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A survey on energy justice: a critical review of the literature

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ABSTRACT

The increasing scarcity of resources and the escalating complexity of reality make the fairness ensuring in energy activities even more difficult. In this context, energy justice, as an emerging cross-field, tries to provide solutions based on practical problems. In the face of the surge of energy justice publications, it is necessary to review them in time, so that we can comprehend the significant achievements and the research directions worthy of further exploration. With the help of visualization tools, this paper conducts a comprehensive quantitative analysis of 1,910 energy justice publications. Based on the results, we reach the following main conclusions: (1) The energy justice publications have only emerged rapidly in recent years; (2) The research hotspots are closely related to the renewable energy transition; (3) The distribution of prominent contributors in this field is relatively concentrated. The main contribution of this study is to comprehensively display the essential characteristics of the literature in this field, such as the evolutions of research themes and the performances of research contributors in different dimensions, so as to provide readers with an effective way to understand the knowledge structure in this field, and help related researchers rationally examine the existing results.

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1. Introduction

Every era is full of challenges and the situation will take on an increasingly complex character. This is mainly due to the fact that natural resources are gradually depleted and the environments are becoming more hostile. Such a situation urges us to look for clean, low-carbon, renewable alternative energy (Levenda et al., 2021) and sustainable development models (Li & Li, 2019). For instance, based on the grey relational analysis, Wei et al. (2020) applied the multi-attribute group decision making method to the case of siting of electric vehicle charging stations. Hasheminasab et al. (2022) sought the most sustainable fossil fuel options in concrete practice, on the basis of

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circular economy ideas and decision-making techniques. Meanwhile, the development of science and technology has reached an unprecedented new height, and the understanding of environmental protection and humanistic care has become sober and more profound.

Instead of blindly pursuing economic prosperity at the cost of sacrificing the living environment and consuming excessive resources, we have begun to think about the mutual constraints between economic growth, environmental protection and social issues, and have been attempting to find a balance between them. For example, Khoshnevis Yazdi and Golestani Dariani (2019) used empirical analysis to delve into the causal relationships between energy consumption, urbanisation, economic growth and CO_2 emissions in Asian countries over a certain period of time. Huang et al. (2022) explored the short- and long-term impacts of green energy, human capital, and sustainable economic growth on carbon emissions in emerging economies; Lei et al. (2022) probed into the asymmetry effects of financial deepening on non-renewable and renewable energy consumption based on yearly data from China. Clearly, energy-related issues have become a top priority (Batrancea et al., 2019).

We show solicitude for equity in energy activities, especially when it comes to marginalized populations, and place increasing emphasis on developing metrics that are universal. In this context, energy justice (EJ) with obvious social attributes has aroused significant concerns and is growing rapidly at this juncture (Jenkins et al., 2018). Scholars have carried out plenty of studies in this field. Pellegrini-Masini et al. (2020) traced the philosophical and political roots of EJ theory to strengthen the concept of EJ and improve its applicability in policy making. van Bommel and Höffken (2021) provided an in-depth look at community EJ and dialectically discussed the impact of community energy initiative on energy transition. Ciplet (2021) proposed an application framework that integrates the concepts of sustainable development and EJ, which could be used to assess the fairness of certain energy activities. Whether it is theoretical research or practical exploration, the number of corresponding relevant publications is swiftly accumulating.

As an emerging cross-field, EJ is enlightened by environmental justice (LaBelle, 2017) and climate justice (Heffron & McCauley, 2017). Meanwhile, it is advancing side by side with energy security (Jenkins et al., 2016), energy democracy, and energy transition (van de Poel & Taebi, 2022), etc. Therefore, EJ owns rich and complex connotations. Unlike other justice models and energy topics, EJ owns its own uniqueness and shoulders different responsibilities (Jenkins, 2018). We need to comprehend the kernel of EJ, i.e., the conceptual framework, which contains definitions, principles, methodology, and disciplinary composition. Moreover, we should keep a watchful eye on the research results in related fields. Although demands inside and outside the field have created conditions for the explosive growth of the number of EJ documents in recent years, the more rapid the expansion, the more vigilant and sober one must be. With the accumulation of practical experience and theoretical research, it is indispensable and significant to systematically review and reflect on the existing achievements in the field. For instance, Sovacool and Dworkin (2015) reviewed in detail how EJ as a conceptual tool can help decision makers in practical applications; Jenkins et al. (2021) and Jenkins et al. (2020) reflected on the current status of research in

this field and put forward targeted suggestions for future exploration. This type of work is able to reinforce the drive for fruitful and promising research directions, while adjusting or removing work contents of duplication and inefficiencies on time.

The subject's attractiveness endowed by fitting the themes of the times and responding to actual needs, as well the reflective thinking trained in objective retrospective and critical reflection on the past course, are the necessary conditions for this field to mature.

For this purpose, we conceive of reviewing a large number of publications on EJ so far and using visual tools to conduct a bibliometric analysis further to observe its development trajectory from the quantitative analysis results. To be specific, we perform this research by carrying the expectation and determination of contributing in the following four aspects: (1) Present the basic quantitative characteristics and annual trends of EJ publications, thus reflecting the development tendency and prosperity degree of this field. (2) Investigate the topic change and thematic distribution of EJ, so that the research hotspots over the years and the way forward in the near term can be grasped. (3) Analyse the citations of EJ publications so as to understand their quality performance and peer recognition. (4) Identify outstanding contributors in EJ publications from different perspectives.

