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Renewable Energies and Sustainable Development: A Bibliometric Overview

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Abstract: Sustainable development has positioned itself as a fundamental element of a transversal nature, being linked to the energy transition. In this sense, it must be included as a mainstream objective of all actions and strategies developed at the social, academic, business, and political levels. However, to the best of our knowledge, no bibliometric work has been carried out to date to analyze the main contributions to the literature focused on the concepts of renewable energy and sustainable development. The main aim of this paper is to establish the key trends and academic contributions made in the field of renewable energies and sustainable development. For this purpose, a bibliometric and co-citation analysis has been carried out using the Bibliometrix® tool, an open-source R package. The results show that this is a field of study that has significantly increased its importance in recent years, which is illustrated using different indicators. We conclude that research trends seem to be directed towards managing the transition to a new, more sustainable energy model composed of renewable energy production systems, in addition to the adoption of new technologies to increase the efficiency of products and power transmission systems. In this respect, the transition towards a new, more sustainable energy model seems to be a fundamental step to guarantee the sustainability of human action.

Keywords: renewable energy; sustainable development; bibliometric analysis; Bibliometrix®; WoS

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1. Introduction

In recent years, research in renewable energies and their impact on social and economic development and the quality of the environment has significantly increased its relevance [1–5]. Then, among energy, environmental, and scientific experts, a growing conversation has evolved on the effects of the global climate variations on the standard of living of the population and environmental sustainability [6]. On numerous occasions, decision makers and scientists have underlined the need for lowering the emissions of harmful gases, especially those related with the greenhouse effect, which are recognized as the principal driver of unusual climate variations, to prevent the disaster of global warming [7,8].

Since the severe effects of environmental degradation, such as climate change and global warming, have started to be felt on a worldwide scale, governments have been pushed to seek a collective solution. Different climate meetings, such as those held in Kyoto or Paris, have failed to appropriately address climate change concerns [9]. Consequently, several researchers and scholars have concluded that environmental efficiency must be supported through the introduction of new laws, legislation, and economic policies [10–13]. Therefore, the major challenge for policymakers is to increase economic development without diminishing environmental quality [14–17].

Renewable energy is a key factor to enhance the sustainability of the environment from the perspective of climate change [18–20]. Furthermore, investments in renewable energies generally result in lower carbon emissions than conventional energies [21–23]. Therefore,

countries may enhance the sustainability of the environment and build a sustainable and secure global context by promoting the use of renewable energies. In addition, from an economic standpoint, the development of green sources of energy provides considerable benefits [24–28]. There are previous research studies that analyze the literature focused on various renewable energy sources, as well as other ones on sustainable development and the impact of human activity on the environment. However, to the best of our knowledge, there are no previous studies that analyze, using bibliometric methods, the literature on both renewable energy and sustainable development, trying to unveil the main contributions (authors, journals, countries, collaborations, etc.) to these fields of study.

In this vein, this study provides a bibliometric analysis on renewable energy and sustainable development issues, considering all articles published up to 23 November 2022, the date on which the data were obtained. Applying advanced bibliometric techniques and R-based software, it is intended that this analysis goes deeper than the intellectual structure towards the conceptual and thematic underlying framework, uncovering topic rankings, gaps in current research, and opportunities for future research.

The main objective of this paper is to identify the seminal papers and the most important authors, institutions, countries, and collaborations among researchers that have laid the groundwork and paved the way for renewable energy and sustainable development research.

We opted for bibliometric analysis over conventional review approaches in this research because bibliometric techniques are unbiased, objective, analytical, robust, transparent, and valuable in revealing unique but related networks within a field and provide overviews of the domain [29]. Properly performed bibliometric reviews can greatly enhance the domain by enabling and empowering researchers in obtaining a comprehensive overview, finding the gaps in research, and making critical evaluations of relevant contemporary research questions. Our review is based on 8349 articles from 135 countries published before 23 November 2022 and co-authored by 23,493 authors. Single-authored documents amount to 1040 articles from 906 authors, while the remaining 7309 articles present an average of 3.84 authors per document. These 8349 documents received 181,006 citations and contained 328,799 references. This work is structured as follows. After this introduction, the methodology used is explained. Then, in the third section, the main results are shown. Finally, the conclusions developed are presented, in addition to the main limitations and possible future lines of research.

2. Materials and Methods

Web of Science database and, particularly, the following indexes were used to collect and compile trustworthy documents: Science Citation Index Expanded (SCI-E), Social Sciences Citation Index (SSCI), Emerging Sources Citation Index (ESCI), and Conference Proceedings Citation Index-Science (CPCI-S). Then, a search engine formula of "TS = sustainable development" AND "renew* energy*" was introduced in the search box of the advanced window for a time period from 1900 to 2022 (extracted on 23 November 2022). As a result, 12,860 documents were retrieved, with the outstanding information of this documents being extracted from WoS using comma-separated value file formats.

Once the previous search was carried out and despite having been formerly developed to be used in carrying out systematic literature reviews, the "Preferred Reporting Items for Systematic Reviews and Meta-Analysis" (PRISMA statement) was adopted to refine the search results [30,31]. The whole process is shown in Figure 1.

The adoption of the PRISMA statement was motivated by the fact that this statement provides the potential to increase reliability across reviews, recognition is based on its comprehensiveness, and that it has recently started to be used in a great number of bibliometric studies [32–36]. After applying the "articles only" filter and checking the absence of duplicate papers, the number of documents was reduced to 8349 articles. Peer reviewed articles are documents in which knowledge is certified [37]. The process of the revision can

be interpreted as a mechanism of control that enables validation of the knowledge such peer-reviewed scholarly journal articles provide [38,39].

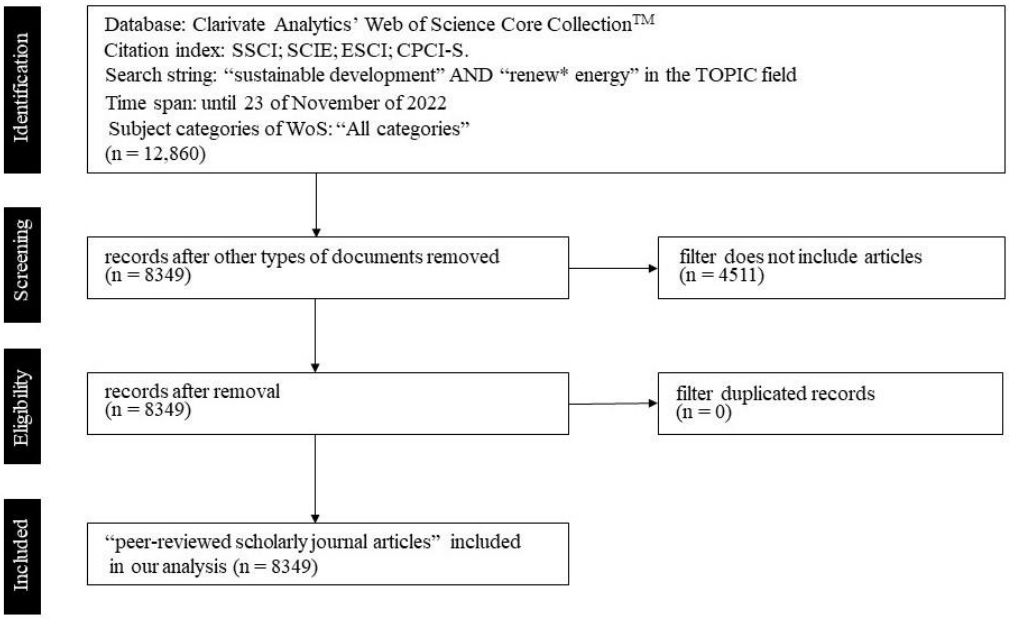

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA statement).

Then, the primary objective of this research being to evaluate the present state of knowledge on sustainable development and renewable energy, a bibliometric approach was selected [40]. This research methodology is appropriate for analyzing the state of a field based on several indicators, such as the most prominent and referenced articles, journals, authors, institutions, and nations [41]. In addition, it permits the evaluation of the collaborative network between authors, institutions, and nations. In a broader sense, this research methodology permits the examination of voluminous publishing data at both the macroscopic and microscopic levels [42]. Consequently, bibliometric analysis may be utilized to undertake knowledge analysis on any study subject to identify objective and unobservable trends [43–47].

In this research, the powerful bibliometric analysis tool Bibliometrix® was used. Bibliometric analysis should include, among others, descriptive and collaborative network analysis, such as co-citation, bibliographic coupling, and co-occurrence testing. Bibliometrix® provides a thorough analysis of scientific mapping, using the biblioshiny interface [48]. In addition, VOSviewer is capable of handling huge datasets, has greater mapping features, and presents greater display options [48–50]. Both tools support the entire range of functions explored.

Furthermore, scholars have found that major breakthroughs within a given domain of science were interconnected chronologically, newer findings generally being dependent on older ones [51]. Based on the compiled papers, the features of the sustainable development and renewable energy fields were examined. In this vein, basic statistical features were addressed. Diverse indicators are used to assess the importance and fruitfulness of published articles [52], among which we can highlight the number of citations, documents, and the H-index. In addition, using Bibliometrix®, a visual analysis can be performed regarding the results.

3. Results

After being extracted from WoS, the dataset consisting of papers on sustainable development and renewable energy is shown in Table 1, which provides interesting information on the research analysis.

Table 1. Main information about the dataset.

Main Information Data	
Sources (Journals, Books, etc.)	1665
Documents	8349
Annual Growth Rate %	6.92%
Document Average Age	4.4
Average citations per doc	21.68
References	328,799
Document contents	
Keywords Plus (ID)	9447
Author's Keywords (DE)	18,101
Authorship	
Authors	23,493
Authors of single-authored docs	906
Authors collaboration	
Single-authored docs	1040
Co-Authors per doc	3.84
International co-authorships %	34.27%

3.1. Production and Most Important Journals in Sustainable Development and Renewable Energy

Research on renewable energy and its effect on sustainable development remains remarkably insufficient in the literature and, for the most part, the growing ratio and related scales were utilized as sustainable development indicators when investigating the link between these two variables [53–61]. Nevertheless, although research on these topics is still insufficient, in recent years, research focused on the study of sustainability and renewable energy has increased exponentially.

Thus, as can be seen in Figure 2, although there is an increase in interest on the subject, it is in 2015 where this growth occurs with greater intensity, with 2017 being the year that generates a turning point in the number of publications. In this regard, the most recent data to be considered as definitive would be those for the year 2021.

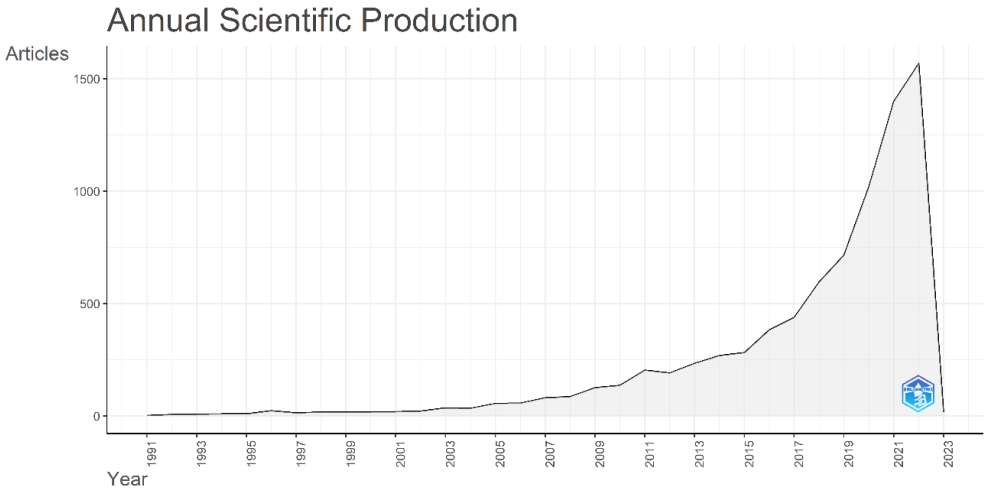

Figure 2. Evolution of production over time.

