately 22.18 %.

Each document in the dataset had an average age of 6.05 years. On an average, each document received 25.05 citations. The dataset included one reference, although additional information regarding its source was unavailable. The documents were connected to 33,562 Keywords Plus (ID) and 23,246 author (DE) keywords. A total of 33,938 authors contributed to the documents, with 2,100 of these being single-authored publications. Collaboration among authors was prevalent, with an average of 3.49 co-authors per document. Approximately 25.65% of co-authorships involve international collaboration.

The dataset encompasses a diverse range of document types, with the most prevalent being articles (7,555), followed by conference papers (2,469), and book chapters (1,349). Other document categories are present in

smaller numbers, such as books, editorials, reviews, and letters. The dataset did not contain information about specific citations, references, or online citations. The dataset's training data sources included academic publications, books, articles, and websites.

Table 1: Descriptive information

| | |
|---|---|
| Timespan | 2000:2023 |
| Sources (Journals, Books, etc) | 4252 |
| Documents | 13516 |
| Annual Growth Rate % | 22.18 |
| Document Average Age | 6.05 |
| Average citations per doc | 25.05 |
| References | 1 |
| DOCUMENT CONTENTS | |
| Keywords Plus (ID) | 33562 |
| Author's Keywords (DE) | 23246 |
| AUTHORS | |
| Authors | 33938 |
| Authors of single-authored docs | 2100 |
| AUTHORS COLLABORATION | |
| Single-authored docs | 2438 |
| Co-Authors per Doc | 3.49 |
| International co-authorships % | 25.65 |
| DOCUMENT TYPES | |
| article | 7555 |
| book | 262 |
| book chapter | 1349 |
| conference paper | 2469 |
| conference review | 57 |
| data paper | 11 |
| editorial | 147 |
| erratum | 4 |
| letter | 54 |
| note | 170 |
| retracted | 3 |
| review | 1380 |
| short survey | 55 |

**4.2; Analysis of Scholarly Output Trends (2000-2023)**

Fig.1 shows that this study examines scholarly output trends from 2000 to 2023, revealing a consistent and substantial upward trajectory.

The analysis demonstrates a gradual but steady rise in the number of published articles from 2000 to 2005, followed by a remarkable surge post-2006.The 2010s witnessed a pivotal point with a notable acceleration in publication growth, characterized by a rapid and sustained upward trajectory in subsequent years. Specific years,

such as 2016, 2019, 2021, and 2022, stand out as milestones with significant increases in published articles. Notably, the year 2023 reached an unprecedented high of 2207 articles, signifying the continued upward trend.

