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Review

Renewable Energy as a Strategic Mechanism for Achieving the Sustainable Development Goals: A Bibliometric Review

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Abstract

This study offers a comprehensive bibliometric and scientific mapping review of the literature examining renewable energy as a strategic mechanism for achieving the Sustainable Development Goals (SDGs). Drawing on a structured bibliometric review approach and advanced bibliometric methods, the analysis covers 278 peer-reviewed articles indexed in the Web of Science database. This study explores how research on the SDG–renewable energy nexus has evolved over time, highlighting publication trends, geographical patterns, influential journals and authors, and the intellectual structure of the field, with particular attention to developments observed after 2022. The results show a rapidly growing and increasingly interdisciplinary body of research in which renewable energy systems are consistently framed as core elements of sustainable development strategies, energy transition pathways, and policy-relevant frameworks. Beyond descriptive mapping, the study provides a mechanism-oriented interpretation of thematic clusters, explicitly linking renewable energy research trajectories to specific SDGs and their systemic interactions. By identifying dominant research themes, emerging directions, and existing research gaps, this review provides strategic insights that can support future academic research and inform policymakers and energy stakeholders involved in steering the transition toward sustainable energy systems.

Keywords: sustainable development goals (SDGs); renewable energy systems; energy transition; sustainable energy policy; bibliometric analysis; scientific mapping; strategic sustainability pathways

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1. Introduction

Sustainable development constitutes one of the key challenges of the contemporary global economy, as it involves integrating social, economic, and environmental objectives. In response to escalating climate-, resource-, and society-related challenges, this concept has evolved toward increasingly complex and multidimensional analytical frameworks.

In the literature, issues related to sustainable development are examined from both a macroeconomic perspective—encompassing systemic transformations and public policies [1–3]—and a microeconomic perspective, focusing on firm-level activities, technological innovations, and changes in production and consumption patterns [4,5]. In both dimensions, particular attention is devoted to the role of renewable energy, which is widely

perceived as a factor enabling the simultaneous achievement of environmental and socio-economic objectives [6].

The rapidly growing number of publications, combined with the diversity of theoretical and empirical approaches, highlights the need for a systematic organization of the existing body of scientific literature and for the identification of dominant research streams and research gaps in the analysis of the relationship between renewable energies (RE) and the Sustainable Development Goals (SDGs).

The Sustainable Development Goals were established in 2015 by the United Nations (UN) and set out an agenda for global action to promote peace, sustainable development, and social justice [7–12]. The SDGs are grounded in principles of equality, fairness, and shared responsibility, with a strong emphasis on respect for human rights, environmental protection, and the fight against climate change [13–15]. Research on the SDGs and RE is constantly evolving, and various researchers are trying to better understand the implications of their implementation, from cost–benefit analyses of different technologies to broader approaches to resource management [16–18].

Highly cited studies in this research domain address diverse aspects of sustainable development in the context of renewable energy. Below are the research objectives of the five most cited publications, the subject of which was related to SDGs and RE in the years 2015–2024.

In their research, Gielen et al. (2019) describe the energy transition framework needed for sustainable progress from now to 2050 and highlight the contribution of renewable energy to these global changes, using the latest data on renewable energy [19]. The study demonstrates that increasing energy efficiency and adopting renewable energy technologies are crucial elements of this transition, and their combined effectiveness is substantial. The authors emphasize that many policymakers and analysts have not yet fully recognized the potential of this energy transition. Nevertheless, this awareness is essential to achieving many of the Sustainable Development Goals (SDGs) and offers an opportunity for fair and equitable economic development.

Bekun (2018) conducted research examining the long-term relationships and causal links between the use of renewable and non-renewable energy and economic development concerning carbon dioxide emissions [20]. Using balanced panel data for 16 EU countries covering the period 1996–2014, the study shows that non-renewable energy consumption and economic growth contribute to higher greenhouse gas emissions, whereas renewable energy use is associated with emission reductions. In addition, the analysis identifies a causal relationship between natural resource income and economic growth. This leads to the formulation of essential policy recommendations that support the development of modern and environmentally friendly energy solutions, particularly in the context of achieving the Sustainable Development Goals.

Sarkodie et al. (2019) analyze the relationships between foreign direct investment inflows, economic growth, and energy use in the context of greenhouse gas emissions in the years 1982 to 2016 for the five largest emitters of greenhouse gases due to fuel combustion among developing countries—China, India, Iran, Indonesia, and South Africa [21]. Reducing greenhouse gas emissions relies on enhanced energy efficiency; the implementation of clean and advanced energy technologies, including renewable sources and nuclear power; as well as the incorporation of carbon capture and storage methods in fossil fuel and biomass energy generation.

Schroeder et al. (2019) emphasize the importance of circular economy (CE) methods in achieving the Sustainable Development Goals [22]. The results of the literature review and analysis indicate that CE methods can significantly contribute to achieving many of the SDGs. The most obvious links can be found between CE practices and SDG 6, SDG 7, SDG 12, and SDG 15. The article also analyzes the cooperation that can be established between

different SDGs using CE methods. In addition, it highlights potential conflicts between the goals of fair employment, a safe working environment, and public health, as well as existing approaches to the circular economy regarding municipal waste, electronic waste, and wastewater recycling. It offers recommendations on how to resolve these issues. The authors argue that the practices in Central Europe can be used as a "toolkit" of practical strategies for effectively achieving multiple Sustainable Development Goals.

In their article, Alola et al. (2019) analyze the elements required to achieve Sustainable Development Goals in terms of reducing environmental pollution in EU member states [23]. The study focused on 16 EU countries between 1997 and 2014. The study assessed the interrelationships between ecological footprint, real gross domestic product, international trade, fertility rate, as well as renewable and non-renewable energy sources. The results highlighted the negative impact of non-renewable energy consumption on environmental degradation, while the use of renewable energy was found to increase environmental sustainability.

Existing empirical studies, including those focusing on European and global contexts, consistently demonstrate that renewable energy plays a critical role in mitigating environmental degradation and supporting broader sustainability objectives. However, these studies typically concentrate on specific regions, time horizons, or outcome variables, such as emissions, ecological footprints, or economic growth, and apply heterogeneous methodological frameworks. As a result, the accumulated evidence, while substantial, remains analytically fragmented and conceptually dispersed. This fragmentation limits the ability to derive a coherent understanding of how renewable energy is positioned within the broader Sustainable Development Goals agenda and how different research streams collectively frame its strategic relevance. Consequently, a systematic synthesis of the literature is required to organize existing knowledge, identify dominant thematic patterns, and clarify the conceptual pathways through which renewable energy contributes to the achievement of the SDGs.

Research Objective and Research Questions

Scientific output concerning the SDGs and RE has started to increase since 2015. This is attributed to the approval of the SDGs by the United Nations in 2015, marking the beginning of the sustainability-focused research, for which the SDGs provided the framework. Nevertheless, the historical series of reviewed research output began in 1992. This is evident from the United Nations Conference on Environment and Development held in Rio de Janeiro, which already began to discuss the idea of creating a possible Agenda 21 to solve the challenges that the Earth will have to face in the 21st century, with a particular emphasis on the importance of supporting renewable energy. It is important to mention that there was a moderate increase in the emergence of scientific results in the second half of the first ten years of the 21st century, resulting in rapid development that continues to this day. This can be attributed to two main factors. Firstly, in 2000, the Millennium Summit led to the establishment of the MDGs, thus creating a fundamental plan to improve economic, social, and environmental sustainability through the implementation of these goals. This development was succeeded by the launch of the SD21 project in 2012 by the United Nations to foster sustainable growth in today's world, where renewable energy is crucial for reaching this objective.

Although there are many bibliometric analyses on the topic of linking renewable energy to the SDGs, this research covers the period up to 2022 [24]. The continuation of these studies is still essential.

The aim of this review is to synthesize trends in the development of research on the relationship between the development of renewable energy and the Sustainable Development Goals. And to specify in more detail, this study aims to assess the size, growth trajectory, and

geographical distribution; identify key journals, authors, and documents; as well as analyze the intellectual structure and highlight emerging themes in the SDG–RE literature.

This study introduces a novel approach by integrating a literature review with a bibliometric analysis to provide a comprehensive overview of the relationship between renewable energy development and the implementation of the Sustainable Development Goals. Previous studies have emphasized these aspects separately or to a limited extent, and most previous works have only considered the literature up to 2022. To the best of the authors' knowledge, there is no recent bibliometric study that captures the changing trends, research frontiers, and thematic structures in this field after that year. This article aims to fill this gap by providing an updated and holistic map of the scientific landscapes that are highly relevant for guiding further research toward evidence-based policy making. To address this gap more explicitly, this study develops a *mechanism-oriented conceptual framework*, synthesized from bibliometric evidence, which explains how renewable energy operates as a strategic mechanism for achieving the Sustainable Development Goals. Specifically, the framework identifies technological, financial, institutional, and governance pathways through which renewable energy contributes to SDG implementation, thereby moving beyond descriptive mapping toward mechanism-level interpretation. To fill the research gap and achieve the study objectives, the following research questions (RQs) were formulated:

RQ1. *How has the volume and geographical distribution of research on SDGs and REs been changing over time? (Focus: temporal vs. spatial trends in the publications.)*

RQ2. *Who are the most significant, impactful contributors (authors, institutions, and journals) in the field of SDG and RE research, and what is the impact of citation of their work? (Focus: key actors and research impact.)*

RQ3. *What are the main thematic clusters and conceptual structures within the research literature on SDGs and RE? (Focus: intellectual and thematic mapping.)*

Each research question will be given an independent answer in the Section 3, starting with RQ1 in Sections 3 and 3.1, RQ2 in Sections 3 and 3.2, and RQ3 in Sections 3 and 3.3.