Regarding the most active journals in these fields of study, Figure 3 shows the top 10 journals from the list of 1665 journals in sustainable development and renewable energy fields.

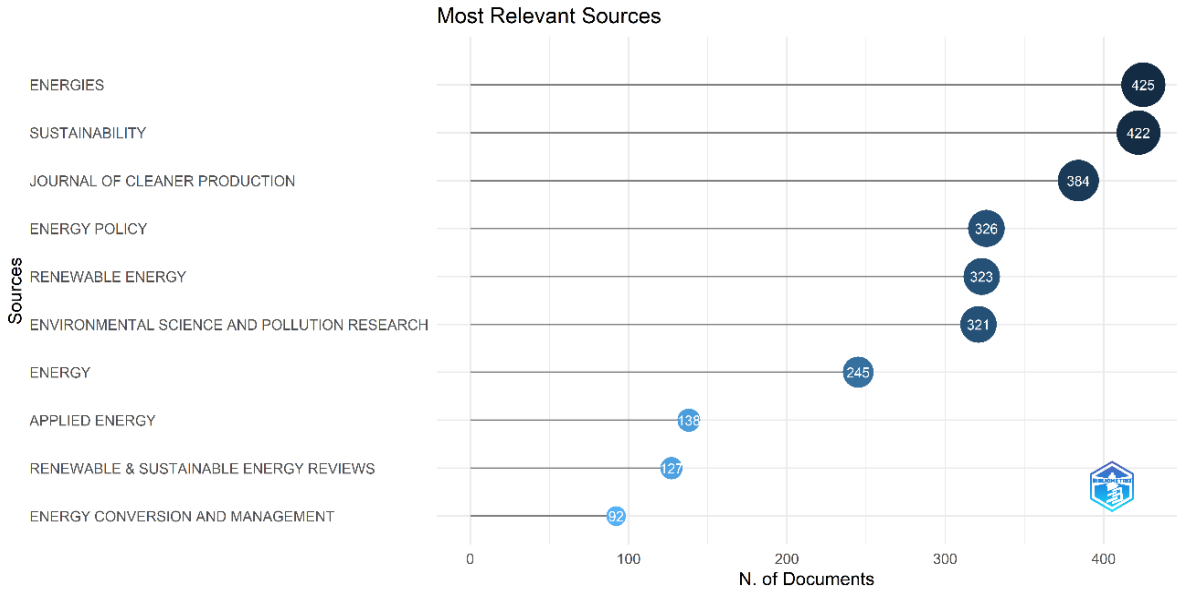

Figure 3. Top 10 most important journals in sustainable development and renewable energy.

As can be seen, the main journals of this list are *Energies* (425 articles), *Sustainability* (422 articles), and *Journal of Cleaner Production* (384 articles). These are currently high-impact journals that focus on energy and environmental, social, and economic sustainability.

Previous paragraphs have shown the main journals on sustainable development and renewable energy fields, the top three journals being *Energies*, *Sustainability*, and *Journal of Cleaner Production*. As the most important journals on these issues, their number of publications have been analyzed over time, which are shown in Table 2. From 2015 onwards, the journal *Energies* has experienced an exponential growth in its number of publications in these fields, reaching the top position in 2020 and maintaining it in 2021, with a total of 131 articles published. The journal *Sustainability* ranks second, with 94 articles in 2021, while *Journal of Cleaner Production* is in third place with 67 articles published. Therefore, these three journals published 14.74% of the total of articles published by the 1665 journals identified in sustainable development and renewable energy. To facilitate the visualization of the data incorporated in Table 2, the information corresponding to the papers published by the three journals is shown in Figure 4.

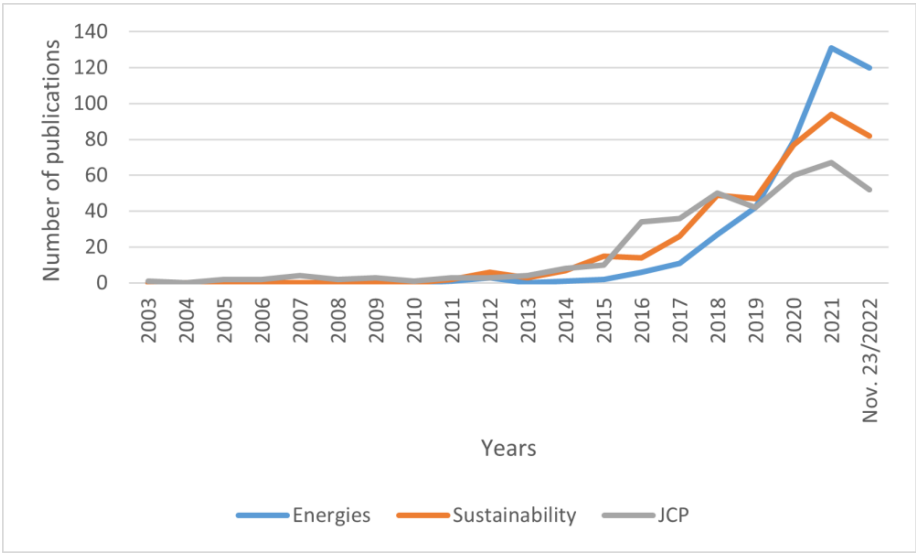

Figure 4. Evolution in the number of articles published by the top 3 journals in sustainable development and renewable energy over time.

Table 2. Number of articles published by the top 3 journals in sustainable development and renewable energy.

	Energies	*Sustainability*	*JCP*	**Total**
2003	0	0	1	1
2004	0	0	0	0
2005	0	0	2	2
2006	0	0	2	2
2007	0	0	4	4
2008	0	0	2	2
2009	2	0	3	5
2010	0	0	1	1
2011	1	2	3	6
2012	3	6	3	12
2013	0	3	4	7
2014	1	7	8	16
2015	2	15	10	27
2016	6	14	34	54
2017	11	26	36	73
2018	27	49	50	126
2019	42	47	42	131
2020	79	77	60	216
2021	131	94	67	292
23 November 2022	120	82	52	254
Total	425	422	384	1231
%	5.09%	5.05%	4.60%	14.74%

Source: own elaboration. Note: JCP = *Journal of Cleaner Production*.

3.2. Most Relevant Authors, Affiliations, and Countries in Sustainable Development and Renewable Energy

In connection with the ranking of the most prolific authors, Table 3 shows the top-10 list of the main authors on sustainable development and renewable energy published in the mentioned database, considering the output of articles, their number of local citations, and their h-index. It is worth mentioning that these ten authors managed to publish over 25 articles, whereas the rest of the authors published 24 papers or less. In addition, the positions of the most local cited and higher h-index authors classification are shown in the ranking of the most productive authors list. For example, Ahmad, M. is the most productive author in the field of analysis, in addition to having the highest h-index, while Bekun, F.V. is the second author in scientific production and local citations and the third one in h-index rank. Furthermore, there are several authors that are included in more than one classification, demonstrating its relevance in this field of study by means of different indicators.

Table 3. Ranking of the top 10 most relevant authors.

Rank	**Authors**	**A.P.**	**MLC Authors**	**Citations**	**Rank A.P.**	**Authors**	**H-Ind.**	**Rank A.P.**
1	Ahmad, M.	50	Alola, A.A.	526	3	Ahmad, M.	24	1
2	Bekun, F.V.	43	Bekun, F.V.	509	2	Alola, A.A.	21	3
3	Alola, A.A.	36	Sarkodie, S.A.	423	36	Bekun, F.V.	20	2
4	Streimikiene, D.	35	Ahmad, M.	313	1	Kaygusuz, K.	17	6
5	Zhang, Y.	32	Sinha, A.	305	16	Sinha, A.	16	16
6	Kaygusuz, K.	30	Kaygusuz, K.	236	6	Streimikiene, D.	16	4
7	Liu, Y.	28	Sharif, A.	213	26	Adebayo, T.S.	15	11
8	Li, Y.	26	Lund, H.	204	50	Sharif, A.	15	26
9	Huang, G.H.	25	Khan Sar	197	28	Zhang, Y.	15	5
10	Murshed, M.	25	Kirikkaleli, D.	194	17	Duic, N.	14	19

Source: own elaboration. Note: MLC = most local cited; A.P. = articles published; H-ind. = H-index.

In this regard, the publications of the top 10 authors in scientific production, considering in this case the number of articles fractioned by the authors involved in their development, are showed in Table 4.

Table 4. Ranking of the top 10 most relevant authors based on the number of articles fractioned by the authors involved.

Authors	Articles	Articles Fractionalized	Authors	Articles	Articles Fractionalized
Kaygusuz, K.	30	22.20	Ahmad, M.	50	11.56
Alola, A.A.	36	13.93	Yuksel, I.	12	9.53
Dincer, I.	24	12.33	Khan, I.	15	7.52
Bekun, F.V.	43	12.29	Demirbas, A.	8	7.50
Streimikiene, D.	35	12.01	Kilkis, S.	13	7.13

Source: own elaboration.

In addition, Figure 5 shows the production over time of some of the most important authors, considering all these indicators. In the same way as observed in Figure 3, most of the scientific productivity in this field from the top 10 authors is concentrated from 2015 onwards.

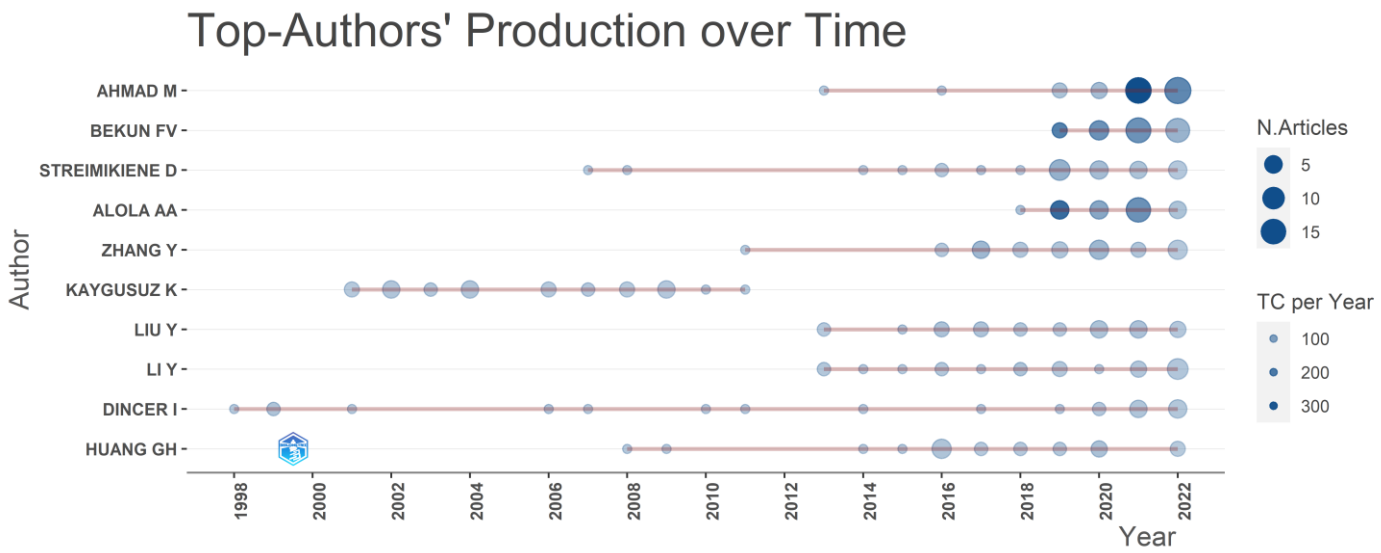

Figure 5. Top 10 authors' production over time.