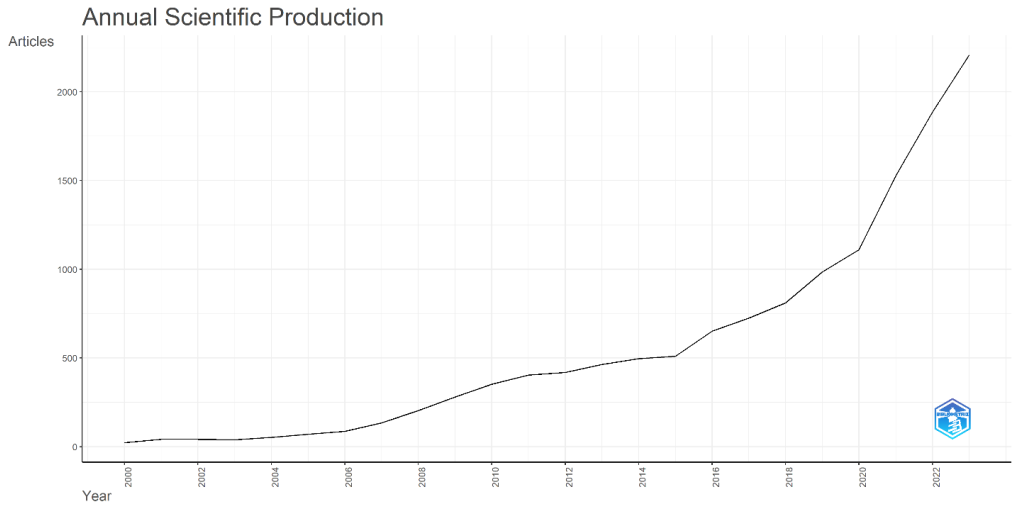


Fig 1: Annual scientific production

**4.3 Average citations per year (2000-2023)**

Table 2 shows the trends in scholarly impact, measured by Mean Total Citations per article (MeanTCperArt) and Mean Total Citations per year (MeanTCperYear), alongside the Citable Years parameter from 2000 to 2023. Initially, MeanTCperArt values were low, indicating a lower average impact of published articles. Increase and Peak (2002-2006): From 2002 onwards, MeanTCperArt exhibits a discernible increase, reaching a peak of 107.69 in 2006, signifying a substantial rise in article impact. This trend is mirrored by a synchronous increase in MeanTCperYear, suggesting a parallel rise in annual citations and individual article impact. Recent Decline (2023): Notably, MeanTCperArt values in recent years have declined, reaching a low of 3.64 in 2023. This trend suggests a potential shift in citation dynamics or changes in how the academic community recognizes published work, and the decline in Citable Years over time indicates a shorter duration for which articles receive citations. This could potentially reflect changes in publication and citation practices.

The observed trends in MeanTCperArt, MeanTCperYear, and Citable Years collectively depict the dynamic landscape of scholarly impact. The initial rise followed by the recent decline in MeanTCperArt merits further investigation to understand the underlying factors that influence these dynamics. The observed changes in Citable Years also warrant exploration in the context of evolving publication and citation patterns.

**Table 2;** Average citations per citable year

| Year | MeanTCperArt | N | MeanTCperYear | CitableYears |
|---|---|---|---|---|
| 2000 | 16.14 | 22 | 0.65 | 25 |
| 2001 | 27.36 | 42 | 1.14 | 24 |
| 2002 | 71.27 | 41 | 3.1 | 23 |
| 2003 | 38.1 | 39 | 1.73 | 22 |
| 2004 | 27.17 | 53 | 1.29 | 21 |
| 2005 | 40.44 | 70 | 2.02 | 20 |
| 2006 | 107.69 | 87 | 5.67 | 19 |
| 2007 | 53.8 | 134 | 2.99 | 18 |
| 2008 | 51.55 | 203 | 3.03 | 17 |
| 2009 | 40.2 | 280 | 2.51 | 16 |

| | | | | |
|---|---|---|---|---|
| 2010 | 51.64 | 352 | 3.44 | 15 |
| 2011 | 34.27 | 403 | 2.45 | 14 |
| 2012 | 36.47 | 419 | 2.81 | 13 |
| 2013 | 32.27 | 464 | 2.69 | 12 |
| 2014 | 32.47 | 496 | 2.95 | 11 |
| 2015 | 37.31 | 510 | 3.73 | 10 |
| 2016 | 38.67 | 651 | 4.3 | 9 |
| 2017 | 32.53 | 724 | 4.07 | 8 |
| 2018 | 32.59 | 811 | 4.66 | 7 |
| 2019 | 29.65 | 984 | 4.94 | 6 |
| 2020 | 26.04 | 1,110.00 | 5.21 | 5 |
| 2021 | 19.51 | 1,528.00 | 4.88 | 4 |
| 2022 | 11.51 | 1,886.00 | 3.84 | 3 |
| 2023 | 3.64 | 2,207.00 | 1.82 | 2 |

**4.4 Core Sources by Bradford's Law**

This study examines the distribution of scientific journals in the field of energy, seeking evidence from Bradford's Law. This principle predicts a specific pattern: a concentration of highly productive journals at the top ranks, followed by a gradual decline in productivity as lower-ranked journals are considered (Nicolaisen et.al., (2007)).