Despite the growing number of bibliometric reviews addressing renewable energy and sustainability, existing studies predominantly focus on descriptive mappings of publication trends, citation structures, or keyword co-occurrences. Far less attention has been paid to interpreting these patterns in a way that clarifies how renewable energy operates as a strategic mechanism linking energy transitions to the achievement of specific Sustainable Development Goals. This study addresses this gap by moving beyond descriptive bibliometric analysis toward a mechanism-oriented synthesis of the literature. By systematically interpreting thematic clusters as distinct but interrelated pathways through which renewable energy contributes to SDG implementation, the review explicitly connects dominant research themes with specific SDGs and their cross-cutting interactions. In doing so, this study not only enhances methodological transparency in bibliometric research on energy and sustainability but also provides a conceptually grounded framework that supports policy-relevant interpretation of the renewable energy–SDG nexus.

2. Materials and Methods

2.1. Data Selection and Scientific Mapping Approach

This study is designed as a PRISMA-informed bibliometric review. PRISMA guidelines are applied to ensure transparency and replicability of the literature search and screening process, while bibliometric mapping techniques—including co-occurrence, co-citation, and collaboration network analysis—constitute the core analytical approach. Consistent with the objectives of bibliometric research, this study does not apply formal quality appraisal

tools typical of evidence synthesis-based systematic reviews, as its aim is to map the intellectual and thematic structure of the field rather than to synthesize effect sizes or evaluate intervention quality. The analysis is based on scientific mapping to provide a systematic, bibliometric synthesis of trends in articles indexed by WoS. To maintain a consistent and rigorous academic approach, the search was limited to documents classified as "articles" in the Web of Science indexing system. Other types of publications, such as review articles, conference proceedings, editorial materials, and book chapters, were not considered. The exclusion of review articles was intentional, as review papers tend to dominate citation structures and may obscure the mapping of original knowledge production; theoretical syntheses from review literature were instead incorporated into the Introduction and Discussion sections. Focusing on peer-reviewed journal articles ensured a consistent dataset suitable for robust bibliometric and network-based analyses This ensured a consistent dataset suitable for bibliometric and substantive analyses.

Scientific mapping is widely applied in contemporary bibliometric research as an approach to systematically assessing the structure and evolution of a given knowledge base. As established in the literature [25–27], scientific mapping enables analysis along four complementary dimensions:

- Size refers to the amount of accumulated knowledge;
- Time covers trends in publications in a given field;
- Space covers the geographical origin of documents within a specific knowledge base;
- Composition refers to the organization of the intellectual knowledge framework.

2.2. Database Selection and Structural Bias

The Web of Science database was selected due to its standardized bibliographic records, curated journal coverage, and stable citation indexing, which are essential for reproducible bibliometric and network-based analyses. WoS provides strong coverage of high-impact journals in energy research, sustainability science, and applied environmental studies, which constitute the core domains of this analysis.

At the same time, it is acknowledged that WoS exhibits structural coverage biases, particularly in relation to policy-oriented publications, regional journals, books, and grey literature, which may be more extensively covered by databases such as Scopus, Dimensions, or Google Scholar. Consequently, some development- and policy-focused research streams may be underrepresented.

In this study, the term "global intellectual landscape" is therefore interpreted in a bibliometric-structural sense, referring to the internationally visible, peer-reviewed research core that shapes dominant scholarly networks and thematic structures within the SDG–renewable energy research field.

2.3. Search Strategy, PRISMA-Informed Screening, and Bibliometric Analysis

To ensure transparency and reproducibility of the identification and screening of publications, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were employed as a procedural reporting framework supporting the search and selection stages of the bibliometric review [26,27]. Figure 1 illustrates the PRISMA-informed bibliometric review methodology applied in this study. The bibliometric review encompasses scientific articles from various disciplines focusing on the Sustainable Development Goals and renewable energy. Sources were identified in the Web of Science database using logical operators. After applying the search algorithm on 26 October 2024, a total of 278 articles containing the following keywords were retained:

"sustainable development goal*" OR "SDG*"

AND

"renewable energy*" OR "clean energy*"

After refining the search (by manually removing individual sources from the database), data from Web of Science in the form of a.csv file was extracted. It should be emphasized that PRISMA was applied exclusively to document the search, identification, and screening procedures. In line with this study's objective—mapping the intellectual and thematic structure of the literature—no formal quality appraisal or risk-of-bias assessment of individual studies was conducted. The subsequent analysis relies on bibliometric mapping techniques. The third stage involved scientific mapping of research using bibliometric methods. In this conference paper, bibliometric analysis and visualization were performed using VOSviewer software (version 1.6.19).

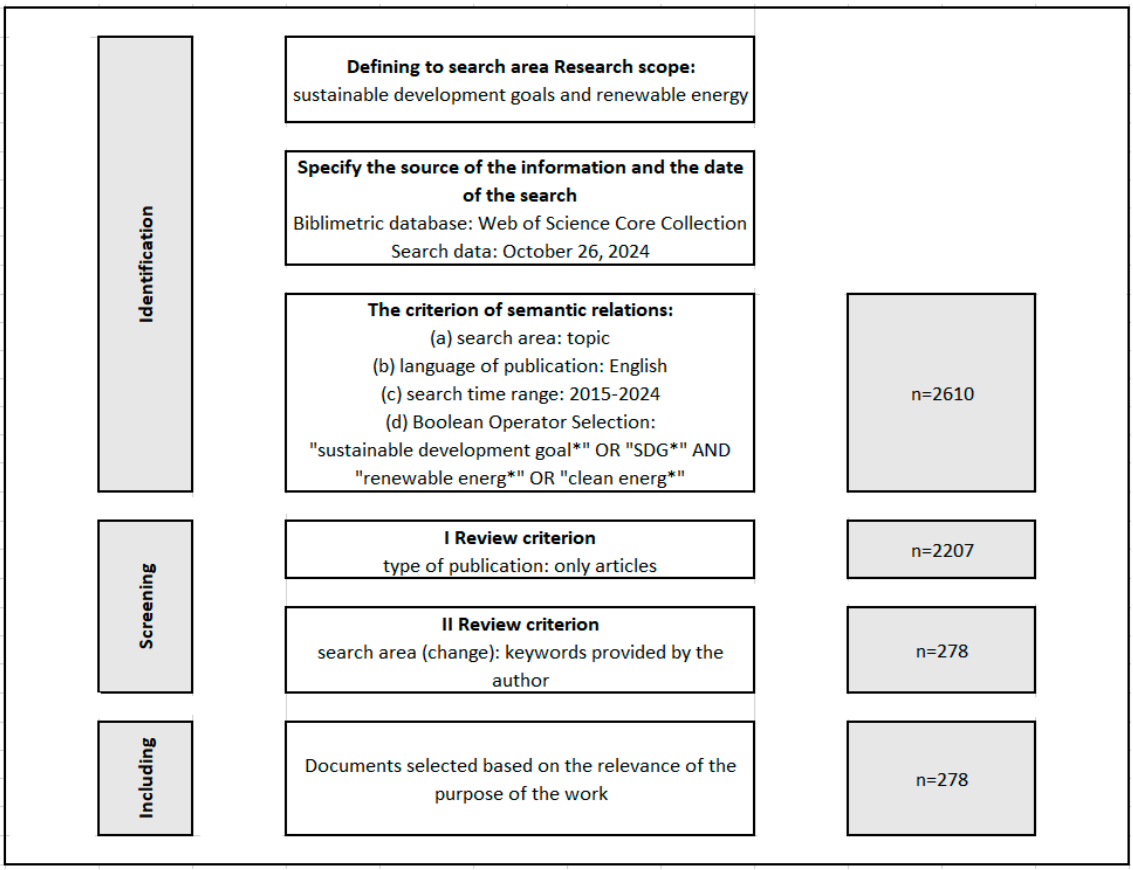

Figure 1. PRISMA-informed flowchart documenting the identification and screening procedure applied in the bibliometric review. Source: Authors' own elaboration based on PRISMA guidelines.

The bibliometric analysis was conducted using bibliographic metadata as provided by the Web of Science database. No additional algorithmic author disambiguation or manual harmonization of author or institutional names was applied beyond the standardized country information available in the Web of Science records. Consequently, author-, institution-, and country-level indicators are interpreted as descriptive representations of the indexed metadata rather than as fully disambiguated or definitive rankings.

In this study, "leading" authors and journals are identified using descriptive bibliometric indicators derived from the Web of Science metadata, including publication counts and total citation counts within the analyzed dataset. These indicators are employed to characterize prominence and visibility within the mapped literature rather than to evaluate scholarly quality or impact in a normative sense. No citation time normalization (e.g., citations per year), h-index calculations, or exclusions of self-citations were applied, in line with the mapping-oriented objective of the bibliometric analysis.

The observed prominence of specific SDGs reflects thematic patterns within the retrieved dataset rather than normative or causal dominance, in line with the mapping-oriented nature of bibliometric analysis.

In the third stage, scientific mapping of the literature was performed using bibliometric techniques. VOSviewer was used to measure and visualize a dataset related to SDGs and RE. VOSviewer is a software tool for creating maps based on network information and for viewing and analyzing these maps. This bibliometric software(VOSviewer version 1.6.19) was developed using the Java programming language. VOS mapping methods enable a more effective representation of basic data compared to maps, owing to their multidimensional approach. Therefore, in this analysis, VOSviewer software is used to create so-called "network maps" showing the connections between different attributes of the SDGs and RE process knowledge base.