The most global and local cited papers are detailed in Tables 5 and 6, respectively. The term "global citations" refers to the total number of citations that each paper has received, considering all papers published in any field and region. In turn, the concept of local citations means the number of citations received by each document from the rest of the documents that make up the analyzed set.

Regarding the ranking of the most relevant affiliations in sustainable development and renewable energy published in the WoS database, the top 10 are shown in Table 7. The North China Electric Power University is positioned in first place with a wide margin, reaching a total of 157 documents, being followed by Tsinghua University with 85 documents and Istanbul Gelisim University with 82 documents. Then, the fourth and fifth places are held by Jiangsu University and the Chinese Academy of Sciences with 78 and 68 documents, respectively. Finally, there are three universities which have published 64 articles (Beijing Normal University, Cyprus International University, and Islamic Azad University) and two that have published 61 (King AbdulAziz University and King Saud University).

Table 5. Most global cited documents.

Document	TC	TC per Year	Normalized TC
Song, C.S., 2006, Catal Today [62]	1331	78.29	17.91
Gielen, D., 2019, Energy Strateg Rev [63]	1090	272.50	42.02
Wang, W., 2013, Adv Funct Mater [64]	1035	103.50	28.28
Dunn, S., 2002, Int J Hydrogen Energ [65]	998	47.52	14.83
Kuhl, K.P., 2014, J Am Chem Soc [66]	955	106.11	27.26
Olah, G.A., 2011, J Am Chem Soc [67]	855	71.25	18.71
Lund, H., 2007, Energy [68]	841	52.56	17.85
Devine-Wright, P., 2009, J Community Appl Soc [69]	772	55.14	16.61
MCLaughlin, S.B., 2005, Biomass Bioenerg [70]	760	42.22	12.37
Ursua, A., 2012, P IEEE [71]	719	65.36	23.20

Source: own elaboration. Note: TC = total citations.

Table 6. Most local cited documents.

Document	Year	LC	GC	LC/GC Ratio	NLC	NGC
Bekun, F.V., 2019, Sci Total Environ [72]	2019	117	556	21.04%	46.40	21.43
Gielen, D., 2019, Energy Strateg Rev [63]	2019	93	1090	8.53%	36.88	42.02
Alola, A.A., 2019, Sci Total Environ [73]	2019	89	318	27.99%	35.29	12.26
Lund, H., 2007, Energy [68]	2007	77	841	9.16%	23.19	17.85
Sarkodie, S.A., 2019, Sci Total Environ [74]	2019	77	484	15.91%	30.54	18.66
Bhattacharya, M., 2017, Renew Energ [17]	2017	70	315	22.22%	39.46	11.08
Zafar, M.W., 2019, J Clean Prod [75]	2019	68	243	27.98%	26.97	9.37
Danis, K., 2020, Sustain Cities Soc [76]	2020	67	335	20.00%	30.70	17.38
Khan, Z., 2020, Sci Total Environ [77]	2020	64	250	25.60%	29.33	12.97
Inglesi-Lotz, R., 2016, Energ Econ [78]	2016	57	342	16.67%	37.00	10.87

Source: own elaboration. Note: LC = local citations; GL = global citations; NLC = normalized local citations; NGC = normalized global citations.

Table 7. Ranking of the top 10 most relevant affiliations.

Rank	Affiliations	Location (Country)	Articles
1	North China Electric Power University	China	157
2	Tsinghua University	China	85
3	Istanbul Gelisim University	Turkey	82
4	Jiangsu University	China	78
5	Chinese Academy of Sciences	China	68
6	Beijing Normal University	China	64
7	Cyprus International University	Cyprus	64
8	Islamic Azad University	Iran	64
9	King AbdulAziz University	Saudi Arabia	61
10	King Saud University	Saudi Arabia	61

Source: own elaboration.

After analyzing the list, it is noteworthy that five of the ten entities on the list are located in China, one of the most polluting countries in the world (European Parliament News webpage: https://www.europarl.europa.eu/news/en/headlines/society/20180301STO98928/greenhouse-gas-emissions-by-country-and-sector-infographic, accessed on 25 November 2022). It seems that China is investing a great deal of effort and resources to try to improve the sustainability of the country's energy production and socioeconomic development. In addition, Saudi Arabia appears to be investing similarly in academic research in this area.

Nevertheless, to verify the above data, Table 8 exposes the countries that have higher levels of scientific production, and those ones are the most cited on sustainable development and renewable energy.

Table 8. Top 10 countries by scientific production and by number of citations.

Rank	Country	A.P.	SCP	MCP	MCP Ratio	Country	Citations	A.A.C.	Rank by A.P.
1	China	1661	996	665	40.04%	China	36,917	22.23	1
2	USA	502	363	139	27.69%	USA	21,066	41.96	2
3	UK	403	260	143	35.48%	UK	12,532	31.10	3
4	India	375	293	82	21.87%	Turkey	9383	27.68	6
5	Italy	339	247	92	27.14%	Germany	7704	24.69	7
6	Turkey	339	276	63	18.58%	Australia	7052	32.80	10
7	Germany	312	228	84	26.92%	Italy	6874	20.28	5
8	Poland	270	219	51	18.89%	Spain	4670	18.39	9
9	Spain	254	182	72	28.35%	India	4641	12.38	4
10	Australia	215	115	100	46.51%	Denmark	4621	58.49	27

Source: own elaboration. Notes: A.P. = articles published; SCP = intra-country collaboration; MCP = multi-country collaboration; AAC = average article citations.

As can be seen, China is both the most productive and cited country in sustainable development and renewable energy research (with 4223 articles and 36,917 citations), followed by the United States of America and the United Kingdom (with 1416 citations and 21,066 references and 1007 citations and 12,532 references, respectively). Furthermore, the country that presents a higher rate of multi-country collaboration is Australia (46.51%), followed by China (40.04%), the United Kingdom (35.48%), Spain (28.35%), the United States of America (27.69%), Italy (27.14%), Germany (26.92%), India (21.87%), Poland (18.89%), and Turkey (18.58%).

Table 9 shows the most frequent words linked to sustainable development and renewable energy, according to the WoS database. Then, the keywords most employed by the authors are highlighted. The greatest number of occurrences, as could be expected, is for renewable energy with a frequency of 1646, followed by sustainable development with 1187.

Table 9. Most frequent keywords.

Rank	Words	Occur.	Rank	Words	Occur.
1	Renewable energy	1646	11	Energy policy	180
2	Sustainable development	1187	12	Solar energy	173
3	Sustainability	549	13	China	172
4	Renewable energy sources	253	14	Energy consumption	163
5	Economic growth	252	15	Energy transition	155
6	Energy	250	16	Sustainable development goals	151
7	Climate change	242	17	Sustainable energy	137
8	Energy efficiency	225	18	Wind energy	130
9	Biomass	209	19	Environment	114
10	CO_2 emissions	192	20	Optimization	113

Source: own elaboration. Note: Occur.: occurrences.

This illustrates the importance of these key concepts as fields of study. Then, from the third to the tenth word in the ranking, sustainability (549), renewable energy sources (253), economic growth (252), energy (250), climate change (242), energy efficiency (225), biomass (209), and CO_2 emissions (192) are found.

These words might clarify the existing challenges to maximize the use of renewable energies, with the aim of achieving economic growth, increased energy efficiency, sustainability of energy production and supply, and business activity in general.

In fact, it is not only a simple evolution towards the generation of energy from renewable sources but a new socioeconomic system that allows for increased efficiency in energy consumption and the effective application of new methods, production models, and strategies to optimize operations and resources and achieve the fundamental objective of sustainable development. In this regard, it can be seen how the word optimization is part of the top 20 most frequent keywords.

In this regard, Figure 6 and Table 10 present the co-occurrence network of keywords. As showed, the 50 items considered can be classified into three clusters: the first cluster, which has 8 items that treat aspects related to the measurement of the impact of sustainable development and renewable energy; the second cluster, with 36 items, in which different issues linked to the improvement of the sustainability of the development strategies and energy production are included; and the third cluster, with 6 items, that presents keywords related to energy sources created from organic substances.

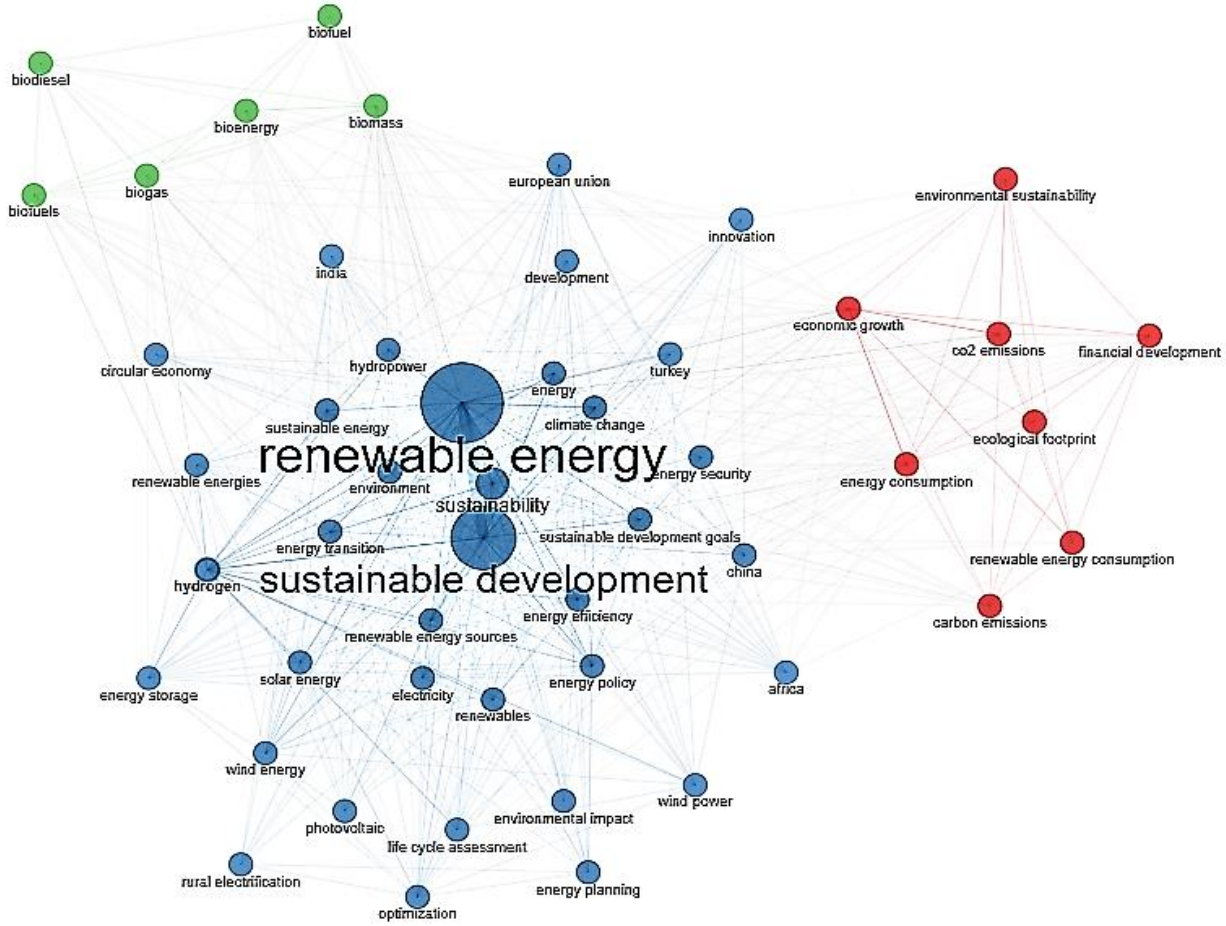

Figure 6. Co-occurrence network of keywords.