Fig.2 shows the Bradford's law of scattering.

The analysis revealed strong adherence to Bradford's law. Zone 1, encompassing the top-ranked journals, exhibits a significant concentration of publications, with a few journals contributing a substantial proportion of the total output. This is evident in the dominance of journals, such as ENERGIES (frequency: 480), RENEWABLE AND SUSTAINABLE ENERGY REVIEWS, and ENERGY POLICY. The rapid increase in the cumulative frequency within Zone 1 highlights the core set of journals constituting the primary literature in the field.

As we proceed through the ranks (Zone 2 and beyond), the frequency of journals and the rate of cumulative frequency increase demonstrably decline, aligning with Bradford's law. This signifies the existence of a broader array of journals with lower productivity.

The observed distribution of journals in the energy field strongly supports Bradford's law. This finding emphasizes the uneven distribution of productivity across journals, with a small number contributing to the majority of publications in specific fields. Further research could explore the implications of this uneven distribution for information accessibility and research visibility.

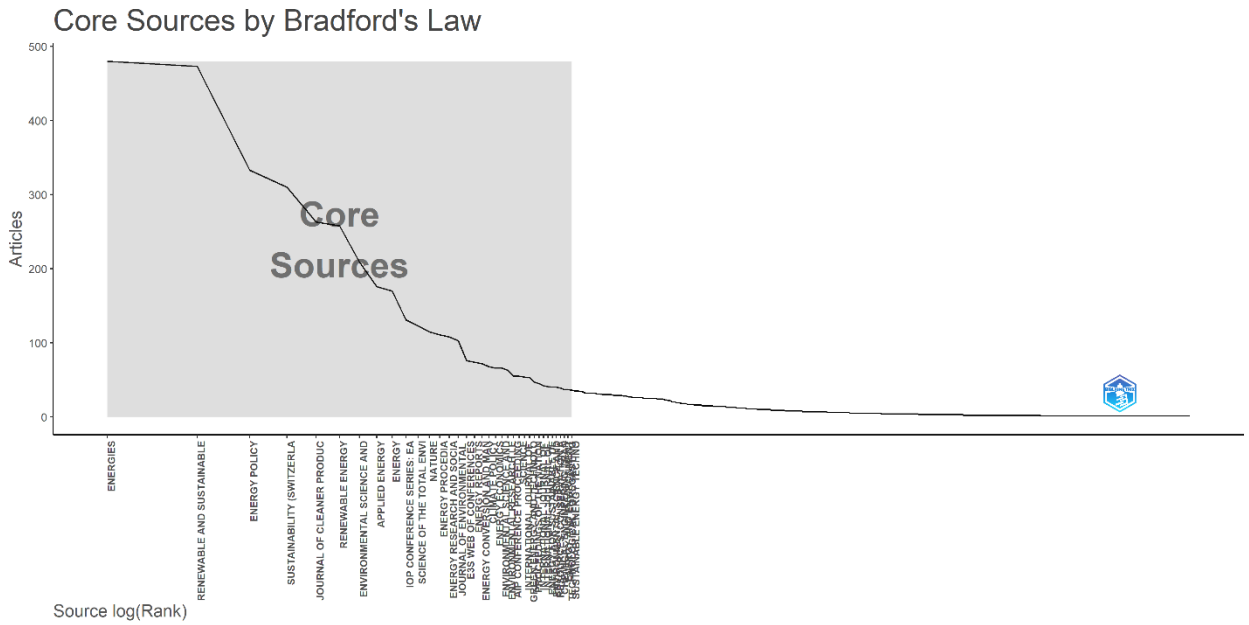


**Fig 2:** Bradford's law of scattering

### 4.5 Analyzing Author Coauthorship Impact: Beyond Citation Counts

Analyzing author co-authorship, also known as co-authorship network analysis, is a technique used to understand the **collaborative relationships** between researchers and the **structure of research communities (Velden et.al., (2010)).**

Of the 37,740 authors analyzed, only 386 met the criteria of having a minimum of five documents each. For these 386 authors, we will compute the collective strength of their coauthorship connections with others.