The following analyses were performed using VOSviewer software (Table 1):

- Citation analysis: This allows researchers to detect the popularity of sources, publications, and authors;
- Co-citation analysis: This provides an understanding of the extended impact of citations on a specific topic of knowledge and can occur in various variants, e.g., as journal co-citation analysis (JCA), author co-citation analysis (ACA), and document co-citation analysis (DCA);
- Bibliographic coupling: This allows researchers to view related documents, authors, and even journals based on the number of standard references;
- Co-authorship analysis: This allows researchers to find articles they have co-authored.

Table 1. VOSviewer guide detailing type analysis.

Type of Analysis	Description of the VOSviewer Instructions
Contributor analysis	The connection between elements is defined by how many documents they have co-authored together
Citation analysis	The connection between the elements is defined by the frequency with which they reference one another
Co-citation analysis	The connection between elements is established based on the frequency of their mutual references
Bibliographic join	The element binding is based on the quantity of references they have in common

2.4. Methodological Logic and Research Questions

The methodological design of this study was structured to ensure a transparent linkage between the applied bibliometric techniques and the research questions asked. The first research question, addressing the volume, geographical distribution, and temporal dynamics of SDG–renewable energy research, was examined using descriptive bibliometric indicators, including annual publication trends, country-level productivity, and co-authorship analysis. The second research question, which focused on identifying influential authors, journals, and the intellectual structure of the field, was addressed through citation analysis, journal co-citation analysis, document co-citation analysis, and author co-citation mapping. Finally, the third research question, concerning the thematic and conceptual structure of the SDG–renewable energy literature, was investigated using keyword co-occurrence analysis and temporal overlay visualization. Together, these complementary methods enable a coherent reconstruction of both the structural patterns and the underlying mechanisms organizing the SDG–renewable energy research landscape.

3. Results and Discussion

The individual subsections present answers to the research questions asked in the introduction.

3.1. How Has the Volume and Geographical Distribution of Research on SDGs and RE Been Changing over Time?

The research question aims to uncover the volume, growth trajectory, and geographical distribution in the literature on the SDG and RE process. Figure 2 shows the number of publications per year, and Figure 3 shows the number of individual publications related to each SDG. While the -Section 3 reports structural patterns identified through bibliometric mapping, this discussion aims to explain why these patterns emerge by linking them to differences in development stages, political economy, and institutional contexts. The observed bibliometric structures are interpreted as indicators of policy priorities, funding mechanisms, and institutional incentives rather than as purely statistical regularities. Analyzing Figure 2, it can be seen that the trend line reveals two time phases of the SDG and RE literature. The first phase spanned the period from 2015 to 2021. This is the prenatal stage, characterized by a few to a maximum of 30 publications per year that include keywords related to the Sustainable Development Goals and renewable energy. This stage can be seen as the stage in which researchers tried to understand the concept of relationships between these research areas [24].

From 2022 to 26 October 2024, a stage of growth can be identified in research on the theme of SDGs and RE. Particular attention should be paid to the large (2.6 times larger in comparison to 2021) increase in publications in 2022. After 24 February 2024, we observe the biggest cost-of-living crisis in a generation, which threatens the progress of the SDGs to create a better world in 2030 [28]. Additionally, disruptions in the global energy supply chain have thwarted efforts to decarbonize the energy ecosystem to achieve net-zero carbon emissions as part of sustainability commitments [29]. It is also unclear how the energy supply challenges caused by the conflict may affect the prospects for global sustainable development [30]. Therefore, it can be assumed that scientists have conducted a number of studies and analyses, hence this sudden increase in interest in the subject of implementing Sustainable Development Goals and the development of renewable energy [31–34].

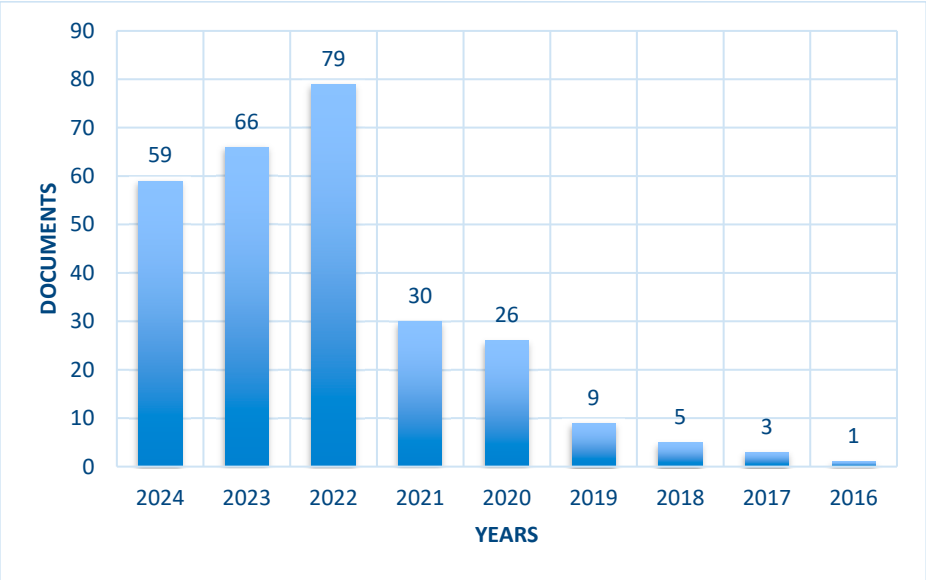

Figure 2. Number of publications from the criterion (Figure 1) in individual years of analysis.

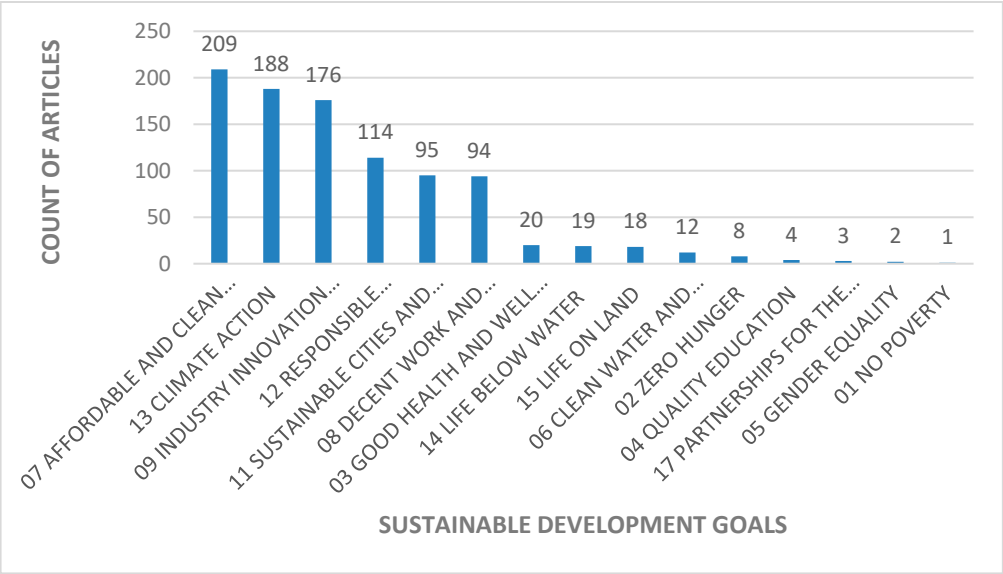

Figure 3. Number of publications from the criterion (Figure 1) assigned to each SDG according to WoS.

It is also worth noting that the research conducted over the nine-year period has addressed all seventeen Sustainable Development Goals (Figure 3). However, the literature shows a pronounced concentration around SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action), which together account for 397 scientific publications. This strong focus can be explained by the central role of the energy–climate policy nexus in global sustainability agendas. Renewable energy operates at the intersection of these two goals by translating climate commitments into concrete energy system transformations. Moreover, international policy frameworks—including Nationally Determined Contributions (NDCs), COP processes, and climate-related financing instruments—explicitly prioritize energy transition pathways, thereby shaping research incentives. Other SDGs tend to appear as secondary or indirect outcomes of renewable energy deployment, which explains their comparatively lower visibility in the bibliometric structure.

Co-authorship analysis includes the collaboration of dissenting authors and details of their individual publications. To better understand international cooperation, the mapping of co-authorship of countries by author affiliation is shown in Figure 4. In addition, the characteristics of cluster citations are given in Table 2. The selected 278 articles came from 87 countries. All countries that submitted at least five publications are included. This condition was true for 32 countries, and five clusters were obtained with 184 links and a total link strength of 363. The size of the circle reflected the number of publications (weights) in the dataset that were related to the country.

The map (Figure 4) shows that the literature on the SDG and RE process is represented in a large part of the world (according to WoS from 87 countries (Table 2)), which shows great interest among the global scientific community. China is the country with the highest number of publications, close to 22.7%, followed by India (16.4%) and Pakistan (10.8%). These three countries account for close to 50% of the total number of publications, indicating their prominent position in the field of research. In addition, publications from China received the highest number of citations (2001), with India (1849) and Pakistan (1068), accounting for 38.5% of all citations, which shows that these countries dominate in terms of publication numbers and have a solid academic influence in the field of research. Using the map, which represents an analysis of co-authorship with different countries, it was shown that the Chinese wrote as many as 100 times the number of articles as 18 countries, with

Pakistan contributing 18 times more and India contributing 11 times more. The conclusion is that the most frequently writing and most quoted countries co-create with each other.