To accomplish these tasks, the rest of this paper is organized as follows: Section 2 mainly reviews the three core principles of EJ and related important literature. Section 3 introduces the required preparations for visual analysis of EJ literature from data acquisition and analysis strategy. In Section 4, we divide the bibliometric analysis into 5 subsections, which comprehensively cover the characteristics of EJ literature in terms of quantity and growth trend, the distribution of hot topics and themes, and the structure of literature citations, etc. Section 5 discusses in detail the key features of EJ reflected in the quantitative analysis. Finally, we evaluate the work done in this paper and express our expectations for the future development of EJ in Section 6.

2. Theoretical framework

There are three core concepts in EJ, namely distributional justice, procedural justice and recognition justice (McCauley et al., 2013). Although other significant principles such as restorative justice and cosmopolitanism justice have also received attention with the in-depth research and enrichment of connotations, the three original tenets are still the key entry points to understand the field of EJ. Distributional justice concerns the equal distribution of the benefits and burdens brought by energy activities among stakeholders (Hu, 2020). Procedural justice emphasizes developing and improving energy-related decision-making steps and processes to ensure fair and equal participation by all stakeholders (Hazrati & Heffron, 2021). Recognition justice focuses on identifying and understanding the specific needs of different groups (minorities, older people, women, marginalized people, etc.) in terms of energy services (Lee & Byrne, 2019).

These three tenets have been keeping pace with the changing times. There are numerous documents recording this long process and reflecting the transformation of expectations and responsibilities carried by the EJ field in reality. Gurney et al. (2021)

discussed distributional justice in environmental governance by taking the distribution of benefits in a co-managed marine protected area in Fiji as an example, and concluded that concepts of distributional fairness need to be further identified and understood in relevant events. Marlin-Tackie et al. (2020) examined the EJ dimensions embodied in Memorandums of Understanding in Colorado community conflict, and highlighted the importance of the daily practices of government representatives in recognition and procedural justice promotion. According to the different contents and demands of each principle, various studies may only select one or two relatively more suitable ones among them for discussion or expansion when faced with distinct practical scenarios. However, we must be aware that all the principles contained in EJ are in fact closely related and mutually reinforcing.

After a preliminary understanding of the three core tenets of EJ, we see that this field involves the weighing of multiple dimensions such as society, law, ethics, and environment. Apparently, this situation arises in large part from its roots in environmental justice as well as climate justice and its incorporation of social justice elements (Lacey-Barnacle et al., 2020). There are scholars promoting the improvement of the theoretical framework of EJ by exploring those connections (Galvin, 2020), while others are comprehensively applying knowledge in multiple justice fields to solve practical problems. For example, Hess et al. (2022) drew on EJ and environmental justice research to analyse 70 practical cases against energy infrastructure construction.

The world is suffering from the dual dilemma of population surge and resource reduction (Afzal et al., 2022). Researchers in the field have always been inquiring whether the actions in energy issue are just or not and working on exploring how to formulate corresponding guarantee measures of fairness. In most cases, these discussions are closely linked to energy-related scenarios such as energy poverty, energy democracy, and energy transitions. Setyowati (2021) investigated the efforts of Indonesia, which has an energy poverty challenge, to achieve an EJ vision in low-carbon energy transition. McCauley et al. (2019) depicted the EJ framework and provided key insights into the energy transition, making it clear that EJ issues must be considered in the transition process.

Evidently, EJ incorporates a large number of multi-domain concepts and theories, and continues to develop and evolve based on complex realities. The transformation of sustainable development around the world has stimulated the explosion of EJ literature, and it is vital to carefully examine the quality and contribution of the existing research. Our task consists of taking an objective view of the current state of the field and looking ahead to future directions accordingly.

3. Methodology

Bibliometrics, as a systematic tool for the analysis of scientific data, has shown itself to be increasingly powerful in reviewing, exploring and interpreting the multidimensional characteristics possessed by the vast amount of literature in a given field with advances in information technology (Zhang et al., 2021). The popularity of bibliometric analysis in recent years has provided researchers in various fields with a

convenient and effective way to explore the intellectual edifice. Donthu et al. (2021) comprehensively reviewed and summarized the purposes, frameworks and procedures used in bibliometric analysis based on this reality. It inspires us to choose bibliometric analysis as the basic analytical methods to explore and expound the fast growing and accumulating body of publications in the field of EJ.

There are numerous EJ-related publications covering a wide range of topics. This study attempts to capture the hotspots and other significant characteristics of the available research in the field as a whole without losing details, which is in line with the guidelines for the application of bibliometric analysis. We therefore consider it to be the relatively most appropriate method for our study. Next, we would describe in detail the methodology used in this paper, both in terms of data acquisition and analysis strategy.

3.1. Data acquisition

Reliable analytical results cannot be divorced from scrupulously collecting and selecting data from the outset. As a powerful aid to academic research, Web of Science Core Collection is one of the most authoritative bibliographic databases in the world and has been widely used to document high-quality academic research in a wide range of fields (Liu, 2021). For instance, based on literature data obtained from the Web of Science Core Collection database, Huang et al. (2020) and Xu et al. (2020) both conducted scientometric analyses on the topics of forest carbon sequestration and disruption risk in supply chain management respectively.