This study examined the relationship between citation counts and total link strength, exploring their combined ability to assess the impact of authors within the academic landscape. Table 3 displays the 15 most influential authors, as determined by both citations and network connections. Additionally, Figure 3 presents an overlay visualization revealing 11 distinct clusters with 192 connections between them, culminating in an overall connection strength of 410. The data reveals authors like Abbas, Shujaat, Abdelkareem, Mohammad Ali, and Adams, Samuel, with impressive citation counts exceeding 1000. Interestingly, the total link strength (143) suggests a potential limitation. Although their work is widely cited, it may not be extensively referenced within the broader network of academic literature. Similarly, authors such as Adebayo, Tomiwa Sunday, Adedoyin, and Festus Fatai demonstrate notable citation counts (289-684), but their link strength (142) aligns closely with the first group. This highlights the need to consider factors beyond citation counts to understand the influence of authors. Authors such as Alharthi, Majed, Ali, Saleem H., and Ali, Shahid, display a different pattern. While possessing moderate citation counts (342-600), their significantly lower total link strength (82-99) suggests potential distinctions in their publication sources or collaborative networks compared with the previously mentioned groups. This disparity warrants further investigation of the specific publication outlets and collaborative patterns associated with these authors.

Conversely, the data displays authors such as Bekun, Festus Victor, and Breyer, Christian, exhibiting a unique combination. Despite substantial citation counts (1365 and 1957, respectively), their high total link strength (15 and 18, respectively) suggests a potential influence beyond their individual publications. This combination suggests the possible contribution of strong academic networks or collaborative efforts to the prominence of their work within the academic landscape. Finally, the dataset encompasses authors with diverse publication counts ranging from 5 to 34. Notably, some authors with fewer publications demonstrate high citation counts, implying that their research has a significant impact within their respective fields, despite a potentially smaller volume of

published works. This observation underscores the importance of considering factors other than publication quantity when evaluating the impact of an author, emphasizing the limitations of relying solely on citation counts to assess the impact of an author. By incorporating the total link strength, a more nuanced understanding of an author's influence within a broader academic network can be achieved. Further investigation into specific publication sources, collaborative networks, and publication volume can provide deeper insights into the factors impacting author influence and the dissemination of their research. A multifaceted approach that considers various indicators is essential for comprehensively evaluating and understanding the impact of authors in the academic realm.

Table 3: Fifteen most influential authors based on citations and network connections.

| Sl No | Author | Documents | Citations | Total Link Strength |
|---|---|---|---|---|
| 1 | Abbas, Shujaat | 7 | 137 | 143 |
| 2 | Abdelkareem, Mohammad Ali | 9 | 1249 | 143 |
| 3 | Adams, Samuel | 6 | 1045 | 142 |
| 4 | Adebayo, Tomiwa Sunday | 15 | 684 | 142 |
| 5 | Adedoyin, Festus Fatai | 9 | 289 | 142 |
| 6 | Aghahosseini, Arman | 12 | 752 | 142 |
| 7 | Aghbashlo, Mortaza | 6 | 211 | 142 |
| 8 | Agyekum, Ephraim Bonah | 6 | 166 | 142 |
| 9 | Ahmad, Munir | 5 | 466 | 142 |
| 10 | Ahmed, Zahoor | 6 | 318 | 142 |
| 11 | Akimoto, Keigo | 7 | 139 | 142 |
| 12 | Al-Ansari, Tareq | 5 | 35 | 142 |
| 13 | Al-Ghamdi, Sami G. | 6 | 155 | 142 |
| 14 | Al-Mohannadi, Dhabia M. | 6 | 24 | 142 |
| 15 | Albatayneh, Aiman | 6 | 27 | 142 |

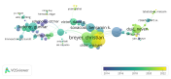

Fig 3**:** An overlay visualization displaying 11 distinct clusters, where 192 connections exist between them, and the overall strength of these connections is 410.