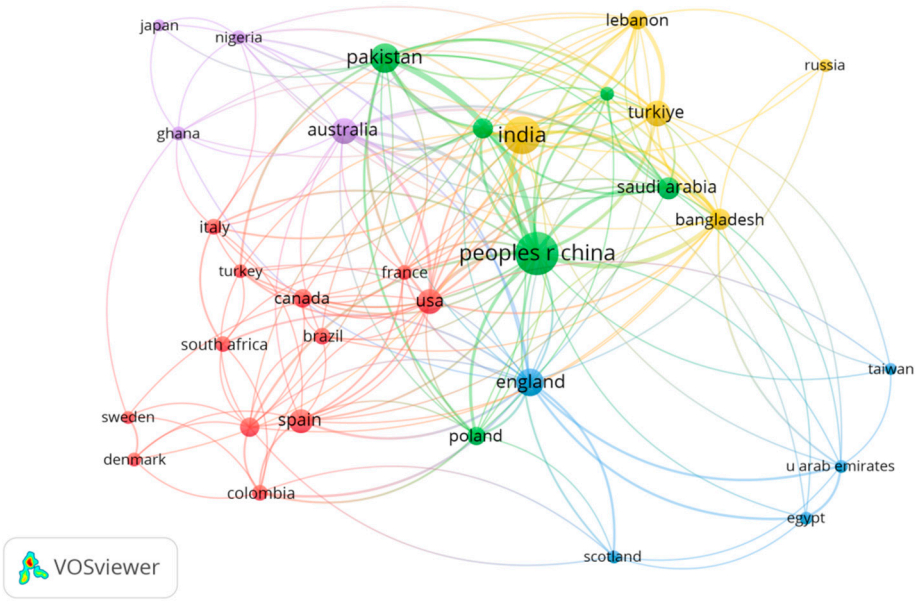

Figure 4. Clusters based on co-authorship of countries by author affiliation.

Table 2. Characteristics of cluster citations based on co-authorship of countries by author affiliation.

Clusters	Country	Number of Publications	Number of Citations
Red cluster	Brazil, Canada, Colombia, Denmark, France, Germany, Italy, South Africa, Spain, Sweden, Turkey, USA	124	2518
Green cluster	Malesia, Pakistan, China, Poland, Saudi Arabia, Vietnam	143	4617
Blue cluster	Egypt, England, Scotland, Taiwan, United Arab Emirates,	49	890
Yellow cluster	Bangladesh, India, Lebanon, Russia, Turkey	103	3104
Fillet cluster	Australia, Ghana, Japan, Nigeria	41	1016

The prominence of the China–India–Pakistan collaboration network reflects a development stage-driven research dynamic rather than a purely academic concentration. These economies face rapidly growing energy demand, high exposure to air pollution, and strong pressure to reconcile economic growth with climate and sustainability commitments, which naturally directs research attention toward renewable energy and SDG-related topics. In addition, south–south collaboration mechanisms, including regional research programs and shared policy challenges, contribute to dense co-authorship networks within this group. Importantly, the observed centrality primarily reflects the publication volume and agenda-setting capacity, rather than an assessment of the methodological quality or impact of individual studies.

The second map (Figure 5), which is the result of the same analysis, shows how countries writing on the subject of Sustainable Development Goals and renewable energy have cooperated during these several years of publication (color: yellow). It can be seen that the latest publications have been created owing to the cooperation of Asian countries such as Lebanon, Vietnam, Turkey, the United Arab Emirates, and Taiwan.

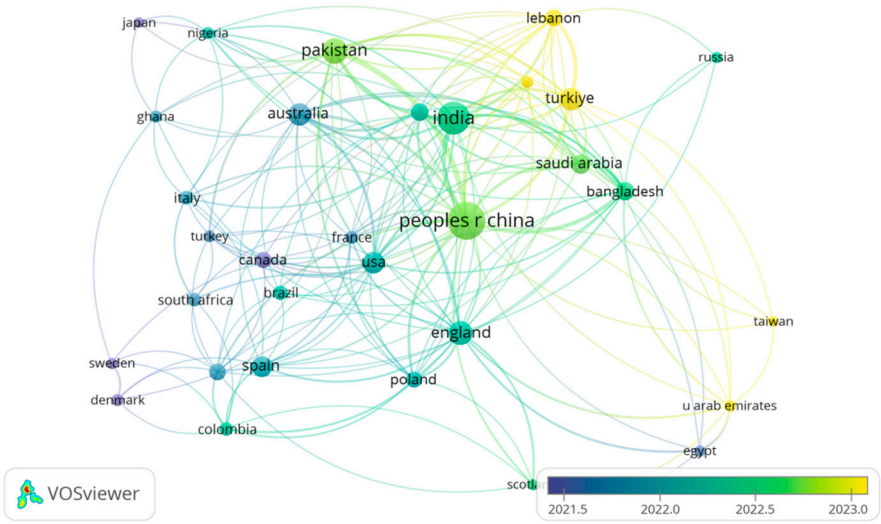

Figure 5. Temporal overlay on clusters based on co-authorship of countries by author affiliation.

3.2. Who Are the Most Significant, Impactful Contributors (Authors, Institutions, and Journals) in the Field of SDGs and RE Research, and What Is the Impact of Citation of Their Work?

The second research question aims to discover influential journals, authors, and knowledge base articles on SDGs and RE. The most cited journals in this field are presented in Table 3 (with a threshold of at least four publications). The Journal of Cleaner Production is the most cited, with 466 citations, followed by the journal Energies (388 citations) and the journal Environmental Science and Pollution Research, with 338 citations.

Table 3. The most cited journals in this field (source: VOSviewer).

Journal	Number of Publications	Number of Citations
Journal of Cleaner Production	9	466
Energies	23	388
Environmental Science and Pollution Research	17	338
Renewable Energy	11	314
Sustainability	18	286
Applied Energy	4	223
Renewable & Sustainable Energy Reviews	5	203
Resources Policy	4	189
Sustainable Development	9	175
Energy	4	161

The distribution of articles in individual journals shows great variety, but most of the articles are published in the fields of sustainable development, energy, and environmental protection.

Journal co-citation analysis (JCA) was then used to find the journals that have the greatest impact on the subject matter studied. To do this, the bibliometric tool VOSviewer was used. There, a threshold was set of at least 30 citations of articles published in a given journal due to the representative purpose. Figure 6 shows the 86 journals with the most citations grouped into brackets. The journal Renewable & Sustainable Energy Reviews has an extensive reach, with a peak number of contributions (749), indicating the high impact of this journal on the topic constituting the basis of this analysis, i.e., SDGs and RE. Other high-impact journals include Environmental Science and Pollution Research (683), Energy Policy (649), and the Journal of Cleaner Production (591).

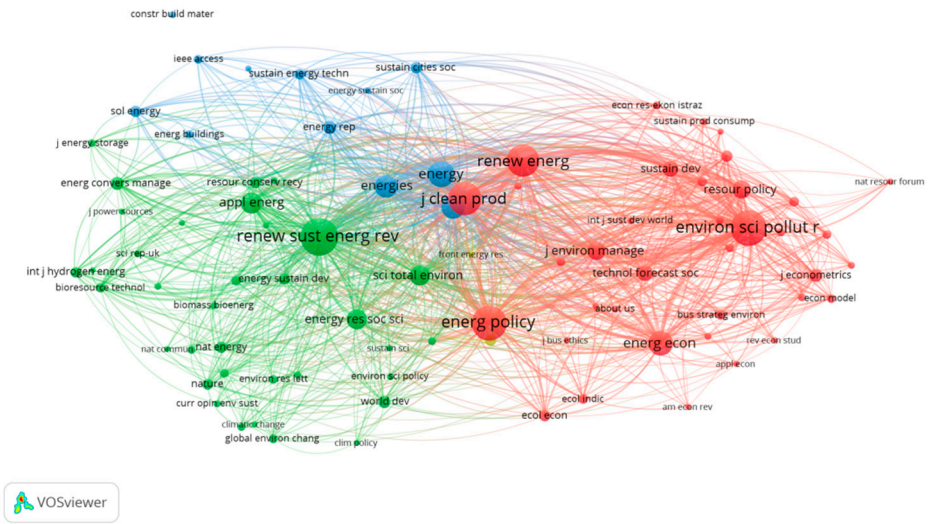

Figure 6. Network of journal co-citations of the literature on SDGs and RE dependencies (threshold: 30 citations).

Another advantage of bibliometric analysis is the ability to identify the main authors in a given research field. Table 4 shows the ten key authors by WoS index, publications, and citations.

Table 4. Ranked order of the most cited authors on the subject of SDGs and RE.

Authors	Documents	Citations
Avik Sihna [35–42]	10	821
Murshed Muntasir [43–50]	9	420
Anwar Ahsan [51,52]	3	346
Pradeep Kautish [42,53,54]	3	308
Rajesh Sharma [42,53]	3	308
Rajvikram Madurai Elavarasan [35,55,56]	4	262
G. M. Shafiullah [55,56]	3	233
Haider Mahmood [49]	4	174
Mithulananthan Nadarajah [35,55]	3	164
Abdullah Emre Caglar [57–61]	6	156
Samiha Khan [43,45–47]	4	153
Zahoor Ahmed [44]	3	139
Rawshan Ara Begum [62–64]	3	102
M.A. Hannan [62]	3	102
Pin Jern Ker [62–64]	3	102
Mohammad Ali Abdelkareem [65,66]	3	82
Muhammet Dastan [57,58]	3	52
Festus Victor Bekun [67–70]	4	34
Godwell Nhamo [71–73]	3	24

Table 4 shows that Avik Sihna, whose research area, according to Google Scholar, is environmental modeling, energy economics, sustainable development, and applied econometrics, wrote 10 scientific articles that were cited 821 times; Murshed Muntasir, whose research area is macroeconomics, econometrics, financial economics, environmental economics, and energy economics wrote nine publications, with a total number of 420 citations; and Anwar Ahsan, whose research area, according to ORCID, is energy economics, environmental economics, transport economics, and sustainable development has written

three publications, with a total number of 346 citations, are the scientists who have the most influence on the SDGs and RE literature.