At the same time, the two aspects that need to be considered when accessing to EJ-related literature, quality and quantity, are both well met by the Web of Science Core Collection. EJ has developed rapidly in recent years and the very large amount of relevant publications included in the WoS. It means that we can gather sufficient data for quantitative analysis from WoS to ensure the possibility of studying the current state of development of the field from a macro perspective. Moreover, EJ, as an emerging cross-cutting field, is widely involved in multiple directions of exploration. This is actually well reflected in the bibliometric analysis process of the selected literature from WoS in this study.

Therefore, we choose Web of Science (WoS) as the data source after comprehensively considering three aspects: authority, information richness, and compatibility with various bibliometric analysis software tools. Then, we search through the WoS to get 1952 EJ-related documents published from 1900 to January 14, 2022. To be specific, we use the following settings for data collection in the Web of Science Core Collection database, Topic= "energy justice", Publication date = "All years (1900-2022)". Simple keyword identification would inevitably cover some publications with similar expressions of subjects in other fields, such as confusion with the concept of "energy" in Medicine and the concept of "justice" in Government & Law. Finally, we manually screen out the documents that do not belong to the scope of this discussion, especially those high-cited and low-relevance articles prone to have a more significant impact on the subsequent quantitative analysis. Ultimately, 1,910 publications are used to analyse the theme EJ with visualization tools systematically.

EJ involves and needs to absorb various kinds of knowledge, and our intention is to depict rich domain knowledge maps as much as possible. Hence, we set the principle to avoid compressing the material available for analysis to the point of being too monolithic. So, the 1,910 publications obtained in the previous screening stage are relatively the most suitable objects for this study.

3.2. Analysis strategy

We pursue a clear and deep hierarchical investigation structure without losing focus. EJ literature data to be analysed is large in volume and abundant in connotation. We then design from four significant aspects, i.e., fundamental quantity and annual change characteristics, research direction, citation structure, and thorough analysis at several layers (authors, sources, institutions, countries/regions), to dig the development situation, leading contributors and other important information in the field. The right choice of tools is essential to achieve good results in analysis.

The rapid growth of bibliometrics and computer technology has spawned many assistant quantitative analysis software packages with excellent performances and a rich feature set (Xu et al., 2021). Currently, frequently used scientific knowledge mapping tools include Vosviewer, Bibliometrix R-package, CiteSpace, BibExcel, and CitNetExplorer. Although there are overlaps in partial functional settings, they all have unique elements to ensure their irreplaceability. This reminds us to determine the relatively more proper instruments in both function and operation according to the analysis purpose and strategy (Wang et al., 2021; Li & Xu, 2022).

Van Eck and Waltman (2010) provided an in-depth investigation of aspects such as the type of functionality and technical implementation of Vosviewer, and highlighted its powerful co-citation analysis capabilities. Aria and Cuccurullo (2017) proposed an excellent open-source bibliometric analysis tool designed by themselves, Bibliometrix, and systematically introduced its flexible features and convenient operations. Consequently, we decide to take Bibliometrix and Vosviewer as the main tools (Qin et al., 2022) to realize the visualization of the primary indicators of each subject and the network relationship between them from different perspectives. Also, we apply other programs such as the WoS built-in analysis module and EXCEL to improve the convenience and richness of the process. Furthermore, due to the consistent data format requirements of the two major software packages, the "Full Record and Cited References" data of documents prepared previously in "Plain text file" format are imported and analysed, respectively.

Specifically, based on EJ publications, this study mainly uses Bibliometrix to complete the analysis of trending topics, theme distribution, prolific authors' production, productive countries/regions and their collaborations, core journals, prolific institutions, etc., while using Vosviewer to perform the analysis of keyword co-occurrence, publications citation network, author cooperation network, and institutional bibliographic coupling network, etc. As for other basic analysis, such as publication type, annual publications and citations, high-cited publications, etc., we directly perform data analysis in WoS and present the analysis results with the help of EXCEL (Figure. 1).