### 4.6 Coauthorship Analysis: Examining Collaboration and Research Impact

This study explores co-authorship patterns among organizations based on a dataset containing information on 28,146 organizations. A minimum document threshold of 5 was applied, resulting in a selection of 106 organizations for further analysis. Table 5 shows the top organizations based on citations and total link strength.

The analysis identified the top 20 organizations based on their combined performance in citations and total link strength, providing insights into both their research impact and collaborative networks. Notably, the table presented in the methodology section summarizes these organizations. The list of top organizations shows a global representation, encompassing institutions from diverse geographical locations such as Lebanon, China, Iran, Romania, Denmark, Saudi Arabia, and Portugal. This geographical spread highlights the international scope of collaborative research.

Several organizations exemplify diverse research focuses and collaborative landscapes. For instance, the Adnan Kassar School of Business (Lebanon) demonstrates a substantial collaborative network, despite having a smaller publication volume (17 documents). Conversely, the Biofuel Research Team (Brteam) from Iran has a significant impact in its field (379 citations with seven documents), while exhibiting a moderate level of collaboration (total link strength of 19). The inclusion of total link strength alongside citation metrics provides valuable insights into the intensity of collaboration between organizations. This metric complements traditional citation analysis by offering a broader perspective on research impact, encompassing not only the number of citations received but also the extent of collaborative networks established, which revealed the multidisciplinary nature of the collaborative research. Organizations representing diverse academic disciplines, including business, economics, chemistry, engineering, and environmental studies, are among the top performers. This observation underscores the importance of interdisciplinary collaboration in addressing complex research challenges and provides a preliminary understanding of co-authorship patterns based on organizations. These findings highlight the importance of examining both citation metrics and collaborative networks when evaluating the impact of research. Further exploration of the data, including delving into specific co-authorship patterns, thematic areas of research, and publication venues utilized by these organizations, can offer even deeper insights into the complex dynamics of collaborative research within the academic landscape.

Table 4: Top organizations based on citations and total link strength.

| Sl No | Organization | Documents | Citations | Total Link Strength |
|---|---|---|---|---|
| 1 | Adnan Kassar School of Business, Lebanese American University, Beirut, Lebanon | 17 | 295 | 23 |
| 2 | Beijing Key Lab of Energy Economics and Environmental Management, Beijing, 100081, China | 6 | 151 | 20 |
| 3 | Biofuel Research Team (Brteam), Karaj, Iran | 7 | 379 | 19 |
| 4 | Bucharest University of Economic Studies, Bucharest, Romania | 5 | 21 | 13 |
| 5 | Center For Energy and Environmental Policy Research, Beijing Institute of Technology, Beijing, 100081, China | 15 | 737 | 13 |
| 6 | Center For Energy Technologies, Department of Business Development and Technology, Aarhus University, Denmark | 12 | 880 | 12 |
| 7 | Center Of Excellence in Environmental Studies (Cees), King Abdulaziz University, Jeddah, Saudi Arabia | 5 | 327 | 10 |
| 8 | Cesam, Physics Department, University of Aveiro, Aveiro, 3810-193, Portugal | 5 | 96 | 9 |
| 9 | China Institute of Development Strategy and Planning, And Center for Industrial Economics, Wuhan University, Wuhan, 430072, China | 6 | 116 | 9 |