To further develop these traditional citation analyses, this study was extended to include document co-citation analysis (DCA). As previously emphasized, "DCA examines the extent to which documents in the review database have been 'co-cited' with documents on the reference lists" [36] of other SDGs and RE documents. It is important to note here that co-cited articles do not need to be in the Web of Sciences database to be included in the analysis.

The results of the analysis of co-citations presented in Table 5 indicate that the most frequently cited bibliography of the analyzed articles concerned the construction and analysis of econometric models, especially panel models [74–79].

Table 5. Ten most cited SDG and RE articles.

Bibliography Cited	Title	Number of Citations in the Analysed Group of 278 Publications
(Pesaran, 2021) [80]	General diagnostic tests for cross-sectional dependence in panels	22
(Pesaran, 2007) [81]	A simple panel unit root test in the presence of cross-section dependence	21
(Pesaran and Yamagata, 2008) [74]	Testing slope homogeneity in large panels	19
(Westerlund, 2007) [75]	Testing for Error Correction in Panel Data	19
(Transforming our World: The 2030 Agenda for Sustainable Development, 2024) [82]	Transforming our World: The 2030 Agenda for Sustainable Development	15
(Breusch and Pagan, 1980) [76]	The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics	14
(Gielen et al., 2019) [19]	The role of renewable energy in the global energy transformation	13
(Nerini et al., 2018) [83]	Mapping synergies and trade-offs between energy and the Sustainable Development Goals	13
(Dumitrescu and Hurlin, 2012) [77]	Testing for Granger non-causality in heterogeneous panels	12
(Dumitrescu and Hurlin, 2020) [84]	Interplay between technological innovation and environmental quality: Formulating the SDG policies for next 11 economies	12
(Balsalobre-Lorente et al., 2017) [85]	How economic growth, renewable electricity and natural resources contribute to CO_2 emissions?	11
(Sharif et al., 2020) [86]	Revisiting the role of renewable and non-renewable energy consumption on Turkey's ecological footprint: Evidence from Quantile ARDL approach	11
(Bekun et al., 2019) [20]	Toward a sustainable environment: Nexus between CO_2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries	10
(Destek and Sinha, 2020) [87]	Renewable, non-renewable energy consumption, economic growth, trade openness and ecological footprint: Evidence from organisation for economic Co-operation and development countries	10
(Pesaran, 2006) [78]	Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure	10
(Shahbaz et al., 2018) [88]	Environmental degradation in France: The effects of FDI, financial development, and energy innovations	10
(Zafar et al., 2020) [89]	How renewable energy consumption contribute to environmental quality? The role of education in OECD countries	10

Econometric models were used by the authors of the publication to examine the relationships between the studied features and to explain the mechanism of changes occurring in the studied area. Most of the remaining literature concerns the relationship between the role of renewables in climate change [19,20,85,87,88,90,91]. Some references are more closely related to sustainable development and its goals [20,84,92].

The prominence of the leading authors, journals, and highly cited references identified in this section (Tables 3–5; Figures 6 and 7) reflects not only academic influence but also the methodological and conceptual orientation of the SDG–RE literature. In particular, the

strong presence of econometric and policy evaluation studies among the most influential contributions (Table 5) indicates a systematic focus on long-running relationships, transmission channels, and structural effects associated with renewable energy deployment. Moreover, the concentration of citations in high-impact energy, sustainability, and policy journals (Table 3; Figure 6) suggests that renewable energy is increasingly examined as an integral component of broader technological, economic, and institutional systems rather than as an isolated environmental variable. Together, these patterns reinforce the interpretation that the field has progressively evolved toward mechanism-oriented analyses underpinning the role of renewable energy as a strategic mechanism for SDG achievement.

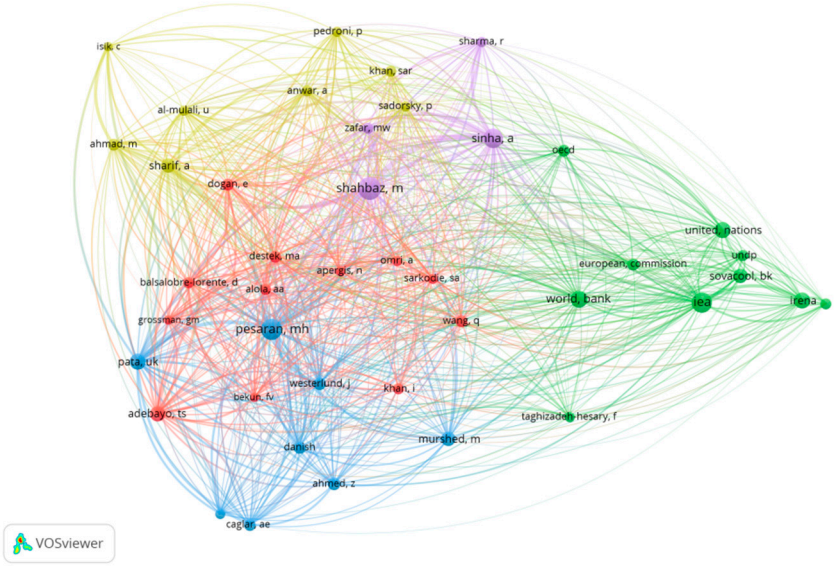

Figure 7. Author co-citation analysis of the SDG and RE literature.

3.3. What Are the Main Thematic Clusters and Conceptual Structures Within the Research Literature on SDG and RE?

The last research question concerns the intellectual structure underlying the relationship between SDGs and RE. To shed some light upon this issue, we used author co-citation analysis (ACA), a tool commonly used in conjunction with VOSviewer, which is a useful software for this analysis. The advantage of using this bibliometric software tool is that it calculates the co-citation of the authors and also creates a co-citation map that shows the similarities in the authors' literature. The author co-citation structure depicted in Figure 7 reflects the intellectual foundations of SDG–RE research and reveals distinct research streams that contribute to understanding renewable energy as a strategic mechanism for SDG achievement.

Notably, the most frequently cited authors were Shahbaz (107), Pesaran (92), Sinha (76), and Pata (53). Scientists are represented by nodes, to which the following rule applies: the larger the size, the more co-citations the author has, and therefore, the greater the influence. The thickness of the connections between scientists indicates the number of times a scientist has been co-cited by another author. An additional function that VOSviewer performs is the grouping of authors into colored clusters:

- The purple cluster represents a mechanism-testing research stream, in which renewable energy is examined through economic and technological transmission channels affecting sustainable development and climate-related outcomes. Studies in this cluster predominantly focus on how energy transitions interact with macroeconomic performance, technological progress, and environmental quality, thereby providing empirical evidence on the pathways linking renewable energy deployment with SDGs. In the cluster, the most influential author is Shahbaz, but there are scientists such as

Sinha, Sharma, and Zafir. Their papers belong to the seventeen most co-cited papers in the analyzed set of articles. The topics raised by these scientists concern the relationship between economic and technological indicators and the development of renewable energy or climate change [85,88,90];

- The green cluster captures the institutional and regulatory mechanism, encompassing foundational policy documents and strategic frameworks that define the governance architecture for integrating renewable energy into the SDG agenda. This cluster provides the normative and institutional context within which technological and economic mechanisms operate. The green cluster brings together legal documents that are the basis for many analyses on this topic [82,93,94];
- The blue cluster reflects a methodological and analytical mechanism, centered on econometric modeling and advanced panel data techniques used to identify long-running relationships, heterogeneity, and transmission channels between renewable energy variables and sustainable development outcomes. This is a cluster in which Pesaran is the most influential author. It brings together scientists in the field of econometrics and econometric modeling [75,78,92];
- The red cluster represents the integrative sustainability mechanism, where renewable energy is analyzed as a core component of sustainable development systems, interacting simultaneously with economic growth, environmental protection, and social objectives across multiple SDGs. The red cluster is the most numerous cluster, in which Adebayo is the most influential author, but other authors include Balsalobre-Lorente, Bekun, Alola, and Sarkodie, whose papers belong to the most co-cited papers in the analyzed set of articles. The authors discuss topics including sustainable development and energy from renewable sources. What is more, they elaborate on the subject matter closely related to the subject of this work [20,21,23].

Moreover, in the third research question, we aim to shed light on the most important areas of the SDG and RE knowledge base. The keyword co-occurrence analysis allows the conceptual structure of the SDG–RE literature to be interpreted through a mechanism-oriented lens, highlighting the dominant channels through which renewable energy contributes to sustainable development. To do this, we used a keyword co-occurrence analysis. This type of analysis allows you to identify thematic trends in a specific domain. Zupic and Čater [25] state, "When words often co-occur in documents, it means that the concepts behind those words are closely related. The result of the co-word analysis is a network of topics and their relations that represent the conceptual space of a given field." The VOSviewer bibliometric software was reused, and the search was set to include all keywords, with a minimum threshold of nine instances of a co-occurring keyword. A map of keyword comorbidity (Figure 8) provides a visual representation of similarities, and a map of keyword co-occurrence over time (Figure 9) also categorizes topics in terms of their prevalence over a specific period. This analysis allowed us to recognize the connections between the keywords, which were shown by their proximity on the map in Figures 8 and 9. For practical purposes, we have included those keywords that appear in the considerations at least 10 times. The size of the nodes is proportional to the number of instances of the keyword.