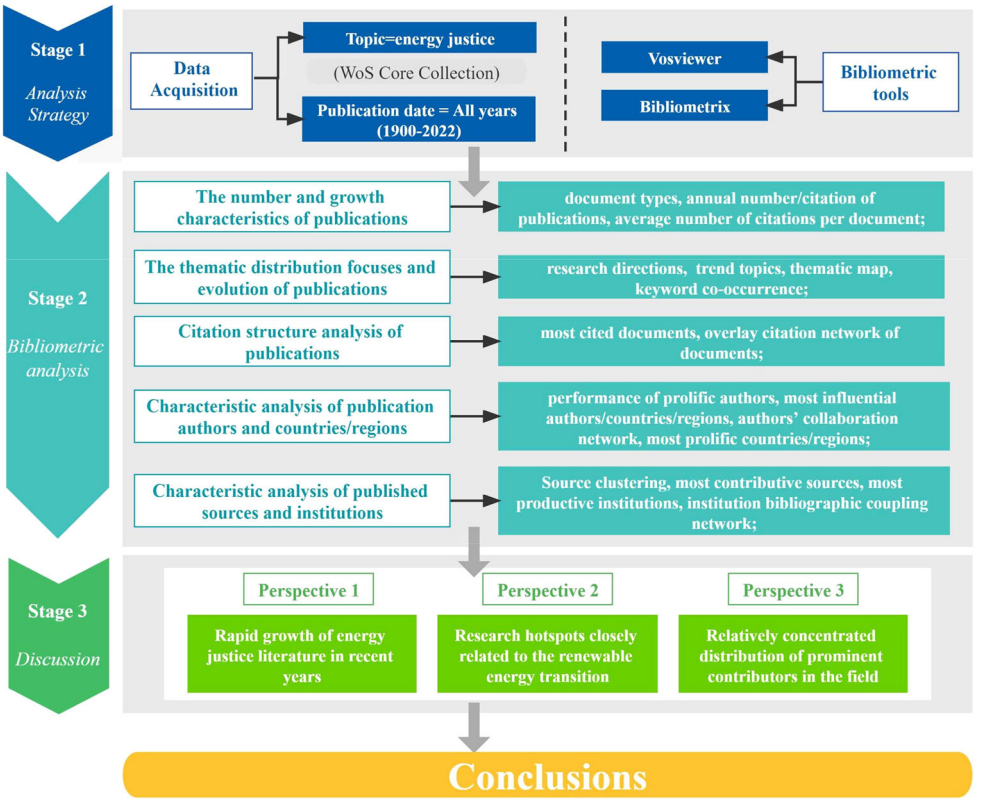


Figure 1. The overall framework of methodology.
Source: Authors' research.

In order to visually demonstrate the analytical ideas of this paper, the complete flowchart is shown as follows:

4. Results

In this section, we map the EJ's intellectual landscape with the help of tools such as Vosviewer and Bibliometrix R-package. Drawing support from plenty of diagrams, we show in order the trend of the documents number in the field since 1975, the distribution and evolution of key topics, the citation statues, and the literature performances at different levels, including country/region, institution, journal, and author.

4.1. The number and growth characteristics of publications

Based on the collected 1,951 documents in the field of EJ, we use a pie chart in Figure 2 to briefly display all the document types involved. Although there are as abundant as 13 kinds of types, article comes out on top, accounting for 82.88% of the total, followed by review articles (153, 8.01%), proceeding papers (112, 5.86%), early access (53, 2.78%), editorial materials (45, 2.36%), book reviews (34, 1.78%), and seven other types that makeup only a tiny fraction of about 1%. This distribution

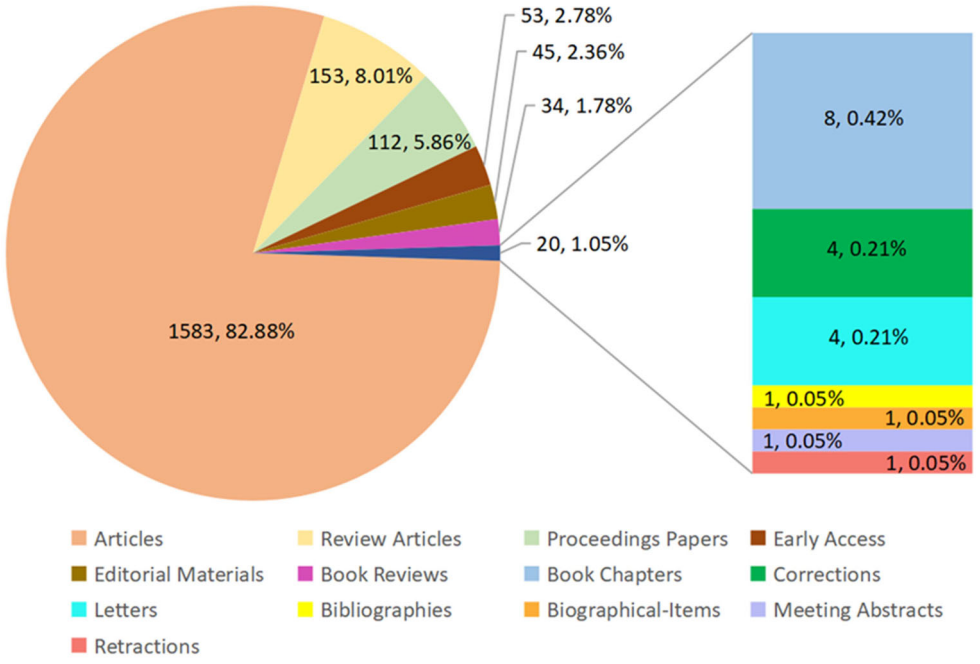


Figure 2. The type distribution of EJ publications.
Source: Authors' research.

reflects that the research results in this field are more inclined to be presented and further disseminated with articles as a carrier.

Combining the yearly trends in the number of publications (NP) and the number of citations (NC) in Figures 3 and 4, the change curves show a continuous and smooth rise and have broken new peaks time after time with a sharp increase in recent years. In the WoS Core Collection database, the first document in this field was published in 1975, while the first citation did not appear until 1988. It is why the abscissas in the two graphs do not start from the same starting time point. It was not until the 21st century that the development of EJ gained the opportunity to form a scale and attract wider attention gradually. The world has ushered in a new era of sustainable development as people realize the significance and severity of environmental protection and social justice issues with each passing day (Zuk & Zuk, 2022).