In addition, when we observe the betweenness centrality, cluster one is dominated by keywords such as economic growth, CO_2 emissions, or energy consumption. Regarding the second cluster, keywords with the higher values of betweenness centrality are, by far, renewable energy and sustainable development. The third cluster is mastered by the keyword biomass.

In Table 11, the co-citation network is depicted. Two papers are co-cited when they are both cited in a third paper. Considered a valuable indicator, co-citation is a useful measure to gauge intellectual output in a particular domain and to reflect how schools of thought are evolving [48].

Through the co-citation analysis, four groups were identified that are clearly distinguishable in Figure 7. Thus, it is worth mentioning the contributions of Kuznets and Noris (1955) and Dogan (2016) in the first cluster, Engle (1987) and Bekun (2019) in the second, Im (2003) and Pedroni (2004) in the third, and Pesaran (2007) and Dumitrescu (2012) in the fourth cluster.

Table 10. Co-occurrence network: betweenness centrality.

Node	Ct	Btw. Centr.	Node	Ct	Btw. Centr.
Economic growth	1	12.80735033	Hydrogen	2	1.99254828
CO_2 emissions	1	3.636313664	Renewable energies	2	0.19710793
Energy consumption	1	1.954041469	Hydropower	2	0.648958365
Carbon emissions	1	0.322238652	Turkey	2	0.698360254
Renewable energy consumption	1	0.292130003	Life cycle assessment	2	0.397351068
Financial development	1	0.42558991	Electricity	2	1.035292634
Environmental sustainability	1	0.414799319	Circular economy	2	0.282127878
Ecological footprint	1	1.323089645	Africa	2	0.915252997
Renewable energy	2	340.6036557	Innovation	2	0.22587387
Sustainable development	2	216.4577325	Energy security	2	0.15221816
Sustainability	2	47.64563016	Rural electrification	2	0.042105175
Renewable energy sources	2	2.658386943	Energy planning	2	0.073572621
Energy	2	13.66376645	European union	2	1.68437152
Climate change	2	6.995001929	Renewables	2	0.939566896
Energy efficiency	2	3.427861349	Wind power	2	0.196424031
Energy policy	2	4.88015071	Environmental impact	2	0.244632844
Solar energy	2	3.527386642	Photovoltaic	2	0.200939003
China	2	2.475363939	Development	2	0.09408488
Energy transition	2	2.612772585	India	2	0.234933131
Sustainable development goals	2	2.595185353	Biomass	3	7.293564981
Sustainable energy	2	1.799810863	Bioenergy	3	1.222581308
Wind energy	2	0.956151449	Biofuels	3	1.053647224
Environment	2	1.115476119	Biogas	3	0.931960257
Optimization	2	1.122092716	Biofuel	3	0.105481429
Energy storage	2	0.271778096	Biodiesel	3	0.153286807

Source: own elaboration. Note: Ct: cluster.

Table 11. Co-citation network.

Node	Cluster	Btw Centrality	Node	Cluster	Btw Centrality
Kuznets, S., 1955 [79]	1	14.21712026	Dogan, E., 2016-1 [80]	1	13.0139325
Pao, H.T., 2011 [81]	1	9.160808946	Dincer, I., 2000 [82]	1	0.264321447
Wüstenhagen, R., 2007 [83]	1	0	Walker, G., 2008 [84]	1	0
Engle, R.F., 1987 [85]	2	9.971516542	Bekun, F.V., 2019 [72]	2	5.736036126
Grossman, G.M., 1995 [86]	2	2.88732154	Alola, A.A., 2019 [73]	2	2.849657155
Balsalobre-Lorente, D., 2018 [87]	2	2.52550982	Bilgili, F., 2016 [88]	2	2.215158742
Grossman, G.M., 1993 [89]	2	2.020116395	Destek, M.A., 2020 [90]	2	1.800078263
Sarkodie, S.A., 2019 [74]	2	1.763636178	Pesaran, M.H., 2001 [91]	2	1.502480292
Danish, K., 2019 [92]	2	1.464169468	Shahbaz, M., 2018 [93]	2	1.311842541
Shahbaz, M., 2013 [94]	2	1.28944021	Chen, Y.L., 2019 [95]	2	1.189045827
Destek, M.A., 2019 [96]	2	1.187019505	Shahbaz, M., 2017 [97]	2	1.017568693
Dogan, E., 2016-2 [98]	2	0.898444104	Charfeddine, L., 2019 [99]	2	0.783289169
Pata, U.K., 2018 [100]	2	0.747061711	Phillips, P.C.B., 1988 [101]	2	0.470699809
Adedoyin, F.F., 2020 [102]	2	0.4107689	Dickey, D.A., 1979 [103]	2	0.357834934
Adebayo, T.S., 2021 [104]	2	0.273711091	Im, K.S., 2003 [105]	3	35.9971932
Pedroni, P., 2004 [106]	3	28.6887552	Apergis, N., 2010 [107]	3	27.30118952
Pedroni, P., 1999 [108]	3	17.84502662	Levin, A., 2002 [109]	3	17.62408762
Pesaran, M.H., 1999 [110]	3	11.06348275	Kao, C., 1999 [111]	3	8.917242166
Bhattacharya, M., 2016 [112]	3	8.071007742	Gielen, D., 2019 [63]	3	0.591680293
Pesaran, M.H., 2007 [113]	4	68.2672215	Dumitrescu, E.I., 2012 [114]	4	54.91456586
Pesaran, M.H., 2021 [115]	4	37.72237576	Westerlund, J., 2007 [116]	4	34.60157964
Breusch, T.S., 1980 [117]	4	19.15446075	Alvarez-Herranz, A., 2017 [118]	4	13.46028189
Pesaran, M.H., 2008 [119]	4	5.846887802			

Source: own elaboration.

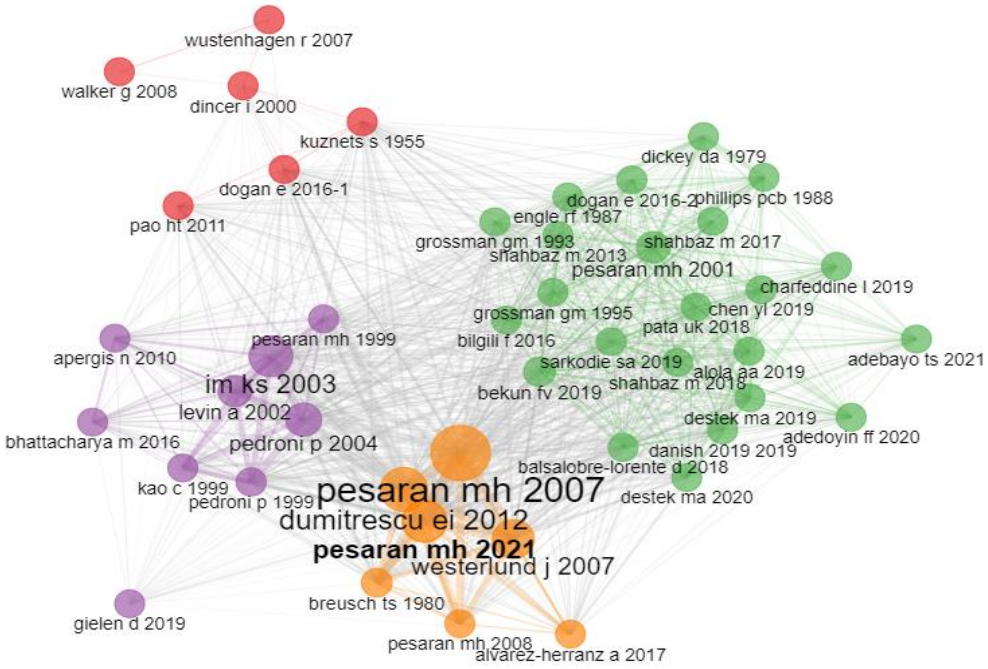

Figure 7. Co-citation network.

Figure 8 presents some key collaboration between countries, establishing a minimum edges threshold of eight. As can be clearly seen, the main cooperation agreements are managed by universities located in China, the United Kingdom, and the United States of America, which build ties to their peers throughout different countries in the world. In addition, Latin American and African countries seem to share a limited number of international cooperation agreements. Table 12 shows in detail the 40 country pairs with the highest frequency of collaboration, China being one of the most collaborative countries in the fields under study that actively cooperates with universities located in countries all around the world, such as Pakistan, the United States of America, the United Kingdom, Turkey, Canada, and Australia, among others.

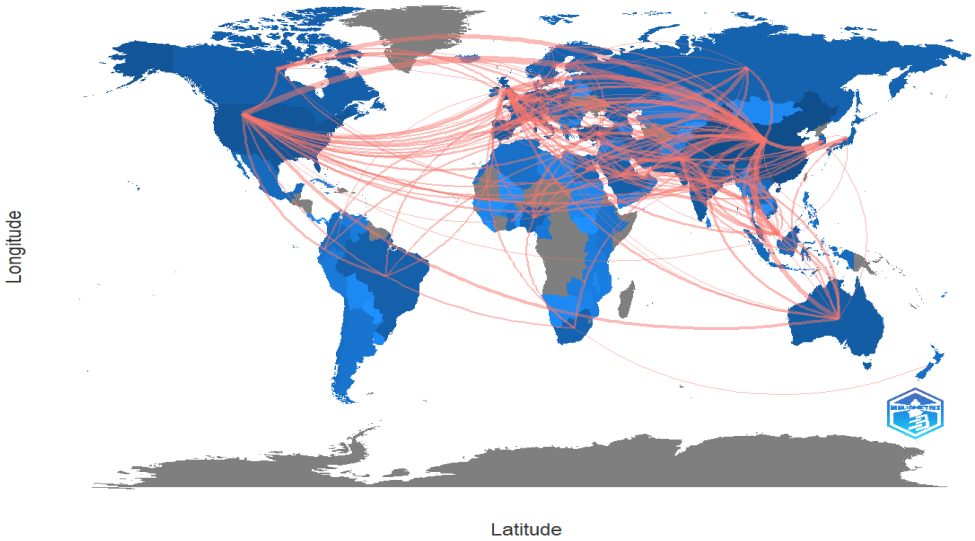

Figure 8. Collaboration world map.