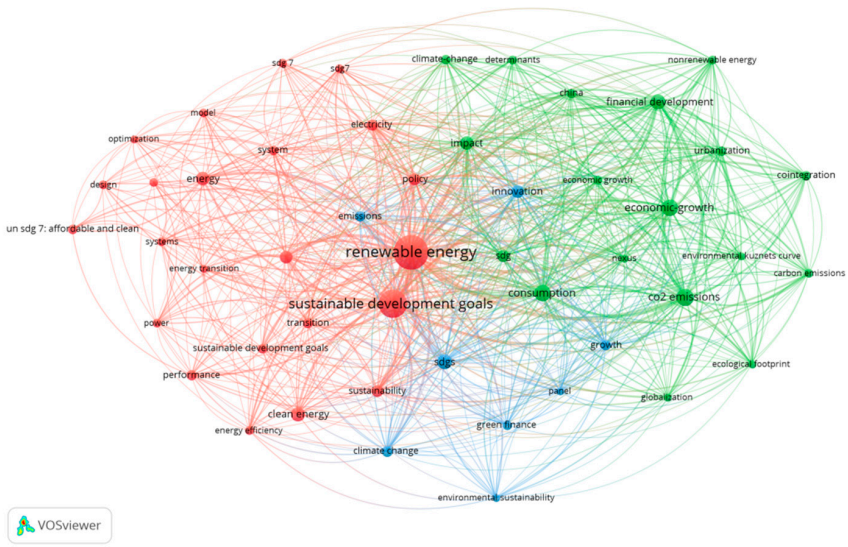

Figure 8. A network map of keyword co-occurrence.

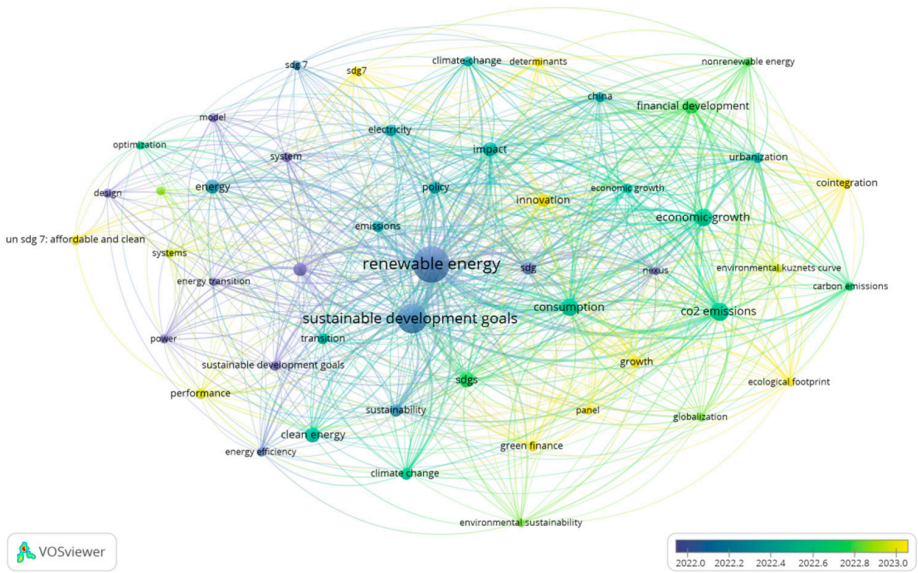

Figure 9. Temporal overlay on a keyword co-occurrence map in the SDG and RE literature.

It is not surprising that the most common keywords in the datasets included "renewable energy" (175) and "sustainable development goals" (120), as the analyzed literature database was collected on the basis of these keywords provided by the author of the publication. The other keywords have much fewer co-occurrences, e.g., the following three keywords in order are "CO_2 emissions" (46) (reduction of CO2 emissions is one of the main objectives of renewable energy), "economic-growth" (40) (the economic dimension is one of the three on which the SDGs are based), and "consumption" (40) (sustainable consumption implies the optimal and conscious use of available resources to achieve development while minimizing the harmful impact on the environment). All 49 keywords are grouped into three clusters:

- The red cluster represents the technological–energy mechanism, through which renewable energy deployment directly supports SDG 7 and indirectly enables progress toward SDGs 9 and 13 via innovation, energy efficiency improvements, and emission reduction. In this cluster (23 keywords), the 2 most common co-occurring keywords, "renewable energy" and the Sustainable Development Goals, together occur 83 times. Other keywords include "energy", climate change", "clean energy", "electricity", "sustainability", and "energy efficiency". In summary, all these keywords form a

cohesive system in which the transition to renewable energy plays a fundamental role in achieving sustainable development, reducing emissions, and counteracting climate change, while simultaneously providing safe and clean sources of electricity. The relevance of these interconnections is well-documented in strategic frameworks developed by international institutions, such as the International Renewable Energy Agency and the International Energy Agency [79,90], and is further substantiated by recent bibliometric and review studies [24,95];

- The green cluster captures the financial–economic mechanism, highlighting how renewable energy interacts with economic growth, financial development, and globalization, shaping investment patterns and influencing the environmental impact of economic activity. Green cluster—a cluster containing 18 keywords, where "economic growth", "carbon emissions", "consumption", "financial development", and "globalization" are most often co-founded. The cluster focuses on linking economic factors with climate change. In summary, while economic growth driven by consumption, financial development, and globalization can lead to increased carbon emissions, these same drivers also offer opportunities to invest in sustainable practices. The challenge lies in managing this growth in a way that minimizes environmental harm while leveraging financial and global interconnectedness to promote cleaner technologies and more responsible consumption practices. This dynamic reflects the broader challenge of aligning economic systems with environmental goals, as widely discussed in the sustainability literature [92,93]. Promoting green innovation, sustainable finance, and global cooperation is essential to mitigate climate impacts while maintaining growth trajectories [94];
- The blue cluster reflects the innovation–finance–governance mechanism, in which green finance and technological innovation act as intermediary channels linking renewable energy development with emission reduction, economic resilience, and long-term SDG implementation. This cluster is the smallest cluster, containing eight keywords, where the word "SDG" is the most common, which occurred 35 times with other words. Other keywords of this cluster are "climate change", "green finance", growth", "innovation", "emission", and "environmental sustainability". In the context of achieving Sustainable Development Goals and combating climate change, support for green finance, which enables investments in modern, eco-friendly solutions, is of utmost importance. These financial instruments facilitate economic growth by channeling investments into innovative technologies that simultaneously help reduce the emissions of harmful greenhouse gases. A key issue here is to achieve a balance between dynamic development and environmental protection—innovations are essential for creating efficient energy systems, smart transportation networks, and the management of natural resources that minimize the negative impact of human activity on the planet. This combination of sustainable economic growth, emission reduction, and environmental care forms the foundation for building a lasting future in which development and environmental protection go hand in hand. Studies indicate that green finance policies influence the reduction of direct emissions, among others, by decreasing managerial short-termism and reducing information asymmetry [96]. Moreover, green finance fosters the development of technological innovations and industrial modernization, which translates into more efficient energy systems and sustainable resource management [95]. The key challenge lies in finding a balance between dynamic economic growth and environmental protection. It is essential to promote green innovations and sustainable financial instruments that enable the achievement of Sustainable Development Goals, particularly SDG 13 related to climate action, while simultaneously building a resilient and low-carbon economy [97].

In addition to these obvious co-occurrences, as shown in Figure 8, we can examine the following recent clusters in Figure 9 (in yellow). This result indicates that the subject matter, and thus the emerging theme of SDGs and RE, is moving towards green finance, ecological footprint, innovation, and research related to SDG 7. The latest research on sustainability, focusing on keywords such as SDG 7, ecological footprint, cointegration, growth, innovation, emissions, green finance, and systems, points to an increasingly integrated approach to the analysis and implementation of sustainability strategies [98,99].

The emergence of themes such as green finance and ecological footprint signals a maturation of the research field from a predominantly technology-focused perspective toward broader governance and system-level considerations. As renewable energy deployment increasingly depends on investment frameworks, risk management, and financial incentives, research attention has expanded toward sustainability finance, ESG criteria, and green investment instruments. At the same time, the growing use of ecological footprint indicators reflects an effort to move beyond single-emission metrics and capture wider environmental pressures associated with energy systems. This thematic shift indicates a transition from analyzing technological potential to evaluating institutional and financial conditions for sustainable implementation.

Although the present bibliometric review does not re-evaluate or replicate empirical results reported in the analyzed studies, the temporal evolution of the identified thematic clusters reflects a clear shift in the dominant types of empirical evidence emphasized within the SDG–renewable energy literature. Early contributions, predominantly published before 2018, primarily focused on energy–growth–emission nexuses, frequently employing econometric frameworks such as environmental Kuznets curve specifications and panel regressions to assess the environmental effects of renewable energy deployment. Studies published in the subsequent period (approximately 2019–2021) increasingly incorporated institutional and moderating factors, including governance quality, financial development, and policy stringency, reflecting a growing recognition of conditional and context-dependent effects. More recent research, particularly after 2022, shows a marked expansion toward empirically grounded analyses of green finance, technological innovation, and policy coordination, with empirical results often highlighting interaction effects, transmission channels, and system-level complementarities across multiple Sustainable Development Goals. This temporal progression indicates that the SDG–RE literature has evolved from relatively narrow, outcome-oriented empirical assessments toward more integrated and mechanism-oriented empirical narratives, a shift that is consistently reflected in the structure and evolution of the bibliometric clusters identified in this study.

This bibliometric review on the relationship between the SDGs and RE employs scientific mapping to deepen the understanding of the field's intellectual structure and knowledge base. The analysis provides valuable insights into the thematic evolution, key contributors, and research trends related to SDGs and RE. As such, it serves as a useful reference not only for experienced scholars already working within this interdisciplinary domain but also for early-career researchers seeking to explore the interconnections between sustainable development and renewable energy. Furthermore, by tracing the temporal development of scientific output, this study highlights the dynamic nature of research in this area and offers a roadmap for future investigation.