In Figure 5, we can observe that the annual performance of this indicator, the average number of citations per document (AC), has more apparent fluctuations and changes compared to NP and NC. Especially the peak in 1998 is very conspicuous considering that only eight papers were published that year, and such a high AC value already proves their influence and recognition. Tracing into the cause, we find *Entering the century of the environment: A new social contract for science* is the top-1 most-cited article among all documents with a total citation of 733. It conveys that scientists at the time have been aware of the inextricable connection between human society and nature, and they have attempted to call on more actors to work together to cope with increasingly urgent new challenges in a rapidly changing environment (Lubchenco, 1998). This fact is obviously still in line with the current theme. In

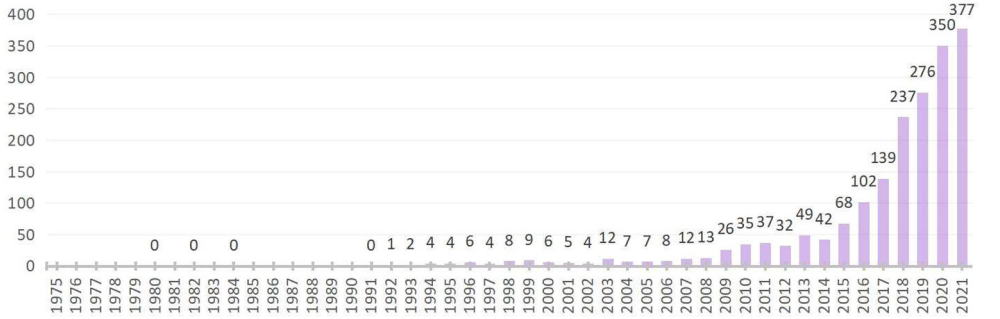


Figure 3. The number of annual EJ publications.
Source: Authors' research.

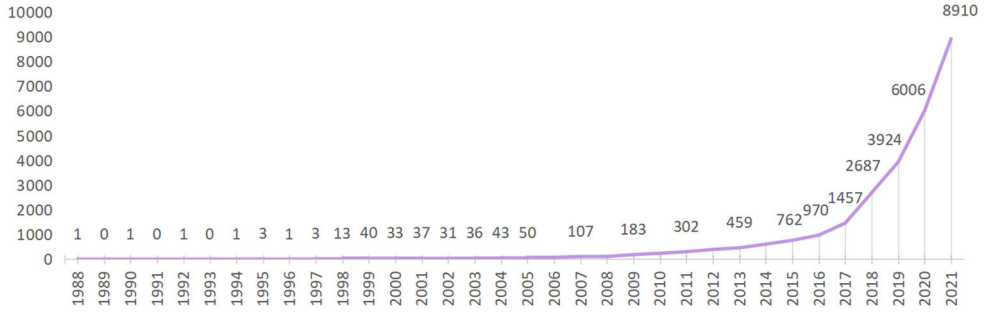


Figure 4. The number of annual citations of EJ publications.
Source: Authors' research.

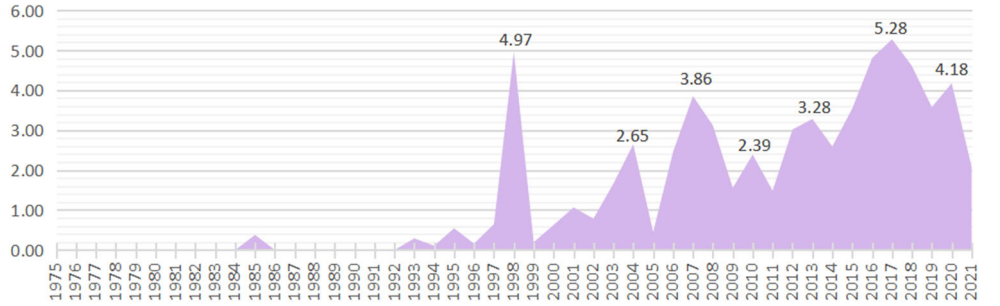


Figure 5. The average citations per EJ publications.
Source: Authors' research.

addition, the value of the indicator AC has shown a steady upward trend after about 2007, which is a good signal that EJ has aroused general and sustained interest. However, since 2022 is not over, this year's performance of the indicator AC will not be considered here for the time being.

4.2. The thematic distribution focuses and evolution of publications

In a bid to explore and understand topics that are of great concern inside the intellectual edifice of EJ, we choose to follow a shallow-to-deep path for exploration. That is, grasping the broader research direction first, then transitioning to more specific

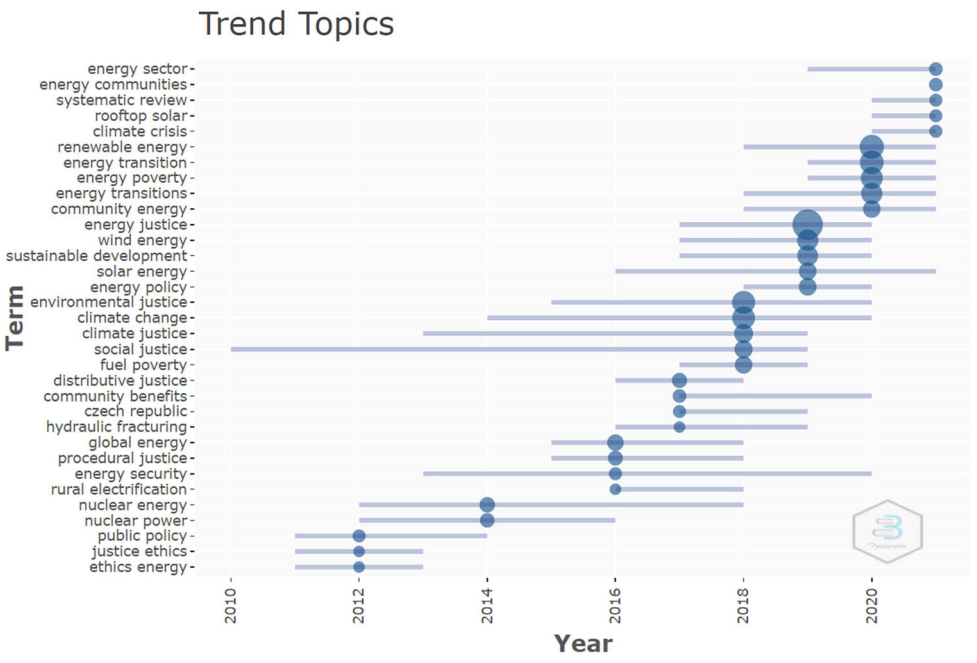


Figure 6. The bigrams trend topics in EJ publications.
Source: Authors' research.

