



Renewable Energy Development Research Trends in Scientific Publications 2013-2022 Based on Bibliometric Analysis

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Abstract. The development of scientific literature plays a crucial role in the advancement of science and technology, including the fields of library science and Renewable Energy Development (RED). Research on renewable energy development has been a major focus in recent decades, yet the mapping of RED research topics remains limited. This study aims to map the development and document scientific publications in the field of Renewable Energy Development and uncover future research opportunities using bibliometric analysis. By mapping the development of RED research, this study provides insights into global scientific contributions and helps researchers and practitioners identify areas needing further research. This study employ a descriptive quantitative method with bibliometric analysis. Data were obtained from the Scopus database, encompassing 9,864 scientific publications on RED from 2013 to 2022. The findings indicate a significant increase in RED scientific publications, peaking in 2022 with 2,480 publications. China, India, and the United States are the main contributors. The global contribution from 160 affiliations demonstrates extensive collaboration in RED research. Total citations reached 183,783, indicating the high relevance and impact of this research. Most authors contributed only one article, consistent with Lotka's Law, but a small number of authors were highly productive. Prolific journals such as *Energies*, *IEEE Access*, and *Renewable Energy* are the primary sources for publishing this research. Keyword analysis shows a research focus on topics such as Renewable Energy Source, Grid, Power System, and Wind Power. These findings aid researchers and practitioners in identifying future research opportunities.

Keywords: Renewable Energy Development, Bibliometrics, Scopus, Lotka Law

1 Introduction

The development of scientific literature plays a crucial role in the advancement of science and technology, including the field of library science. Continuously updated literature allows researchers and practitioners to access the latest information, identify new trends, and stay abreast of the latest developments in various research fields. Monitoring research progress has become increasingly important on key topics such as Renewable Energy Development (RED). In recent decades, research on renewable

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energy development has become a primary focus [1]. Sustainable development is an approach to development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This approach focuses on balancing economic, environmental, and social aspects, aiming to create an environmentally friendly environment for all parties [2]. Several empirical studies reveal that sustainable development is an effort that prioritizes the optimal utilization of natural and human resources while ensuring that the environment is not harmed [3]. This principle is widely recognized by politicians, industrialists, and environmental activists alike. Sustainable development has emerged in response to growing global concerns about environmental degradation and worsening natural destruction [4].

Thousands of studies, projects, and publications such as “Renewable Energy Sources and Energy Production: A Bibliometric Analysis of the Last Five Years” [5], “Research on biomass energy and environment from the past to the future: A bibliometric analysis” [6], and “Way forward for alternative energy research: A bibliometric analysis during 1994–2013” [7] have been conducted to map renewable energy topics using bibliometrics. The mapping of Renewable Energy Development research topics remains limited. Mapping techniques can be used to determine areas or metadata that are more commonly used by researchers and considered more relevant for publication [8].

Bibliometric terminology is a branch of library and information science that was introduced in the 1960s [9]. In this context, a bibliometric analysis of scientific publications from 2013 to 2022 shows that there are still few studies using a bibliometric approach to reveal the mapping of research developments in the field of Renewable Energy Development. By applying bibliometric techniques to renewable energy research, this study aims to map developments and document scientific publications in this field as well as uncover future research opportunities.

2 Methods

This research employs a descriptive quantitative method with bibliometric analysis. The data source used is scientific publications on the theme of Renewable Energy Development obtained from the Scopus database. The population studied includes all Scopus journal article publications on the topic of "renewable energy development" over a 10- year period (2013-2022), totaling 9,864 publications. The sample for this research includes 9,864 scientific publications from 2013-2022, as counted in November 2023.

3 Result and Discussion

3.1 Distribution of 2013-2022 Publications Listed by Scopus

The growth trend of publications shows an interesting and dynamic journey. The distribution of Scopus-indexed publications over the period from 2013 to 2022 was analyzed. The number of annual publications was examined to identify growth trends and highlight significant changes during this period. A total of 9,864 publications were found in the last ten years, with 2022 marking the peak of the highest number of publications, totaling 2,480. The surge in publications related to renewable energy, as highlighted in the analysis of biofuel research, underscores the growing interest and investment in alternative energy sources, reflecting a global shift towards sustainability [10].