Taken together, the author and keyword clustering results discussed in this section demonstrate that the SDG–RE literature is structured around a set of interrelated technological, financial, institutional, and governance mechanisms, supporting the interpretation of renewable energy as a strategic mechanism rather than a standalone environmental intervention.

3.4. Mechanism-Oriented Synthesis of the SDG–RE Literature

This subsection provides a mechanism-oriented synthesis of the literature on the relationship between the Sustainable Development Goals and renewable energy (SDG–RE), derived directly from the bibliometric results presented in Sections 3.2 and 3.3. The identified mechanisms are not inferred from individual empirical studies but are reconstructed from recurrent and stable patterns of co-occurrence among keywords, authors, and research streams revealed by the author co-citation and keyword co-occurrence analyses. In this sense, the mechanisms represent a structural reconstruction of dominant transmission channels that organize the SDG–RE research field. Accordingly, renewable energy is interpreted not as an isolated environmental variable but as a strategic mechanism embedded within broader technological, economic, institutional, and governance systems.

3.4.1. Technological–Energy Mechanism

The technological–energy mechanism is inferred from the dominant keyword cluster in which concepts such as renewable energy, clean energy, energy efficiency, electricity, and climate change occupy central and highly connected positions. Their persistent co-occurrence and network centrality indicate that the SDG–RE literature primarily conceptualizes renewable energy through the lens of technological transformation and energy system restructuring. The inference of this mechanism is therefore grounded in the observation that renewable energy is systematically examined as a direct technological driver of emission reduction, efficiency improvements, and modernization of energy systems. This configuration of concepts supports the interpretation of the technological–energy mechanism as the primary channel through which renewable energy contributes directly to SDG 7 and indirectly facilitates progress toward SDGs 9 and 13.

3.4.2. Financial–Economic Mechanism

The financial–economic mechanism is reconstructed from a distinct keyword cluster in which renewable energy co-occurs with economic growth, financial development, consumption, globalization, and carbon emissions. Such a clustering structure indicates that the literature does not treat renewable energy solely as a technological input but increasingly analyzes it within the context of capital allocation processes, market incentives, and long-running growth dynamics. The inference of this mechanism follows the bibliometric assumption that frequent and stable co-occurrence reflects the existence of a coherent research stream. Consequently, the financial–economic mechanism captures how renewable energy influences SDG outcomes through investment patterns, cost structures, and the reorientation of growth trajectories toward lower carbon intensity and greater sustainability.

3.4.3. Institutional and Regulatory Mechanism

The institutional and regulatory mechanism is derived primarily from the author co-citation structure, in which policy documents, strategic frameworks, and institutionally oriented studies are repeatedly co-cited alongside empirical analyses. This pattern suggests that the effects of renewable energy are systematically interpreted in relation to regulatory quality, policy design, and institutional capacity. The inference of this mechanism is based on the observation that renewable energy is embedded in the literature within a broader institutional context that conditions the effectiveness of technological and financial pathways. Accordingly, renewable energy can be understood as a strategic mechanism only when supported by coherent and stable regulatory frameworks aligned with sustainable development objectives.

3.4.4. Governance and Coordination Mechanism

The governance and coordination mechanism is inferred from the growing prominence of system-level concepts—such as systems, governance, innovation, and green finance—particularly in more recent publications. The temporal concentration and co-occurrence of these concepts indicate an evolution of the SDG–RE literature toward multi-level and cross-sectoral analyses. This pattern suggests that renewable energy is increasingly examined as part of integrated policy frameworks requiring coordination across sectors, governance levels, and institutional actors. The governance and coordination mechanism, therefore, captures the role of policy coherence, strategic alignment, and international cooperation in enabling renewable energy to support SDG implementation in a systemic manner.

3.4.5. Generalizability of the Mechanism-Based Inference

Taken together, the identified mechanisms constitute a coherent analytical framework explaining how renewable energy contributes to SDG achievement through interconnected technological, financial, institutional, and governance pathways. Importantly, these mechanisms are generalizable structural relationships, as they are derived from recurring patterns observed across the entire SDG–RE literature rather than from isolated case studies. From a policy perspective, this synthesis implies that renewable energy can function as a strategic mechanism for sustainable development only when these pathways are activated simultaneously. A narrow focus on deployment targets, without complementary financial instruments, institutional support, and governance coordination, is therefore unlikely to fully realize the SDG potential of renewable energy transitions.

Table 6 synthesizes the mechanism-oriented clusters identified in Sections 3.3 and 3.4 by explicitly linking them to primary, cross-cutting, and underrepresented SDGs. Secondary and underrepresented SDGs were identified based on their peripheral or absent positions in the keyword co-occurrence networks and their limited connectivity to dominant author co-citation clusters, rather than on normative SDG classifications. This synthesis highlights the dominance of SDG 7 and SDG 13 in the SDG–renewable energy literature, as reflected in the structure of the identified bibliometric clusters, while indicating relatively limited representation of social and distributional SDGs.

Overall, the temporal evolution of the SDG–RE literature reveals a clear shift from an early exploratory phase, primarily focused on identifying empirical associations, toward a more advanced stage characterized by system-level and mechanism-oriented inquiry (Figure 2). This evolution reflects a growing recognition of renewable energy as a strategic mechanism operating through interconnected technological, economic, and institutional channels rather than as a standalone environmental intervention in the context of SDG achievement. This interpretation is further supported by the evolving structure of the research agenda, as evidenced by the increasing prominence of system-oriented and finance-related keywords—such as green finance, innovation, ecological footprint, and cointegration—in the most recent period of analysis (Figures 8 and 9). Moreover, the document co-citation analysis indicates a rising dominance of econometric and policy evaluation studies, particularly those addressing long-running relationships and transmission channels, among the most influential references in the field (Table 5), reinforcing the conclusion that the literature is progressively moving toward mechanism-oriented research on the SDG–RE nexus.

Table 6. Thematic mechanisms and their alignment with the Sustainable Development Goals (SDGs).

Mechanism/Cluster	Core Research Focus	Primary SDGs	Secondary/Cross-Cutting SDGs	Underrepresented SDGs	Bibliometric Origin (Figures)
Technological–energy mechanism (renewable energy, clean energy, energy efficiency, electricity, climate change)	This research stream focuses on the restructuring of energy systems through the deployment of renewable energy technologies. The literature highlights efficiency improvements, decarbonization, and technological modernization as direct technological pathways linking renewable energy development with sustainability outcomes.	SDG 7, SDG 13	SDG 9 (innovation and infrastructure), SDG 11 (sustainable cities through clean electricity and air-quality co-benefits), SDG 12 (sustainable production and consumption driven by efficiency gains)	SDG 3 (health), SDG 6 (water), SDGs 14–15 (ecosystems), SDG 10 (inequality)	Keyword co-occurrence cluster (Figure 8); temporal overlay (Figure 9)
Financial–economic mechanism (economic growth, financial development, consumption, globalization, emissions)	This mechanism emphasizes renewable energy as part of broader capital allocation and investment processes shaping long-term economic growth. Studies in this cluster examine trade-offs between growth, consumption, and emissions, as well as macro-financial channels through which renewable energy influences SDG-related outcomes.	SDG 8, SDG 13	SDG 7 (investment enabling clean energy deployment), SDG 9 (innovation financing), SDG 12 (consumption patterns and resource intensity)	SDGs 1–2 (poverty and food security), SDG 5 (gender), SDG 10 (distributional outcomes), SDG 16 (institutions)	Keyword co-occurrence cluster (Figure 8)
Institutional and regulatory mechanism (policy frameworks, regulatory quality, institutional capacity)	This stream concentrates on governance structures and regulatory capacity as key enablers of renewable energy effectiveness. The literature addresses policy design, institutional quality, and the alignment of renewable energy policies with the broader SDG agenda.	SDG 16, SDG 7	SDG 13 (policy-driven decarbonization), SDG 9 (regulation supporting innovation), SDG 12 (policy instruments for sustainable production)	SDG 4 (education and skills), SDG 5 (gender), SDG 10 (equity), SDGs 14–15 (biodiversity)	Author co-citation cluster (Figure 7)
Governance and coordination mechanism (systems, governance, innovation, green finance, ESG)	This emerging mechanism highlights multi-level coordination across sectors and actors. It focuses on integrating renewable energy with sustainable finance, innovation systems, and cross-sector SDG implementation, emphasizing the importance of systemic policy coherence.	SDG 17, SDG 13	SDG 7 (system integration), SDG 9 (innovation systems), SDG 11 (urban transitions), SDG 12 (system-level resource governance)	SDG 3 (health co-benefits remain underexplored), SDG 6 (water–energy nexus), SDG 10 (justice and equity), SDGs 14–15 (ecosystem impacts)	Temporal keyword overlay (Figure 9)

4. Conclusions

This bibliometric review provides a comprehensive overview of the current state and evolution of research on the relationship between the Sustainable Development Goals and renewable energy. The critical role of renewable energy and a clean ecosystem is a top priority. To this end, this study examined the topic based on a bibliometric framework and scientific mapping, collecting data from one of the most reputable WoS databases.

Taken together, the findings of this review can be structured into three levels. First, the core finding concerns the dominant role of renewable energy as a strategic mechanism underpinning SDG 7 and SDG 13 across the literature. Second, a set of secondary findings highlights the growing importance of financial, innovation-related, and institutional channels

linking renewable energy deployment with broader development outcomes. Finally, emerging research directions point toward governance, coordination, and system-level integration as critical but still underexplored dimensions of the SDG–renewable energy nexus.