topics, and finally achieving a more profound comprehension through keywords analysis. To a certain extent, the influence of time factors is considered to extend thinking into the future and make some raw predictions on short-term research directions.

Based on the data collected within WoS and its embedded results analysis function, we obtain the top 10 research directions with the maximum amount of corresponding publication records in this field. In descending order, there are Environmental Sciences Ecology (NP: 951, proportion: 49.79%), Energy Fuels (341, 17.85%), Business Economics (258, 13.51%), Science Technology Other Topics (238, 12.46%), Government Law (175, 9.16%), Geography (152, 7.96%), Engineering (149, 7.80%), Public Administration (115, 6.02%), Social Sciences Other Topics (67, 3.51%), Development Studies (57, 2.98%). Among them, the contents of Environmental Sciences Ecology and Energy Fuels contain the reasons and purposes of the EJ issue and provide the soil and space for its growth. And the Government Law, Public Administration, and Social Sciences Other Topics directions also embody the social study attributes of EJ.

Next, we apply the Trend Topics module of the Bibliometrix tool for further detection by setting the analysis object as "Titles" and adapting the graphical parameters (word minimum frequency and the number of words per year) into 5. The 33 phrases that meet the filter criteria and related information (starting year, most relevant year, and ending year) are sorted in Figure 6 by the frequency value vividly and concretely. The length of the line is the duration of the high frequency of the topic, and the larger the blue node, the higher the frequency of the topic it represents.

We can quickly notice that high-frequency themes have mainly emerged from the 2010s and are more concentrated and notable in 2018-2020. In general, they can be

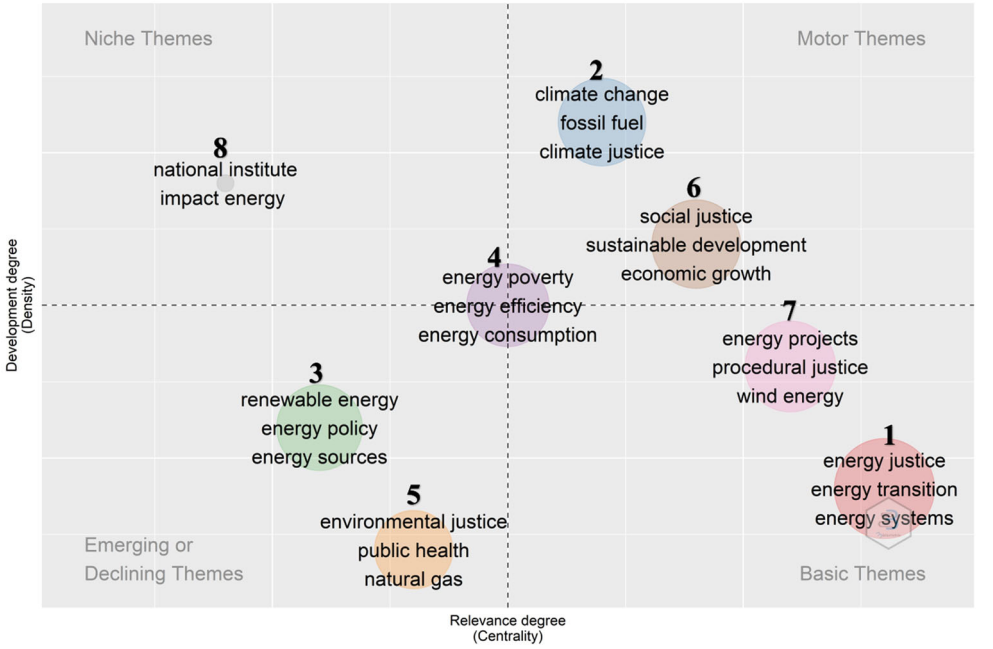


Figure 7. The bigrams thematic map of abstracts in EJ publications.
Source: Authors' research.

divided into two categories. One is the discussion of renewable energy, such as "energy transition" (frequency: 68, peak: 2020), "wind energy" (45, 2019), "solar energy" (21, 2019), and the other is to face social issues in the energy field, such as "environmental justice" (61,2018), "energy poverty" (51, 2020), "community energy" (20, 2020). And from the perspective of duration, "social justice" (23, 2018) and "energy security" (6, 2016) indicate that the challenges of universal recognition of fairness and security guarantees faced by the energy transition require a long time to overcome and adjust.