3.2 Contributing Countries

The number of publications from each country per year revealed that 125 countries contributed to scientific publications on the topic of RED research. China, India, and the United States are the countries that contributed the most to this research topic. A study found that China, India, and the United States are leaders in renewable energy research, ranking among the top 10 [11].

Table 1. Average Publications per Country

No	Negara	Total Publications	Total Citations	Average (%)
1	China	2551	58093	22,8
2	India	2546	25398	10
3	United States	1840	62699	34,1
4	Iran	968	21390	22,1
5	Turkey	710	13692	19,3
6	Saudi Arabia	649	12658	19,5
7	South Korea	624	9814	15,7
8	Russia	542	4829	8,9
9	Japan	433	7630	17,6
10	United Kingdom	303	23931	79

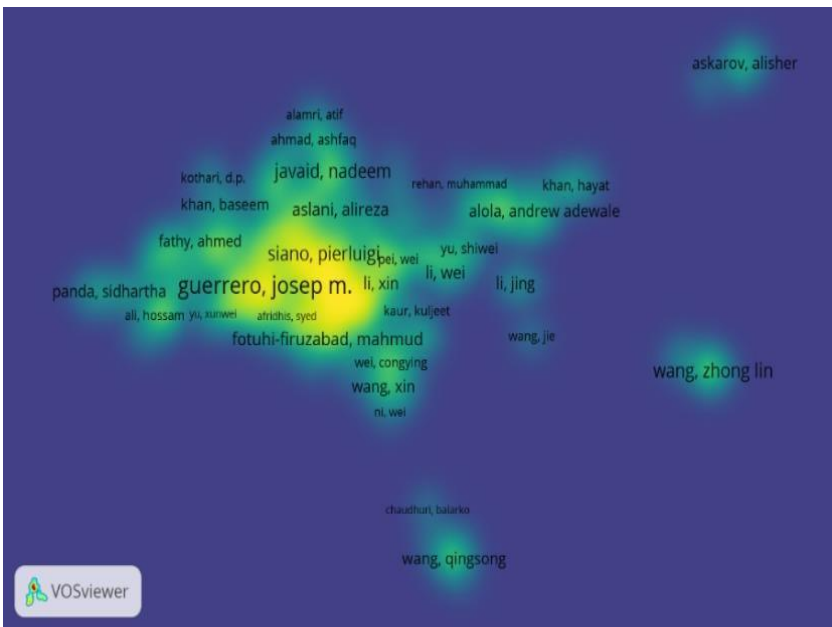
3.3 Contributing Affiliations

Affiliations play a crucial role in generating, promoting, and disseminating knowledge. Therefore, it is essential to study the leading institutions worldwide that have contributed to the theoretical and empirical literature in the field being studied over time. The most productive affiliations in the scientific literature during the period from 2013 to 2022 provide insights into the contributions and impact of research and educational institutions in various countries. Researchers identified 160 affiliations from various countries across Europe, America, Africa, Australia, and Asia.

3.4 Citations of Renewable Energy Development Publications

Citations of publications are an important indicator for measuring the impact and relevance of a research study. The number of citations reflects the extent to which research findings have been cited and utilized by the scientific community. In Figure 1, density is shown with 1,000 primary authors whose articles have the highest number of citations. Over the past 10 years, there have been a total of 183,783 citations.