Table 12. Frequency of the most collaborative entities in sustainable development and renewable energy.

From	To	Frequency	From	To	Frequency
China	Pakistan	241	Turkey	Nigeria	34
China	USA	156	USA	Germany	34
China	UK	102	UK	Netherlands	32
China	Turkey	100	UK	Pakistan	32
China	Canada	74	China	Bangladesh	30
China	Australia	71	China	Korea	30
Pakistan	Saudi Arabia	68	China	Sweden	29
China	Malaysia	66	Malaysia	Saudi Arabia	29
China	India	64	UK	Italy	29
China	Saudi Arabia	58	UK	Turkey	29
China	Japan	51	China	Italy	28
Turkey	Russia	51	China	France	27
Pakistan	Malaysia	50	USA	Canada	27
Turkey	Pakistan	50	USA	India	27
UK	Germany	47	India	Pakistan	26
USA	UK	46	China	Iran	25
China	Vietnam	45	China	Netherlands	25
India	Saudi Arabia	39	Germany	Netherlands	25
UK	Spain	35	USA	Italy	25
USA	Australia	35	China	Germany	24

Source: own elaboration.

Finally, a thematic map has been developed, which is shown in Figure 9. On a two-dimensional thematic map, the most relevant issues in the field, as determined by the authors' keywords, were mapped. The map depicts the strength of their internal (density) and external (connectivity) relationships (centrality).

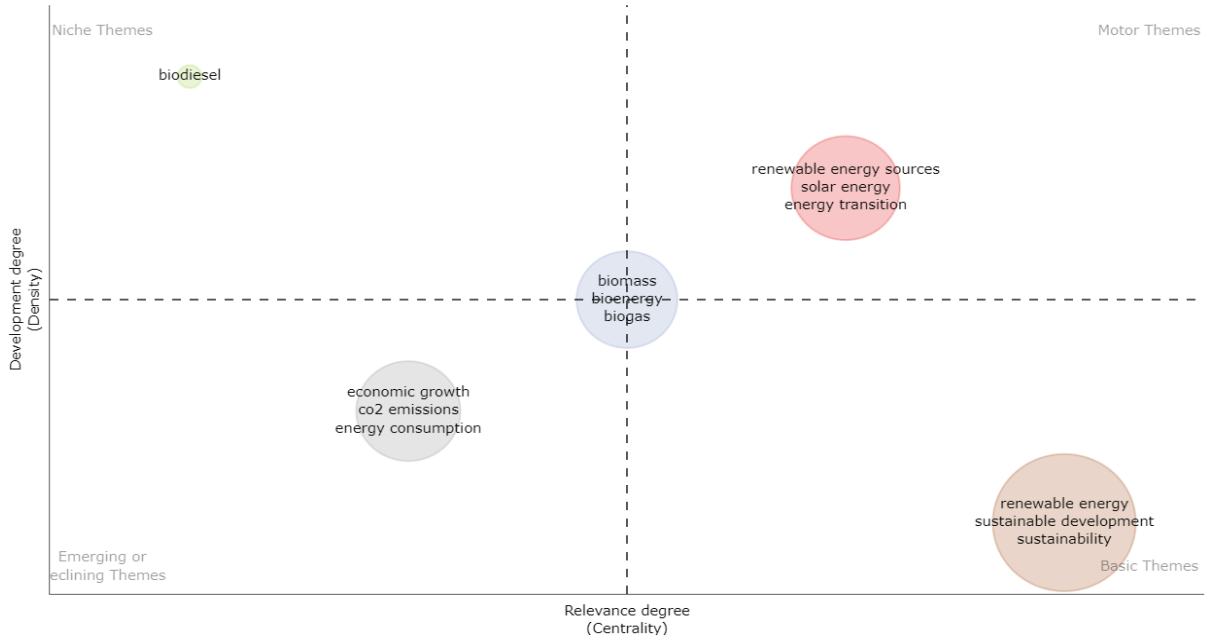

Figure 9. Thematic map.

The density dimension reflects intra-cluster growth, while the centrality dimension represents the relevance or significance of a subject inside a particular area and the intensity of between-cluster links [120]. It consists of four quadrants, each of which represents a distinct characteristic of the themes [121–124].

1. Low density and centrality (emerging themes): The study subjects in the bottom left quadrant are underdeveloped or emerging themes that need more investigation. They often lack significance across networks and develop slowly inside a network. These topics are currently immature and peripheral to the field; they lack significance across networks and grow slowly inside a network. However, these topics are attractive and provide opportunity for further investigation.
2. Low density and high centrality (basic themes): the study subjects in the bottom right quadrant are significant but underdeveloped, fundamental, and transversal and have great relevance across networks but minimal development inside networks.
3. High density and low centrality (niche themes): the study subjects in the upper left quadrant have well-developed internal connections but minimal exterior connections; they are, therefore, barely important to the field at the present time.
4. High density and centrality (motor themes): The study subjects in the upper right quadrant are regarded as major themes in the literature that significantly contribute to the development of a discipline. They are very relevant across networks and highly developed inside networks.

Knowledge about developing and specialized themes is one of the most significant contributions of bibliometric analysis, since these topics provide opportunities for future study.

4. Discussion

The topics analyzed in this paper represent relevant factors that affect every nation on Earth, although the number of resources invested in research differs substantially from country to country. In this section, the main results showed through tables and figures are discussed. In Table 1, we can see that there is a wide range of journals and articles that have developed their research on the fields under study, but the most important is that the average annual growth rate of papers published is almost 7%, so the interest of academicians in these topics has significantly increased over time. These are broad topics, which can explain the fact that the 8349 papers analyzed used a total of 18,101 different keywords. The importance and cross-cutting nature of the topics could have had an impact on the degree of international cooperation among authors, as we can see that the international co-authorships reach a figure of over 34%, 12.46% being the percentage of single-authored papers. The transition to a new energy model based on renewable energy sources and actions aimed at the sustainable development of all the nations of the world are global challenges that must be addressed in a coordinated manner, and the level of cooperation in research and development is a key factor in achieving this goal.

In Figure 2 we can see that, although the average annual growth rate of papers published over time is 7%, this rate has soared in recent years and especially since 2017, which shows that the level of awareness on this issue is considerably higher in the last four years than in previous periods. Although the number of journals that have contributed to the increase in the number of publications in recent years is high, the contributions made by the journals *Energies*, *Sustainability*, and *Journal of Cleaner Production* are noteworthy. Figure 3 shows the top 10 journals with the highest number of publications, while Table 2 and Figure 4 show in detail the annual number of publications made by the mentioned journals, which present the higher number of publications of this ranking. These three are journals focused on energy and economic, social, and environmental sustainability, which are favoring scientific production and the dissemination of results at all levels, as they are open-access journals. Furthermore, *Energy Policy* is ranked fourth in this classification as an active journal in these fields, which could mean that attention is also being drawn to these issues from a political and legislative perspective, so that the sustainable development of nations can be driven via legislating regulations that enforce further use of renewable energies.

Then, Table 3 shows the most prolific authors based on their number of publications, local citations, and h-index. Four of them appear within the top ten in all three rankings, while eight are in two classifications. It is worth noting that there are three authors who

appear in the first four positions in the three rankings, which also belong to the top ten authors when we analyze the ranking of the most prolific authors considering the number of articles fractioned by the authors involved (Table 4), so we can determine that they are some of the most important authors in these fields of study. As it is showed in Figure 5, the production of the most prolific authors is concentrated in the last four years, in line with the information obtained from Figure 2 regarding the whole number of papers published. Regarding the most global and local cited documents, the first ones may show those papers developed from a more transversal perspective, applicable to different fields and subfields of study (Table 5), while the second ones may be highly specialized works in the fields under study, so that they are more widely cited among the specific literature.

In Tables 7 and 8 the main affiliations and countries by scientific production are displayed. As can be seen, China is positioned as a leading country in scientific production in the fields under study. Five universities from this country are ranked in the first six positions of the classification, with the sole exception of the third place, which belongs to Istanbul Gelisim University. In addition, China has published more than three times as many articles as the second-ranked country, the United States of America. In this vein, Chinese papers have also received over 75% more citations than the second country ranked and almost three times more than the third one, the United Kingdom. In this sense, despite being one of the most polluting and contaminated countries in the world, it seems to be making important efforts in research to try to promote the transition towards new energy models based on renewable energies and more sustainable development. It is worth noting that two Saudi Arabian universities belong to the ranking of the most prolific affiliations. In line with the news coming from this country in recent years, it seems to be promoting research in renewable energies and sustainable development as a way of improving its prestige at the international level, as well as diversifying its areas of investment.

When analyzing the most frequent keywords (Table 9), we see that among the most related keywords, such as renewable energy and sustainability, there are other revealing ones, such as economic growth, energy efficiency, optimization, or climate change, that allow us to visualize the main objectives of this energy transition to renewable sources and the efforts made in favor of sustainable development. Furthermore, energy policy is among the most frequent keywords, which reveals the importance of governments as institutions managing this transition through the implementation of specific regulations that guide the actions of public and private agents in terms of energy and environmental sustainability. Regarding the co-occurrence network of keywords, we can classify them in three clusters (Figure 6 and Table 10). The first one groups keywords related to the measurement of the impact of the transition to energy and development models that are sustainable. This reflects the need to establish indicators of the impact derived from the implementation of strategies in the established areas on key factors of the economy, energy efficiency, and sustainability. The second cluster corresponds to keywords related to the management of the transition and the strategies to implement to improve the sustainability of development and energy sources.

In this respect, energy policy, strategic planning at the government level, and the implementation of actions focused on the improvement of the sustainability of human activity, energy efficiency and storage, renewable energy sources, security, and innovations may play a key role to enhance the likelihood of success of this transition. Finally, the third one contains words relating to organic substances that could be used as alternative primary energy sources to current hydrocarbons. Some of these primary sources of energy from organic sources could facilitate the energy transition and sustainable development by reducing the environmental impact of fuel use for power generation. In some cases, the use of biofuels can favor the elimination of some harmful human-generated waste, promoting the regeneration of the natural environment.

The co-citation network of papers allows us to establish the intellectual output of these fields of study (Figure 7 and Table 11). This analysis may be used for further research to uncover the knowledge base of these fields of study through the in-depth analysis of the

papers involved. Regarding collaboration between countries, it is worth mentioning that China is positioned as the country that has established the most international collaborations in renewable energy and sustainable development research (Figure 8 and Table 12).

Based on these data, it could be interpreted that China has the claim to lead scientific research in the fields of energy transition and sustainable development. In this sense, it would be interesting to extend the research to determine whether the strategies, regulations, and actions of this country are linked in the same terms to the achievement of these objectives. As was observed in the ranking of the most important countries, the United States of America and the United Kingdom are positioned as the second and third most important countries, although far behind the figures achieved by China. Finally, in Figure 9 the thematic map is shown, in which four themes are distinguished that reflect the most relevant issues in the field through the analysis of their internal and external relationships. Based on this, we established that renewable energy sources, solar energy, and energy transition are motor themes, which means they significantly contribute to the development of the discipline. Furthermore, economic growth, CO_2 emissions, and energy consumption are identified as emerging fields in this area which need to be developed.