In response to the first research question concerning geographical distribution, temporal dynamics, and publication trends, the analysis reveals a marked increase in scholarly interest in SDG and RE research between 2022 and 2024. This trend was most likely driven by global crises affecting energy security and the achievement of Sustainable Development Goals. This observation underscores the academic community's capacity to address emerging socio-political and environmental challenges. The geographical dispersion of publications across 87 countries demonstrates broad global engagement in the pursuit of the Sustainable Development Goals. Furthermore, co-authorship analysis confirms the intensification of international scientific cooperation, with China, India, and Pakistan as key participants. These cooperation networks increase the global reach and impact of research on the energy transition towards sustainable development.

Addressing the second research question, the analysis of influential authors, journals, and publications identifies a relatively concentrated core of scholars and outlets shaping the SDG–RE research landscape. Leading authors such as Avik Sinha, Murshed Muntasir, and Anwar Ahsan stand out for their high citation impact, indicating their key role in the development of this field. Key journals dedicated to environmental economics, sustainable development, and energy research serve as primary platforms for disseminating research findings. The importance of these collaborators underscores the interdisciplinary nature of this field, which combines environmental, economic, and political perspectives, as reflected in the author co-citation structure discussed in Section 3.3.

In response to the third research question, the analysis identified three main thematic areas—technological and environmental integration, economic and financial implications, and governance and innovation—which reflect a gradual shift from a sectoral to a systemic approach in the literature. This study confirms the key role of RES in achieving Sustainable Development Goals 7 and 13, as evidenced by the dominant keyword clusters identified in Section 3.3, while also highlighting the growing interest in green finance and innovation in recent years. The latest research within the analyzed literature emphasizes the importance attributed to green finance as a facilitating factor for technological innovation, which empirical studies frequently associate with emission reduction and economic growth. At the same time, the literature increasingly adopts a systemic perspective, examining how innovation, finance, policy frameworks, and technologies are discussed as interacting components within sustainable development systems, as shown by the temporal evolution of research themes and their increasing integration over time. This holistic view allows for the identification of synergies and potential conflicts between different goals and strategies. Research suggests that incorporating technological innovation and green finance into development policy is consistently emphasized in the literature. This approach enables the creation of more resilient and sustainable economic and environmental systems.

4.1. Theoretical and Practical Implications

Importantly, the mechanism-oriented interpretation proposed in this study reflects the conceptual and discursive structure of the literature rather than empirically verified causal pathways derived from the bibliometric analysis itself. From a theoretical perspective, this study explicitly identifies a structural gap in the existing SDG–renewable energy literature, namely the dominance of outcome-based and goal-specific analyses that overlook the underlying mechanisms through which renewable energy influences broader development processes.

By addressing this gap, this paper repositions renewable energy from an isolated policy outcome to a strategic, system-level mechanism, operating through interacting technological, economic, financial, and institutional transmission channels across multiple SDGs.

The findings of this study contribute to the theoretical understanding of the relationship between the Sustainable Development Goals and renewable energy by demonstrating that the SDG–RE literature is structured around interconnected technological, economic, financial, and institutional dimensions. By synthesizing the identified thematic patterns through a mechanism-oriented perspective, the analysis supports the view that the transition toward renewable energy constitutes a systemic process rather than a sector-specific environmental intervention. This perspective reinforces recent theoretical advances in sustainability research that emphasize integrated and multi-dimensional pathways linking energy transitions with broader development objectives.

From a theoretical standpoint, the results highlight a clear shift in the literature from fragmented, goal-specific analyses toward a systems-oriented approach that integrates environmental, economic, and financial considerations. This evolution suggests that renewable energy should be conceptualized not only as a driver of climate mitigation (SDG 13) or energy access (SDG 7) but as a strategic mechanism operating across multiple SDGs through interacting transmission channels. Such a framing advances existing SDG scholarship by moving beyond isolated goal mappings toward a more coherent understanding of cross-goal synergies and structural interdependencies.

From a practical and policy-oriented perspective, this study underscores the importance of coordinated policy frameworks that simultaneously address technological deployment, financial instruments, and institutional capacity. The prominence of themes related to green finance, innovation, and responsible consumption indicates that the effectiveness of renewable energy policies depends on their alignment with broader economic and environmental strategies. In particular, the literature suggests that policies combining renewable energy targets with financial incentives and innovation support are frequently associated, in empirical studies, with broader SDG-related spillovers across SDGs while mitigating potential trade-offs.

Furthermore, the interdisciplinary nature of the most influential research streams—spanning energy economics, environmental modeling, macroeconomics, and sustainability policy—highlights the need for integrative research and policy design. For early-career researchers and policymakers alike, this implies that progress in the SDG–RE domain requires engagement with diverse methodological approaches and analytical frameworks. Building on established research traditions while fostering cross-disciplinary collaboration may therefore enhance both the scientific robustness and policy relevance of future studies on renewable energy and sustainable development.

4.2. Limitations and Possible Generalization

Finally, it should be emphasized that this bibliometric review does not establish causal relationships between renewable energy and SDG outcomes. Instead, it maps the structure, evolution, and dominant conceptual narratives of the literature, while causal evidence remains embedded in the empirical studies cited within the analyzed research streams.

Consequently, the mechanisms discussed in this study should be interpreted as conceptual and relational pathways synthesized from the literature rather than as empirically validated or universally generalizable causal effects. Their relevance and strength may vary across institutional, regional, and sectoral contexts, depending on regulatory frameworks, market structures, and stages of economic development.

This review is based solely on articles indexed in Web of Science, excluding conference proceedings, book chapters, and grey literature. Therefore, the results may not represent the full scope of global research on the SDG–renewable energy nexus. Moreover, bibliometric

methods primarily address quantitative patterns of publication activity, citation structures, and thematic co-occurrence, which limits their ability to assess contextual nuance or policy effectiveness. These constraints should be considered when interpreting the findings.

Unlike evidence synthesis systematic reviews, the present study does not apply formal quality appraisal or risk-of-bias assessment tools. This choice is intentional, as the objective is to map the intellectual architecture and dominant mechanisms discussed in the literature rather than to evaluate the robustness of causal claims across heterogeneous empirical designs. Future research could productively combine bibliometric mapping with quality-screened systematic synthesis within selected high-impact or policy-relevant sub-streams.

Another limitation relates to the use of the Web of Science database as the sole data source. While WoS ensures high-quality, standardized bibliographic records suitable for robust bibliometric mapping, it may underrepresent regionally focused, non-English, or policy-oriented publications indexed in other databases. Extending the analysis to complementary sources such as Scopus or regional repositories could improve coverage and enhance the external validity of future mechanism-oriented syntheses.

A residual limitation relates to potential author and institutional name ambiguity in bibliographic metadata, which may marginally affect rankings and network structures.

Citation-based indicators may disadvantage more recent publications (e.g., 2023–2024) and may be influenced by self-citations; therefore, influence-related results should be interpreted as descriptive rather than as definitive rankings.

4.3. Future Research Directions

Future research should also incorporate international and interregional analyses that compare renewable energy and sustainable development while considering social and political frameworks. More research could be conducted on the relationship between the impact of renewable energy on emerging economies, where there has been tremendous growth in adoption and transition to new technologies. There is a need for further research on the implementation of the Sustainable Development Goals, as well as the development of renewable energy investments, economic growth, and innovation, to achieve the Sustainable Development Goals by 2030. Future research should also pay greater attention to underexplored social and distributional dimensions of the SDG–renewable energy nexus, including SDG 10 (reduced inequalities) and SDG 16 (institutions and governance), which remain marginal in the current bibliometric structure.

4.4. Policy Implications

The results of this bibliometric review have important implications for energy and sustainability policies. The policy implications are derived directly from the thematic clusters and their evolution identified in the bibliometric analysis, which reveal distinct mechanisms linking renewable energy development with economic, environmental, and social dimensions of sustainable development. The strong and growing link between the development of renewable energy sources and the implementation of the Sustainable Development Goals, in particular SDG 7 and SDG 13, points to the need to treat renewable energy as a key instrument of national and regional development strategies. Energy policies should therefore go beyond a sectoral approach and be based on an integrated framework combining climate objectives, energy security, and socio-economic development. Beyond SDG 7 and SDG 13, the literature consistently highlights synergistic linkages with SDG 8 (decent work and economic growth) and SDG 9 (industry, innovation, and infrastructure), indicating that energy transition policies often generate broader development spillovers when embedded in innovation and industrial strategies.

The prominence of green finance-oriented clusters indicates differentiated policy needs across country types. Developing economies appear to be more dependent on international financial mechanisms, such as blended finance, multilateral development banks, and risk-sharing instruments, whereas developed economies primarily rely on regulatory frameworks and innovation-driven financial instruments to mobilize private investment. In this context, the literature emphasizes the importance of coherent alignment between financial regulation, climate objectives, and energy policy in order to accelerate technology diffusion and reduce investment uncertainty.

Clusters emphasizing governance, policy coordination, and international cooperation suggest that cross-sectoral and cross-border policy alignment is particularly critical for emerging and transition economies, where renewable energy deployment simultaneously addresses development gaps and climate objectives.

At the same time, the shift towards a systemic and interdisciplinary approach observed in the literature highlights the need for coordinated governance in the areas of energy, financial, industrial and innovation policy. Policymakers should support cross-sectoral cooperation and international partnerships, in particular with emerging economies, where the development of renewable energy sources can bring significant environmental and development benefits. Strengthening international coordination and knowledge transfer can significantly increase the effectiveness of public policies aimed at implementing the 2030 Agenda.

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