Fig 1. Visualization Density of Leading Authors



3.5 Author Productivity

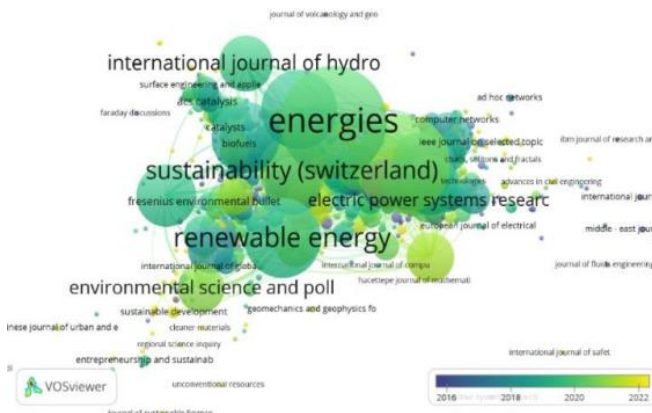
One of the studies found by Lotka concluded that there is an inverse relationship between the number of articles written and the number of authors who write articles in a particular field. In other words, the more articles that are written, the fewer authors contribute to writing them. According to Lotka's Law, about 60% of all authors in a particular field contribute only a single publication [12]. Lotka's Law is often used as a bibliometric tool in discussions of author productivity. Researchers have identified 22,488 authors who published articles on this theme between 2013 and 2022. Among these, 17,124 authors published just one article, representing 76% of the total number of authors. Lotka suggested that the proportion of authors contributing a single article would be 60% of the total number of authors, whereas the percentage of authors in the renewable energy development theme exceeds the number suggested by Lotka. If we follow Lotka's calculation, the number of authors contributing a single article should be 60% of 22,488 authors, or approximately 13,492 individuals.

Next, the number of authors contributing two articles drops to 2,753, representing 12% of the total. The difference between the number of authors contributing one article and those contributing two articles is quite significant, with a difference of 14,371 authors, or about 84%. The number of authors decreases further to 977, or 4%, for those contributing three articles, which aligns with Lotka's 7% proportion, indicating that the productivity of authors contributing three articles is acceptable. For authors contributing four and five articles, the percentage decreases to 2% and 1%, respectively. In this section, the percentage graph of the number of authors does not show a significant difference from Lotka's Law.

3.6 Productivity Journal

The most productive journals were studied to identify and understand publication trends in the scientific literature related to a specific topic. Analyzing the journals that publish the most related research provides valuable insights for researchers in several aspects. The researchers identified 160 journals from various countries, as visualized in Figure 2. The top three journals are *Energies*, *IEEE Access*, and *Renewable Energy*.

Fig 2. Visualization of the Most Productive Journals



3.7 Keywords Trend

In an effort to explore research trends in the field of Renewable Energy Development, researchers have identified a total of 30,746 keywords related to the RED theme over the period from 2013 to 2022. The visualization of keywords in Figure 3 illustrates their usage in scientific articles published during this period and aims to facilitate indexing and retrieval of information.

Fig 3. Word Cloud Visualization of Keyword Usage



Out of this total, the most frequently occurring keyword appears 9,303 times, while the least frequent ones appear only once. Figure 3, obtained from the SciVal database, identifies 20 keywords with higher frequencies compared to others. These 20 keywords are Renewable Energy Source, Renewable Energy, Grid, Power System, Wind Power, Energy Storage, Solar Energy, Microgrid, Solar Energy Conversion, Solar, Fossil Fuel, Storage System, Wind Turbine, Photovoltaic System, Power Plant, Solar Collector, Biofuel, Greenhouse Gas Emission, DC-DC Converter, and Hydropower.

4 Conclusion

This study reveals that scientific publications in the field of Renewable Energy Development (RED) have seen a significant increase during the period from 2013 to 2022, peaking in 2022. China, India, and the United States are the main contributors, with the United States having the highest average citations, indicating a substantial influence in the scientific community. Global contributions from affiliations in various countries signify extensive collaboration in RED research. The total number of citations reached 183,783, highlighting the relevance and significant impact of this research. The majority of authors contributed only one article, although a small number of authors were highly productive. The most productive journals, such as *Energies*, *IEEE Access*, and *Renewable Energy*, are primary sources for this research. Keyword analysis shows a dominant focus on topics such as Renewable Energy Source, Grid, Power System, and Wind Power. This study provides a comprehensive mapping of trends and developments in RED research, assisting researchers and practitioners in identifying future research opportunities.

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