5. Conclusions

The possibility and reality of environmental deterioration have been increasingly obvious during the last decades. Growing evidence of environmental concerns is attributable to a mix of reasons, especially to the environmental effect of human activities. In this vein, a significant amount of a society's environmental effect is attributable to its energy use. Ideally, a society pursuing sustainable growth would solely consume energy sources that have no environmental effect. For this reason, energy production is a key element which currently is in the spotlight of actions in favor of environmental, social, and economic sustainability. Global research efforts in the field of renewable energies increased significantly following the global oil shocks of the beginning of the 1970s. Since then, energy systems based on renewable energy technologies seemed to be the preferred choice due to factors such as the expected high fuel cost, the ease of installation of renewable energy systems, and their projected profitability estimates. In addition, it has been apparent in recent years that renewable energy sources and systems may have a positive influence on significant environmental issues, environmental deterioration, depletion of the world's nonrenewable energy supplies, and rising energy consumption in emerging nations. This is a relatively new topic, which has received a great deal of attention in the last decades and especially in recent years, as can be seen in the graphs showing the evolution in the number of publications.

The aim of this research is to present, in a holistic way, the main features of the research in renewable energy and sustainable development fields. To conduct this study, bibliometric analysis was carried out, which allowed us to provide information about the most relevant authors, journals, affiliations, and countries, in addition to the main areas of research within the field of study. Regarding the journals, it is worth noting that nowadays, *Energies* and *Sustainability* are both among the most relevant journals to publish research in renewable energy and sustainable development. They have significantly increased the number of papers published in these fields in the last years. Furthermore, *Journal of Cleaner Production* ranks third in this classification.

This paper brings essential knowledge to academic, industrial, and political stakeholders, as all of them are, in some way, involved in issues related to sustainable development and renewable energy. A thorough review of the literature revealed the dynamics of the field under study over time. Regarding the practical contributions, some of the top ten countries that have conducted the most research in sustainable development and renewable energy are China and India, which rank 22nd and 5th in the classification of the world's most polluted countries but have significantly improved their levels of pollution from 2018 to 2021 (according to IQAir https://www.iqair.com/world-most-polluted-countries, accessed on 5 December 2022). This may serve as evidence of the importance of research

in improving the sustainability of socioeconomic development. Then, those countries with higher levels of pollution should invest in research to improve their environmental situation and the sustainability of their development strategies.

In this sense, it is necessary to emphasize the need for coordination and implementation of projects at the global level to homogenize, to some extent, the standard of practices in renewable energy to increase the probability of success of the efforts made in improving the sustainability of the development of today's society and economic activity and therefore the quality of life of the whole society. While some of the most developed and less polluted countries are well represented in the rankings and are therefore making great efforts in researching in this area, it is worth highlighting the case of China. This country is the first in the rankings on renewable energy and sustainable development, regarding the number of publications, citations, and collaborations, while also being among the most polluting countries in the world (Information extracted on 25 November 2022 from European Parliament News webpage: https://www.europarl.europa.eu/news/en/headlines/society/20180301STO98928/greenhouse-gas-emissions-by-country-and-sector-infographic). An explanation for this could be that there is a temporal gap between scientific production and the effective transition to a more sustainable development model. In fact, there is evidence of progress made by China in this area (information extracted from the World Bank webpage: https://openknowledge.worldbank.org/handle/10986/36668, accessed on 19 December 2022). Nevertheless, countries located in Africa, South America, or Southeast Asia seem to be lagging behind in terms of research in relation to this development process towards the implementation of renewable energy production models to boost the sustainability of socioeconomic development. It has been observed that the most relevant countries in terms of scientific production in the field of renewable energy and sustainable development are countries with a high degree of development, such as China, the United States of America, or various European countries, although among the main affiliations are also Iranian or Saudi Arabian universities.

In comparison with other areas, this is a relatively recent field of study, since the first publication of the database was 1991. Nevertheless, this field of study has experienced an astonishing increase in the number of publications since then. The number of articles published that year was 2, while 1399 articles were published in 2021 (an average annual growth of 34.08% in the number of publications, which has remained relatively stable over time). This is an impressive growth, especially in recent years, when the absolute value of publications is high, which shows the growing attention received from researchers. Moreover, this trend seems to have been maintained, since the number of papers published up to 23 November 2022 is 1568 (a growth of 12.08% in comparison to 2021 and with five weeks left in the year). This may be related to the increased concern on the part of all social, politic, and economic agents regarding the environmental sustainability of human action.

We are currently experiencing a crisis caused, to a large extent, by the control of traditional energy sources such as oil, gas, or coal. Therefore, the transition to renewable energy production systems could favor, in addition to a reduction in the environmental impact of the process, an increase in the degree of energy autonomy of countries. Considering the above, research trends seem to be directed towards managing the transition to a new, more sustainable energy model composed of renewable energy production systems, in addition to the adoption of new technologies to increase the efficiency of products and power transmission systems. To do so, knowledge sharing and interfirm cooperation with innovative purposes may be some of the most fruitful ways of accelerating the development and implementation of new technologies that favor the transition to new, more sustainable energy models [125–129]. Future research may enlarge the scope of this study and enhance its conclusions by gathering more data from other relevant sources.

Since we utilized specific words to search for the publications in renewable energy and sustainable development, and we used the Web of Science database, a large part of the most relevant works in this field has been included in this study, although it has not been possible to cover all the publications, for obvious reasons. In this vein, future research

could use, in addition to bibliometric tools, other techniques, such as factor and social network analysis, to reveal the current trends of research by analyzing the more recent publications, in addition to considering other relevant databases.

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References

1. Al-Mulali, U.; Tang, C.F.; Ozturk, I. Estimating the environment Kuznets curve hypothesis: Evidence from Latin America and the Caribbean countries. *Renew. Sustain. Energy Rev.* **2015**, *50*, 918–924. [CrossRef]
2. Doğan, B.; Driha, O.M.; Balsalobre Lorente, D.; Shahzad, U. The mitigating effects of economic complexity and renewable energy on carbon emissions in developed countries. *Sustain. Dev.* **2021**, *29*, 1–12. [CrossRef]
3. Fotis, P.; Polemis, M. Sustainable development, environmental policy and renewable energy use: A dynamic panel data approach. *Sustain. Dev.* **2018**, *26*, 726–740. [CrossRef]
4. Kahia, M.; Aïssa, M.S.B.; Lanouar, C. Renewable and non-renewable energy use-economic growth nexus: The case of MENA Net Oil Importing Countries. *Renew. Sustain. Energy Rev.* **2017**, *71*, 127–140. [CrossRef]
5. Brent, A.C. Renewable Energy for Sustainable Development. *Sustainability* **2021**, *13*, 6920. [CrossRef]
6. Lanouar, C.; Al-Malk, A.Y.; Al Karbi, K. Air pollution in Qatar: Causes and challenges. *White Pap.* **2016**, *1*, 1–7.
7. Amran, A.; Periasamy, V.; Zulkafli, A.H. Determinants of climate change disclosure by developed and emerging countries in Asia Pacific. *Sustain. Dev.* **2014**, *22*, 188–204. [CrossRef]
8. Jaforullah, M.; King, A. Does the use of renewable energy sources mitigate CO2 emissions? A reassessment of the US evidence. *Energy Econ.* **2015**, *49*, 711–717. [CrossRef]
9. Sathaye, J.; Shukla, P.R.; Ravindranath, N.H. Climate change, sustainable development and India: Global and national concerns. *Curr. Sci.* **2006**, *90*, 314–325.
10. Cardenas, L.M.; Franco, C.J.; Dyner, I. Assessing emissions–mitigation energy policy under integrated supply and demand analysis: The Colombian case. *J. Clean. Prod.* **2016**, *112*, 3759–3773. [CrossRef]
11. Lu, Y.; Khan, Z.A.; Alvarez-Alvarado, M.S.; Zhang, Y.; Huang, Z.; Imran, M. A Critical Review of Sustainable Energy Policies for the Promotion of Renewable Energy Sources. *Sustainability* **2020**, *12*, 5078. [CrossRef]
12. Razmjoo, A.; Rezaei, M.; Mirjalili, S.; Majidi Nezhad, M.; Piras, G. Development of Sustainable Energy Use with Attention to Fruitful Policy. *Sustainability* **2021**, *13*, 13840. [CrossRef]
13. Musiał, W.; Zioło, M.; Luty, L.; Musiał, K. Energy Policy of European Union Member States in the Context of Renewable Energy Sources Development. *Energies* **2021**, *14*, 2864. [CrossRef]
14. Adebayo, T.S.; Awosusi, A.A.; Adeshola, I. Determinants of CO2 emissions in emerging markets: An empirical evidence from MINT economies. *Int. J. Renew. Energy Dev.* **2020**, *9*, 411. [CrossRef]
15. Shahbaz, M.; Haouas, I.; Sohag, K.; Ozturk, I. The financial development-environmental degradation nexus in the United Arab Emirates: The importance of growth, globalization and structural breaks. *Environ. Sci. Pollut. Res.* **2020**, *27*, 10685–10699. [CrossRef]
16. Shahzad, U.; Radulescu, M.; Rahim, S.; Isik, C.; Yousaf, Z.; Ionescu, S.A. Do Environment-Related Policy Instruments and Technologies Facilitate Renewable Energy Generation? Exploring the Contextual Evidence from Developed Economies. *Energies* **2021**, *14*, 690. [CrossRef]
17. Bhattacharya, M.; Churchill, S.A.; Paramati, S.R. The dynamic impact of renewable energy and institutions on economic output and CO_2 emissions across regions. *Renew. Energy* **2017**, *111*, 157–167. [CrossRef]
18. Brazovskaia, V.; Gutman, S.; Zaytsev, A. Potential Impact of Renewable Energy on the Sustainable Development of Russian Arctic Territories. *Energies* **2021**, *14*, 3691. [CrossRef]
19. Žičkienė, A.; Morkunas, M.; Volkov, A.; Balezentis, T.; Streimikiene, D.; Siksnelyte-Butkiene, I. Sustainable Energy Development and Climate Change Mitigation at the Local Level through the Lens of Renewable Energy: Evidence from Lithuanian Case Study. *Energies* **2022**, *15*, 980. [CrossRef]
20. Kung, C.C.; McCarl, B.A. Sustainable Energy Development under Climate Change. *Sustainability* **2018**, *10*, 3269. [CrossRef]
21. OECD Economic Outlook No. 91. 2013, pp. 499–533. Available online: https://www.oecd.org/ (accessed on 22 November 2022). [CrossRef]