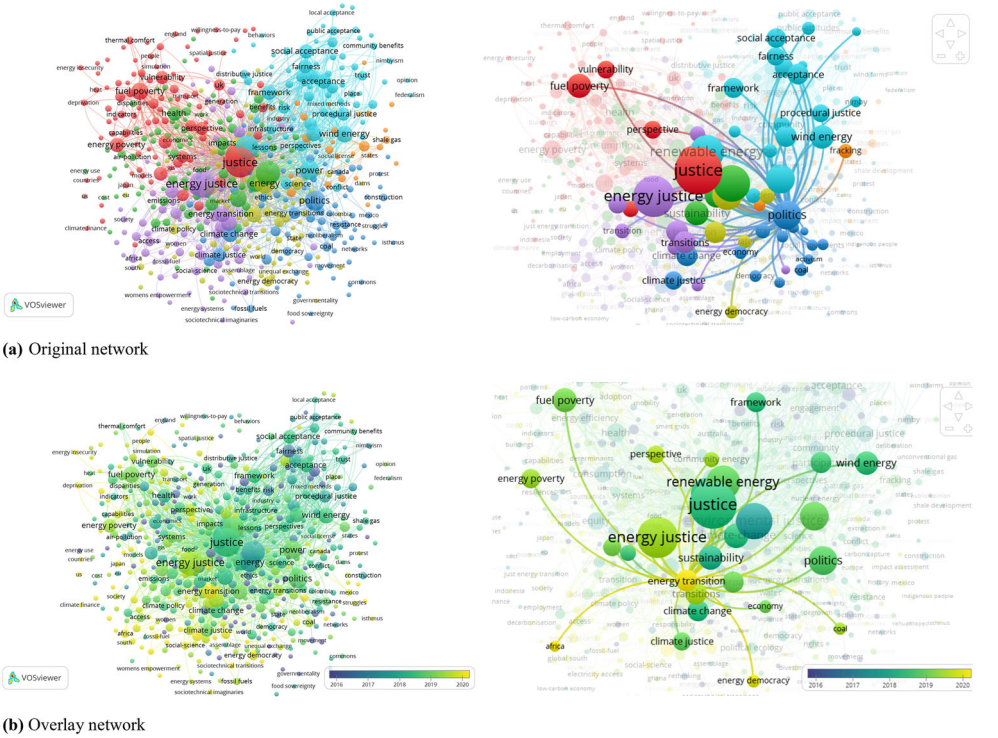
At this point, we have a general understanding of the scope of discussion in the field. However, the degree of development and necessity of these subjects as components of EJ still needs to be further explored. The thematic map in Figure 7 may provide some evidences and clues. As we can see, the horizontal axis represents centrality (relevance degree) and the vertical axis represents density (development degree). Then, the flat has been divided into four intervals, namely the niche topic in the upper left corner (high development level but low importance), motor themes in the upper right corner (high development level and high importance), emerging and declining themes in the lower left corner (low development level and low priority), and basic themes (high importance and low development level) in the lower right corner. After the program examined 520 words extracted from abstracts, there are eight main clusters with frequencies of more than five formed and distributed in different quadrants. Each label only shows the top 3 words with the highest occurrences.

Cluster 2, which contains "climate change", "fossil fuel" and "climate justice", is a relatively significant and the most advanced set. It reveals a phenomenon that the

severe environmental pollution, climate change (Lehmann & Tittor, 2021), and resource shortage caused by the long-term use of fossil fuels make researchers focus continuously on this direction and put a lot of effort into promoting its positive change (David, 2018). It would constantly raise the bar in pursuit of common and democratic justice. Cluster 4 consisting of "energy poverty", "energy efficiency" and "energy consumption" is in the centre position, which also shows that the topics belonging to this cluster have average performances. As for Cluster 1, the most vital but less developed set, we can see from the three representative topics of "energy justice", "energy transition", and "energy system" that it is the cornerstone of the EJ field. Scholars put forward these concepts early and defined them distinctly. Yet, as the environment and policies keep changing, there is still much room for innovation and integration in this area. Moreover, Cluster 6 and Cluster 7 are both noteworthy orientations with good development momentum and are essential to this domain. On the contrary, Cluster 3, Cluster 5, and Cluster 8, all on the left, require attention but should not be distractions when there are more urgent issues needing the most energy to solve.

With a certain extent of intuitive recognitions of the status and change trajectory of a single keyword or research topic, we will end this subsection by studying the co-occurrence of keywords. This is a classic way to interpret research hotspots and development tendencies in the field from the relationships between different keywords. In Figure 8, we draw support from Vosviewer and present the co-occurrence map created by the 526 keywords that meet the minimum co-occurrence threshold of 5. To convey as rich information as possible, two networks with different emphases are depicted and used as objects that can be interpreted and complemented against each other. The larger the size of the label, the more links that extend out. The more occurrences the keyword it represents has, the more keywords that have a co-occurrence relationship with it. The difference in colours of Figure 8 (a) is helpful for the viewers to quickly identify the existing clusters and the closely related keywords classified in the same cluster.

We can see at a glance that "justice" firmly occupies the centre of the net and has a whopping 493 occurrences as the representative keyword for Cluster 1. In addition to those recurring high-frequency keywords, Cluster 3 led by "politics" (occurrence:181, link: 358) and Cluster 7 led by "fracking" (40, 142) give us some new insights instead. From the network on the right with "politics" as the starting point, we can capture "vulnerability" (64, 186), "social acceptance" (77, 188), "economy" (34, 139), and multiple other justice-related phrases. It suggests that the innovation and development of EJ are inseparable from political consultation and regulation, which can coordinate the opinions and interests of stakeholders and propose formal plans as guarantees for the smooth progress. Then, let's talk about "fracking." This is a method of extracting natural gas by pouring high-pressure water containing various substances into shale so that the gas would be released when it ruptures. But the threats of this technology to the ecological environment and human health have caused great controversy (Choma et al., 2016). Its co-occurrence relationship with "politics" also reflects this situation.