| | | | | |
|---|---|---|---|---|
| 10 | College Of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing, 211106, China | 6 | 221 | 9 |
| 11 | College Of Management and Economics, Tianjin University, Tianjin, 300072, China | 6 | 109 | 8 |
| 12 | College Of Resources and Environment, University of Chinese Academy of Sciences, Beijing, 100049, China | 8 | 56 | 7 |
| 13 | Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, Netherlands | 16 | 575 | 7 |
| 14 | Department Of Agricultural Finance and Banking, Bangladesh Agricultural University, Mymensingh, 2202, Bangladesh | 5 | 76 | 7 |
| 15 | Department Of Business Administration, Faculty of Management Sciences, Ilma University, Karachi, Pakistan | 6 | 212 | 7 |
| 16 | Department Of Chemistry, Karadeniz Technical University, 61080 Trabzon, Turkey | 7 | 216 | 6 |
| 17 | Department Of Chemistry, Karadeniz Technical University, Trabzon, Turkey | 5 | 107 | 6 |
| 18 | Department Of Civil Engineering, Xi'an Jiaotong-Liverpool University, Suzhou, 215123, China | 5 | 444 | 6 |
| 19 | Department Of Economics, Noakhali Science and Technology University, Noakhali, 3814, Bangladesh | 6 | 73 | 6 |
| 20 | Department Of Economics, University of Pretoria, Pretoria, South Africa | 5 | 454 | 6 |

**4.7 Coauthorship Analysis: Unveiling Collaboration Patterns Across Countries**

This analysis investigated coauthorship patterns on a global scale by examining data from 298 countries. To ensure a meaningful analysis, a minimum document threshold of five was applied, resulting in a focus on 113 countries.

Figure 4 illustrates an overlay visualization featuring 10 distinct clusters, highlighting 1943 inter-cluster connections and a cumulative link strength of 11085. Table 6 shows the top ten countries based on citations and total link strength. This study delves deeper into the collaborative landscape of research, exploring how different countries interact and contribute to the global knowledge base. This analysis delves into the global landscape of research activity, examining document counts, citation numbers, and total link strength for various countries. The data used in this study highlights several key observations that encompass a diverse array of countries across the globe, reflecting the international nature of research. This global representation underscores the collaborative nature of research and the interconnectedness of the academic landscape, and the United States, China, and India have emerged as leading contributors to global research, as evidenced by their high document and citation counts. Notably, the United States has the highest citation count (79,912), followed by China (48,162) and India (16,927). This demonstrates their significant impact in shaping the global research landscape. Furthermore, Australia has a noteworthy combination of document count (808), citations (32,765), and high link strength (1,495), suggesting that substantial research output, impact, and active collaboration with other countries, such as Germany, Italy, the United Kingdom, and France, have contributed significantly to global research, displaying strong citations and prominent positions within the academic landscape.

China and India, with their impressive document counts and citations, have established themselves as influential research powerhouses in Asia. Their growing contributions significantly impact global scientific output.

Several African countries, including Nigeria, South Africa, and Kenya, have demonstrated active participation in research, displaying the continents' growing role in contributing to the global knowledge base.

Linking strength provides valuable insights into the collaborative efforts between countries. While some nations boast higher document counts and citations, others, such as Algeria, Argentina, and Australia, exhibit strong collaborative networks with high total link strength. This highlights the importance of international collaboration

for advancing research frontiers. Some Middle Eastern countries, such as Saudi Arabia, Qatar, and the United Arab Emirates, display active collaboration, as evidenced by their high link strength. This suggests a commitment to fostering regional and international research partnerships. It is noteworthy that some countries, despite having a relatively low number of documents like Switzerland (277 documents), showcase a significant citation impact (17,198 citations). This observation emphasizes the importance of examining both document counts and citation metrics for a comprehensive understanding of a country's research impact, revealing the diverse nature of research landscapes across different countries. Variations exist in the research foci, collaborative intensity, and overall impact, creating a dynamic and multifaceted global research ecosystem that sheds light on the global landscape of research. The findings highlight the dominance of certain countries, emergence of new research powerhouses, and increasing prominence of collaborative efforts on a global scale. Further investigation into specific research areas, collaboration patterns, and future trends can provide deeper insights into the ever-evolving landscape of global research.


Fig 4: An overlay visualization depicting 10 distinct clusters, with 1943 inter-cluster connections and a total link strength of 11085.