22. Androniceanu, A.; Sabie, O.M. Overview of Green Energy as a Real Strategic Option for Sustainable Development. *Energies* **2022**, *15*, 8573. [CrossRef]
23. Ponkratov, V.V.; Kuznetsov, A.S.; Muda, I.; Nasution, M.J.; Al-Bahrani, M.; Aybar, H.Ş. Investigating the Index of Sustainable Development and Reduction in Greenhouse Gases of Renewable Energies. *Sustainability* **2022**, *14*, 14829. [CrossRef]
24. Blazejczak, J.; Braun, F.G.; Edler, D.; Schill, W.P. Economic effects of renewable energy expansion: A model-based analysis for Germany. *Renew. Sustain. Energy Rev.* **2014**, *40*, 1070–1080. [CrossRef]
25. Dai, H.; Xie, X.; Xie, Y.; Liu, J.; Masui, T. Green growth: The economic impacts of large-scale renewable energy development in China. *Appl. Energy* **2016**, *162*, 435–449. [CrossRef]
26. Spiegel-Feld, D.; Rudyk, B.; Philippidis, G. Allocating the economic benefits of renewable energy between stakeholders on Small Island Developing States (SIDS): Arguments for a balanced approach. *Energy Policy* **2016**, *98*, 744–748. [CrossRef]
27. Tomala, J.; Mierzejewski, M.; Urbaniec, M.; Martinez, S. Towards Sustainable Energy Development in Sub-Saharan Africa: Challenges and Opportunities. *Energies* **2021**, *14*, 6037. [CrossRef]
28. Marco-Lajara, B.; Sánchez-García, E.; Martínez-Falcó, J.; Poveda-Pareja, E. Regional Specialization, Competitive Pressure, and Cooperation: The Cocktail for Innovation. *Energies* **2022**, *15*, 5346. [CrossRef]
29. Arora, S.D.; Chakraborty, A. Intellectual structure of consumer complaining behavior (CCB) research: A bibliometric analysis. *J. Bus. Res.* **2021**, *122*, 60–74. [CrossRef]
30. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G.; Altman, D.; Antes, G.; Tugwell, P. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *J. Chin. Integr. Med.* **2009**, *7*, 889–896. [CrossRef]
31. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Syst. Rev.* **2021**, *10*, 89. [CrossRef]
32. Grosseck, G.; Țîru, L.G.; Bran, R.A. Education for sustainable development: Evolution and perspectives: A bibliometric review of research, 1992–2018. *Sustainability* **2019**, *11*, 6136. [CrossRef]
33. Pham, H.H.; Dong, T.K.T.; Vuong, Q.H.; Luong, D.H.; Nguyen, T.T.; Dinh, V.H.; Ho, M.T. A bibliometric review of research on international student mobilities in Asia with Scopus dataset between 1984 and 2019. *Scientometrics* **2021**, *126*, 5201–5224. [CrossRef]
34. Thukral, S.; Jain, A. Unveiling contemporary dimensions in the internationalisation of family firms through bibliometric analysis and thematic analysis. *Rev. Int. Bus. Strategy* **2021**, *31*, 507–539. [CrossRef]
35. Fauzi, M.A. Knowledge hiding behavior in higher education institutions: A scientometric analysis and systematic literature review approach. *J. Knowl. Manag.* 2022, *Ahead of print*. [CrossRef]
36. Kim, H.; So, K.K.F. Two decades of customer experience research in hospitality and tourism: A bibliometric analysis and thematic content analysis. *Int. J. Hosp. Manag.* **2022**, *100*, 103082. [CrossRef]
37. Merton, R.K. *The Sociology of Science: Theoretical and Empirical Investigations*; University of Chicago Press: Chicago, IL, USA, 1973.
38. Richard, J.; Pillemer, D.B.; Light, R.J. *Summing Up: The Science of Reviewing Research*; Harvard University Press: Cambridge, MA, USA, 2009. [CrossRef]
39. Ordanini, A.; Rubera, G.; DeFillippi, R. The many moods of inter-organizational imitation: A critical review. *Int. J. Manag. Rev.* **2008**, *10*, 375–398. [CrossRef]
40. Rousseau, R. Forgotten founder of bibliometrics. *Nature* **2014**, *510*, 218. [CrossRef]
41. Schaer, P. Applied informetrics for digital libraries: An overview of foundations, problems and current approaches. *Hist. Soc. Res.* **2013**, *38*, 267–281.
42. Kokol, P.; Vošner, H.B. Historical, descriptive and exploratory analysis of application of bibliometrics in nursing research. *Nurs. Outlook* **2019**, *67*, 680–695. [CrossRef]
43. Li, C.; Wu, K.; Wu, J. A bibliometric analysis of research on haze during 2000–2016. *Environ. Sci. Pollut. Res.* **2017**, *24*, 24733–24742. [CrossRef]
44. Li, X.; Ma, E.; Qu, H. Knowledge mapping of hospitality research − A visual analysis using CiteSpace. *Int. J. Hosp. Manag.* **2017**, *60*, 77–93. [CrossRef]
45. Paul, J.; Benito, G.R. A review of research on outward foreign direct investment from emerging countries, including China: What do we know, how do we know and where should we be heading? *Asia Pac. Bus. Rev.* **2018**, *24*, 90–115. [CrossRef]
46. Hao, A.W.; Paul, J.; Trott, S.; Guo, C.; Wu, H.H. Two decades of research on nation branding: A review and future research agenda. *Int. Mark. Rev.* **2019**, *38*, 46–69. [CrossRef]
47. Pattnaik, D.; Hassan, M.K.; Kumar, S.; Paul, J. Trade credit research before and after the global financial crisis of 2008—A bibliometric overview. *Res. Int. Bus. Financ.* **2020**, *54*, 101287. [CrossRef]
48. Aria, M.; Cuccurullo, C. Bibliometrix: An R-tool for comprehensive science mapping analysis. *J. Informetr.* **2017**, *11*, 959–975. [CrossRef]
49. Martínez-López, F.J.; Merigó, J.M.; Valenzuela-Fernández, L.; Nicolás, C. Fifty years of the European Journal of Marketing: A bibliometric analysis. *Eur. J. Mark.* **2018**, *52*, 439–468. [CrossRef]
50. Donthu, N.; Kumar, S.; Pattnaik, D. Forty-five years of Journal of Business Research: A bibliometric analysis. *J. Bus. Res.* **2020**, *109*, 1–14. [CrossRef]

51. Goyal, K.; Kumar, S. Financial literacy: A systematic review and bibliometric analysis. *Int. J. Consum. Stud.* **2021**, *45*, 80–105. [CrossRef]
52. Hsieh, P.N.; Chang, P.L. An assessment of world-wide research productivity in production and operations management. *Int. J. Prod. Econ.* **2009**, *120*, 540–551. [CrossRef]
53. Ozturk, I.; Acaravci, A. Electricity consumption and real GDP causality nexus: Evidence from ARDL bounds testing approach for 11 MENA countries. *Appl. Energy* **2011**, *88*, 2885–2892. [CrossRef]
54. Tugcu, C.T.; Ozturk, I.; Aslan, A. Renewable and non-renewable energy consumption and economic growth relationship revisited: Evidence from G7 countries. *Energy Econ.* **2012**, *34*, 1942–1950. [CrossRef]
55. Soytas, U.; Sari, R. Energy consumption and GDP: Causality relationship in G-7 countries and emerging markets. *Energy Econ.* **2003**, *25*, 33–37. [CrossRef]
56. Oguz, O.C.A.L.; Ozturk, I.; Aslan, A. Coal consumption and economic growth in Turkey. *Int. J. Energy Econ. Policy* **2013**, *3*, 193–198.
57. Sinha, A. Modeling energy efficiency and economic growth: Evidences from India. *Int. J. Energy Econ. Policy* **2015**, *5*, 96–104.
58. Apergis, N.; Danuletiu, D.C. Renewable energy and economic growth: Evidence from the sign of panel long-run causality. *Int. J. Energy Econ. Policy* **2014**, *4*, 578–587.
59. Apergis, N.; Payne, J.E. Renewable energy consumption and growth in Eurasia. *Energy Econ.* **2010**, *32*, 1392–1397. [CrossRef]
60. Bozkurt, C.; Destek, M.A. Renewable energy and sustainable development nexus in selected OECD countries. *Int. J. Energy Econ. Policy* **2015**, *5*, 507–514.
61. Bilgili, F.; Koçak, E.; Bulut, Ü.; Kuşkaya, S. Can biomass energy be an efficient policy tool for sustainable development? *Renew. Sustain. Energy Rev.* **2017**, *71*, 830–845. [CrossRef]
62. Song, C. Global challenges and strategies for control, conversion and utilization of CO2 for sustainable development involving energy, catalysis, adsorption and chemical processing. *Catal. Today* **2006**, *115*, 2–32. [CrossRef]
63. Gielen, D.; Boshell, F.; Saygin, D.; Bazilian, M.D.; Wagner, N.; Gorini, R. The role of renewable energy in the global energy transformation. *Energy Strategy Rev.* **2019**, *24*, 38–50. [CrossRef]
64. Wang, W.; Luo, Q.; Li, B.; Wei, X.; Li, L.; Yang, Z. Recent progress in redox flow battery research and development. *Adv. Funct. Mater.* **2013**, *23*, 970–986. [CrossRef]
65. Dunn, S. Hydrogen futures: Toward a sustainable energy system. *Int. J. Hydrogen Energy* **2002**, *27*, 235–264. [CrossRef]
66. Kuhl, K.P.; Hatsukade, T.; Cave, E.R.; Abram, D.N.; Kibsgaard, J.; Jaramillo, T.F. Electrocatalytic conversion of carbon dioxide to methane and methanol on transition metal surfaces. *J. Am. Chem. Soc.* **2014**, *136*, 14107–14113. [CrossRef]
67. Olah, G.A.; Prakash, G.S.; Goeppert, A. Anthropogenic chemical carbon cycle for a sustainable future. *J. Am. Chem. Soc.* **2011**, *133*, 12881–12898. [CrossRef]
68. Lund, H. Renewable energy strategies for sustainable development. *Energy* **2007**, *32*, 912–919. [CrossRef]
69. Devine-Wright, P. Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *J. Community Appl. Soc. Psychol.* **2009**, *19*, 426–441. [CrossRef]
70. McLaughlin, S.B.; Kszos, L.A. Development of switchgrass (Panicum virgatum) as a bioenergy feedstock in the United States. *Biomass Bioenergy* **2005**, *28*, 515–535. [CrossRef]
71. Ursua, A.; Gandia, L.M.; Sanchis, P. Hydrogen production from water electrolysis: Current status and future trends. *Proc. IEEE* **2011**, *100*, 410–426. [CrossRef]
72. Bekun, F.V.; Alola, A.A.; Sarkodie, S.A. Toward a sustainable environment: Nexus between CO_2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries. *Sci. Total Environ.* **2019**, *657*, 1023–1029. [CrossRef]
73. Alola, A.A.; Bekun, F.V.; Sarkodie, S.A. Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe. *Sci. Total Environ.* **2019**, *685*, 702–709. [CrossRef]
74. Sarkodie, S.A.; Strezov, V. Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Sci. Total Environ.* **2019**, *646*, 862–871. [CrossRef]
75. Zafar, M.W.; Shahbaz, M.; Hou, F.; Sinha, A. From nonrenewable to renewable energy and its impact on economic growth: The role of research & development expenditures in Asia-Pacific Economic Cooperation countries. *J. Clean. Prod.* **2019**, *212*, 1166–1178. [CrossRef]
76. Danish, K.; Ulucak, R.; Khan, S.U.D. Determinants of the ecological footprint: Role of renewable energy, natural resources, and urbanization. *Sustain. Cities Soc.* **2020**, *54*, 101996. [CrossRef]
77. Khan, Z.; Ali, S.; Umar, M.; Kirikkaleli, D.; Jiao, Z. Consumption-based carbon emissions and international trade in G7 countries: The role of environmental innovation and renewable energy. *Sci. Total Environ.* **2020**, *730*, 138945. [CrossRef] [PubMed]
78. Inglesi-Lotz, R. The impact of renewable energy consumption to economic growth: A panel data application. *Energy Econ.* **2016**, *53*, 58–63. [CrossRef]
79. Kuznets, S.; Noris, P. What was true about monarchy more than government [because] the mass of mankind understand it and they hardly anywhere in the world understand any other. *Am. Econ. Rev.* **1955**, *45*, 1–28.
80. Dogan, E.; Turkekul, B. CO_2 emissions, real output, energy consumption, trade, urbanization and financial development: Testing the EKC hypothesis for the USA. *Environ. Sci. Pollut. Res.* **2016**, *23*, 1203–1213. [CrossRef]

81. Pao, H.T.; Tsai, C.M. Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy* **2011**, *36*, 685–693. [CrossRef]
82. Dincer, I. Renewable energy and sustainable development: A crucial review. *Renew. Sustain. Energy Rev.* **2000**, *4*, 157–175. [CrossRef]
83. Wüstenhagen, R.; Wolsink, M.; Bürer, M.J. Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy* **2007**, *35*, 2683–2691. [CrossRef]
84. Walker, G.; Devine-Wright, P. Community renewable energy: What should it mean? *Energy Policy* **2008**, *36*, 497–500. [CrossRef]
85. Engle, R.F.; Granger, C.W. Co-integration and error correction: Representation, estimation, and testing. *Econom. J. Econom. Soc.* **1987**, *55*, 251–276. [CrossRef]
86. Grossman, G.M.; Krueger, A.B. Economic growth and the environment. *Q. J. Econ.* **1995**, *110*, 353–377. [CrossRef]
87. Balsalobre-Lorente, D.; Shahbaz, M.; Roubaud, D.; Farhani, S. How economic growth, renewable electricity and natural resources contribute to CO2 emissions? *Energy Policy* **2018**, *113*, 356–367. [CrossRef]
88. Bilgili, F.; Koçak, E.; Bulut, Ü. The dynamic impact of renewable energy consumption on CO_2 emissions: A revisited Environmental Kuznets Curve approach. *Renew. Sustain. Energy Rev.* **2016**, *54*, 838–845. [CrossRef]
89. Grossman, G.M.; Helpman, E. *Innovation and Growth in the Global Economy*; MIT Press: Cambridge, MA, USA, 1993.
90. Destek, M.A.; Sinha, A. Renewable, non-renewable energy consumption, economic growth, trade openness and ecological footprint: Evidence from organisation for economic co-operation and development countries. *J. Clean. Prod.* **2020**, *242*, 118537. [CrossRef]
91. Pesaran, M.H.; Shin, Y.; Smith, R.J. Bounds testing approaches to the analysis of level relationships. *J. Appl. Econom.* **2001**, *16*, 289–326. [CrossRef]
92. Danish, K.; Baloch, M.A.; Mahmood, N.; Zhang, J.W. Effect of natural resources, renewable energy and economic development on CO2 emissions in BRICS countries. *Sci. Total Environ.* **2019**, *678*, 632–638. [CrossRef]
93. Shahbaz, M.; Nasir, M.A.; Roubaud, D. Environmental degradation in France: The effects of FDI, financial development, and energy innovations. *Energy Econ.* **2018**, *74*, 843–857. [CrossRef]
94. Shahbaz, M.; Hye, Q.M.A.; Tiwari, A.K.; Leitão, N.C. Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. *Renew. Sustain. Energy Rev.* **2013**, *25*, 109–121. [CrossRef]
95. Chen, Y.; Wang, Z.; Zhong, Z. CO2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. *Renew. Energy* **2019**, *131*, 208–216. [CrossRef]
96. Destek, M.A.; Sarkodie, S.A. Investigation of environmental Kuznets curve for ecological footprint: The role of energy and financial development. *Sci. Total Environ.* **2019**, *650*, 2483–2489. [CrossRef] [PubMed]
97. Shahbaz, M.; Van Hoang, T.H.; Mahalik, M.K.; Roubaud, D. Energy consumption, financial development and economic growth in India: New evidence from a nonlinear and asymmetric analysis. *Energy Econ.* **2017**, *63*, 199–212. [CrossRef]
98. Dogan, E.; Seker, F. Determinants of CO2 emissions in the European Union: The role of renewable and non-renewable energy. *Renew. Energy* **2016**, *94*, 429–439. [CrossRef]
99. Charfeddine, L.; Kahia, M. Impact of renewable energy consumption and financial development on CO_2 emissions and economic growth in the MENA region: A panel vector autoregressive (PVAR) analysis. *Renew. Energy* **2019**, *139*, 198–213. [CrossRef]
100. Pata, U.K. Renewable energy consumption, urbanization, financial development, income and CO_2 emissions in Turkey: Testing EKC hypothesis with structural breaks. *J. Clean. Prod.* **2018**, *187*, 770–779. [CrossRef]
101. Phillips, P.C.; Perron, P. Testing for a unit root in time series regression. *Biometrika* **1988**, *75*, 335–346. [CrossRef]
102. Adedoyin, F.F.; Gumede, M.I.; Bekun, F.V.; Etokakpan, M.U.; Balsalobre-Lorente, D. Modelling coal rent, economic growth and CO2 emissions: Does regulatory quality matter in BRICS economies? *Sci. Total Environ.* **2020**, *710*, 136284. [CrossRef]
103. Dickey, D.A.; Fuller, W.A. Distribution of the estimators for autoregressive time series with a unit root. *J. Am. Stat. Assoc.* **1979**, *74*, 427–431. [CrossRef]
104. Adebayo, T.S.; Kirikkaleli, D. Impact of renewable energy consumption, globalization, and technological innovation on environmental degradation in Japan: Application of wavelet tools. *Environ. Dev. Sustain.* **2021**, *23*, 16057–16082. [CrossRef]
105. Im, K.S.; Pesaran, M.H.; Shin, Y. Testing for unit roots in heterogeneous panels. *J. Econom.* **2003**, *115*, 53–74. [CrossRef]
106. Pedroni, P. Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econom. Theory* **2004**, *20*, 597–625. [CrossRef]
107. Apergis, N.; Payne, J.E. Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy* **2010**, *38*, 656–660. [CrossRef]
108. Pedroni, P. Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxf. Bull. Econ. Stat.* **1999**, *61*, 653–670. [CrossRef]
109. Levin, A.; Lin, C.F.; Chu, C.S.J. Unit root tests in panel data: Asymptotic and finite-sample properties. *J. Econom.* **2002**, *108*, 1–24. [CrossRef]
110. Pesaran, M.H.; Shin, Y.; Smith, R.P. Pooled mean group estimation of dynamic heterogeneous panels. *J. Am. Stat. Assoc.* **1999**, *94*, 621–634. [CrossRef]
111. Kao, C. Spurious regression and residual-based tests for cointegration in panel data. *J. Econom.* **1999**, *90*, 1–44. [CrossRef]

112. Bhattacharya, M.; Paramati, S.R.; Ozturk, I.; Bhattacharya, S. The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Appl. Energy* **2016**, *162*, 733–741. [CrossRef]
113. Pesaran, M.H. A simple panel unit root test in the presence of cross-section dependence. *J. Appl. Econom.* **2007**, *22*, 265–312. [CrossRef]
114. Dumitrescu, E.I.; Hurlin, C. Testing for Granger non-causality in heterogeneous panels. *Econ. Model.* **2012**, *29*, 1450–1460. [CrossRef]
115. Pesaran, M.H. General diagnostic tests for cross-sectional dependence in panels. *Empir. Econ.* **2021**, *60*, 13–50. [CrossRef]
116. Westerlund, J. Testing for error correction in panel data. *Oxf. Bull. Econ. Stat.* **2007**, *69*, 709–748. [CrossRef]
117. Breusch, T.S.; Pagan, A.R. The Lagrange multiplier test and its applications to model specification in econometrics. *Rev. Econ. Stud.* **1980**, *47*, 239–253. [CrossRef]
118. Alvarez-Herranz, A.; Balsalobre-Lorente, D.; Shahbaz, M.; Cantos, J.M. Energy innovation and renewable energy consumption in the correction of air pollution levels. *Energy Policy* **2017**, *105*, 386–397. [CrossRef]
119. Pesaran, M.H.; Yamagata, T. Testing slope homogeneity in large panels. *J. Econom.* **2008**, *142*, 50–93. [CrossRef]
120. Callon, M.; Courtial, J.P.; Laville, F. Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemistry. *Scientometrics* **1991**, *22*, 155–205. [CrossRef]
121. Cobo, M.J.; López-Herrera, A.G.; Herrera-Viedma, E.; Herrera, F. An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field. *J. Informetr.* **2011**, *5*, 146–166. [CrossRef]
122. Grivel, L.; Mutschke, P.; Polanco, X. Thematic mapping on bibliographic databases by cluster analysis: A description of the SDOC environment with SOLIS. *J. Knowl. Organ.* **1995**, *22*, 70–77.
123. Nasir, A.; Shaukat, K.; Hameed, I.A.; Luo, S.; Alam, T.M.; Iqbal, F. A bibliometric analysis of corona pandemic in social sciences: A review of influential aspects and conceptual structure. *IEEE Access* **2020**, *8*, 133377–133402. [CrossRef]
124. Rejeb, A.; Rejeb, K.; Abdollahi, A.; Treiblmaier, H. The big picture on Instagram research: Insights from a bibliometric analysis. *Telemat. Inform.* **2022**, *73*, 101876. [CrossRef]
125. Claver-Cortés, E.; Marco-Lajara, B.; Sánchez-García, E.; Seva-Larrosa, P.; Manresa-Marhuenda, E.; Ruiz-Fernández, L.; Poveda-Pareja, E. A Literature Review on the Effect of Industrial Clusters and the Absorptive Capacity on Innovation. *Int. J. Ind. Manuf. Eng.* **2020**, *14*, 494–503. [CrossRef]
126. Sánchez-García, E. Aglomeración Industrial, Capital Social y Capacidad de Absorción como Impulsores del Desempeño Innovador y Empresarial: Una aplicación al Sector de Suministro de Energía eléctrica, Gas, Vapor y Aire Acondicionado en España. Ph.D. Thesis, Universidad de Alicante, Alicente, Spain, 2021. [CrossRef]
127. Marco-Lajara, B.; Zaragoza-Sáez, P.; Martínez-Falcó, J.; Sánchez-García, E. Green Intellectual Capital in the Spanish Wine Industry. In *Innovative Economic, Social, and Environmental Practices for Progressing Future Sustainability*, 1st ed.; Marco-Lajara, B., Zaragoza-Sáez, P., Martínez-Falcó, J., Sánchez-García, E., Eds.; IGI Global: Hershey, PA, USA, 2022; pp. 102–120. [CrossRef]
128. Pizoń, J.; Cioch, M.; Kański, Ł.; Sánchez-García, E. Cobots implementation in the era of Industry 5.0 using modern business and management solutions. *Adv. Sci. Technol. Res. J.* **2022**, *16*, 166–178. [CrossRef]
129. Marco-Lajara, B.; Zaragoza-Sáez, P.C.; Martínez-Falcó, J.; Sánchez-García, E. Does green intellectual capital affect green innovation performance? Evidence from the Spanish wine industry. *Br. Food J.* 2022, *ahead-of-print*. [CrossRef]