Table 5: Top ten country with citations and total link strength

| Sl No | Country | Documents | Citations | Total Link Strength |
|---|---|---|---|---|
| 1 | Algeria | 70 | 1201 | 1655 |
| 2 | Argentina | 23 | 513 | 1628 |
| 3 | Australia | 808 | 32765 | 1495 |
| 4 | Austria | 203 | 13682 | 1077 |
| 5 | Azerbaijan | 9 | 171 | 844 |
| 6 | Bahrain | 15 | 145 | 744 |
| 7 | Bangladesh | 129 | 2501 | 685 |
| 8 | Belgium | 159 | 6629 | 635 |

| | | | | |
|---|---|---|---|---|
| 9 | Benin | 6 | 41 | 634 |
| 10 | Bosnia And Herzegovina | 8 | 28 | 619 |

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### 4.8 Geographical Distribution of Sentiments in Academic Abstracts

Figure 5 presents a breakdown of the sentiment distribution across countries within our dataset of academic abstracts. The data were intentionally sorted by the number of positive sentiments, emphasizing the global prevalence of positive findings. Countries with high academic publication volumes, such as Australia, Canada, and Brazil, demonstrated a significant number of abstracts expressing positive sentiments. While positive sentiments dominate in most cases, noticeable variation exists in the proportion of negative and neutral sentiments across different countries. This divergence suggests potential regional variations in research focus or communication style. Overall, the distribution suggests a global inclination towards positive results in academic research. However, it is crucial to acknowledge the presence of discernible differences between countries that could potentially stem from diverse cultural perspectives, economic realities, or scientific landscapes.

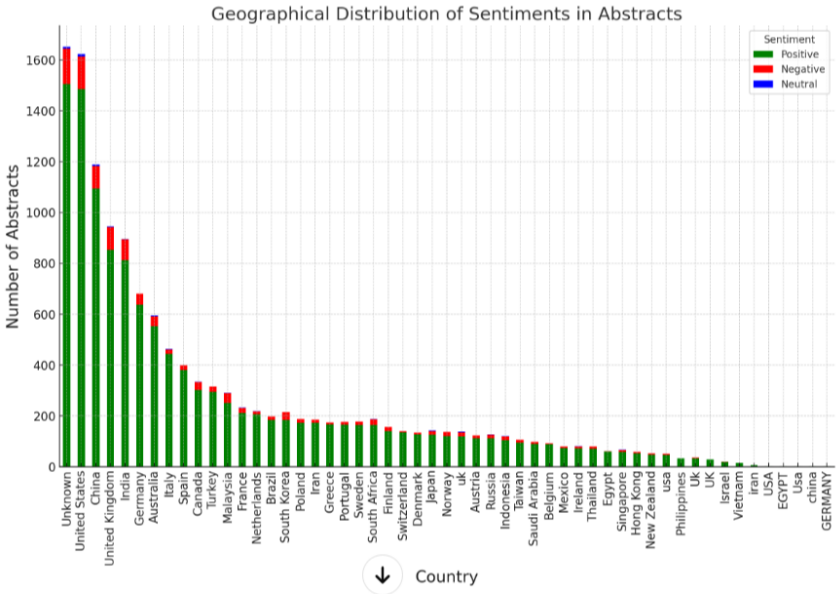


Fig 5: Sentimental Analysis of abstracts

### 4.9 Conclusion:

This study presents a comprehensive bibliometric analysis of renewable energy and climate change research, highlighting significant growth in scholarly output and collaboration across countries and disciplines. Key findings underscore the evolution of research themes, impact of global collaboration, and critical role of renewable energy in addressing climate change challenges.

Limitations:

This research acknowledges limitations, including potential biases inherent in bibliometric analyses, the focus on English-language publications, and reliance on data from specific databases that may not capture all relevant studies.

Future Directions:

Future research should address the identified gaps, such as the need for interdisciplinary approaches and integration of emerging technologies. Expanding the linguistic and geographic scope of these studies could

provide a more holistic understanding of this field. Additionally, exploring the implications of renewable energy policies on economic and social outcomes is essential for guiding sustainable transition.

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