(a) Original network

(b) Overlay network

Figure 8. The co-occurrence network of all keywords in EJ publications.
Source: Authors' research.

After superimposing the indicator of average publication year (APY), Figure 8 (b) displays a distinct colour distribution from Figure 8 (a) according to the range and the interval division of the colour bar in the bottom right. Consistent with the conclusions of the topic trends analysis completed above, almost all keywords here have achieved leap-forward development in many aspects, such as connotations and results after 2016. Nonetheless, "energy transition" (101, 261) stands out for its high overall performance supported by freshness and an increased number of occurrences. It is also evident from its separate co-occurrence network that there is an urgent need for constructive outcomes in "renewable energy" (252, 397) to combat "climate change" (95, 229) and the pressures it brings.

4.3. Citation structure analysis of publications

The type and output of EJ-related research have been greatly expanded and enriched in recent years. At the same time, we should also be aware of the holistic quality of publications in the field. Since citation as an indicator can objectively mirror the influence and recognition of documents in academia, this subsection chooses to conduct an adequate discussion through visualization.

First, we rank the top 10 documents by citations, and correspondingly, the data such as publication year, source, and average annual citations are also summarized in

Table 1. The top 10 most cited EJ publications.

Ref	Title	Year	Source	NC	NC/year
Lubchenco (1998).	Entering the century of the environment: A new social contract for science	1998	Science	733	29.32
Gross (2007).	Community perspectives of wind energy in Australia: The application of a justice and community fairness framework to increase social acceptance	2007	Energy Policy	479	29.94
Jenkins et al. (2016).	Energy justice: A conceptual review	2016	Energy Research & Social Science	451	64.43
Lavenex (2004).	EU external governance in 'wider Europe'	2004	Journal of European Public Policy	316	16.63
Sovacool and Dworkin (2015)	Energy justice: Conceptual insights and practical applications	2015	Applied Energy	315	39.38
Zoellner et al. (2008).	Public acceptance of renewable energies: Results from case studies in Germany	2008	Energy Policy	308	20.53
Fuso Nerini et al. (2018).	Mapping synergies and trade-offs between energy and the Sustainable Development Goals	2018	Nature Energy	287	57.40
Pretty et al. (2010)	The top 100 questions of importance to the future of global agriculture	2010	International Journal of Agricultural Sustainability	281	21.62
Newell and Mulvaney (2013).	The political economy of the 'just transition'	2013	Geographical Journal	261	26.10
Walker and Day (2012).	Fuel poverty as injustice: Integrating distribution, recognition and procedure in the struggle for affordable warmth	2012	Energy Policy	234	21.27

Source: Authors' research.

Table 1. Most of them are identified as possessing highly relevant themes to EJ only by the keywords contained in the titles. As for the fourth and eighth, the former fully considers the perspective of environmental and energy policy when expounding the European Union's external governance agenda (Lavenex, 2004). While the latter regards energy demand and security as vital factors for the agricultural transformation and innovation in climate change (Pretty et al., 2010). The first document in the list is a significant article published in Science by Lubchenco (1998). As early as the previous analysis of the indicator AC, it has been excavated due to its superior performance. Finally, when we look at the average annual citations, the third and eighth publications manifest their high quality and tremendous potential with their high citations under the relatively recent publication dates.

Next, 1,465 publications that have been cited at least once are selected to produce an overlay citation network coloured by the APY value. The diameter of each node is proportional to the number of times the document it represents has been cited. The links between nodes signify that there existing citation (citing or being cited) relationships. For example, "Lubchenco (1998)", Gross (2007)", "Jenkins et al. (2016)", "Sovacool and Dworkin (2015)", Lavenex (2004)", "Zoellner et al. (2008)", Fuso Nerini et al. (2018)", "Pretty et al. (2010)", Newell and Mulvaney (2013)" and Walker and Day (2012)" correspond in turn to the ten documents in Table 1 in the form of "first author (publication year)." Most of them are discernible in Figure 9, (a) or (b).

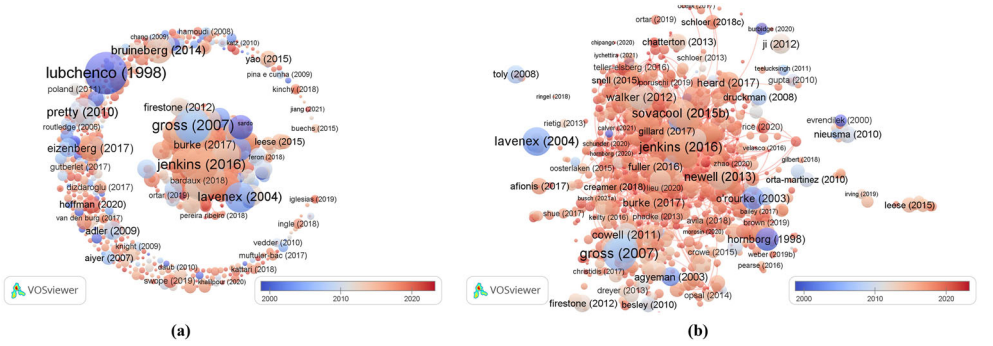


Figure 9. The overlay citation network of the EJ documents.
Source: Authors' research.

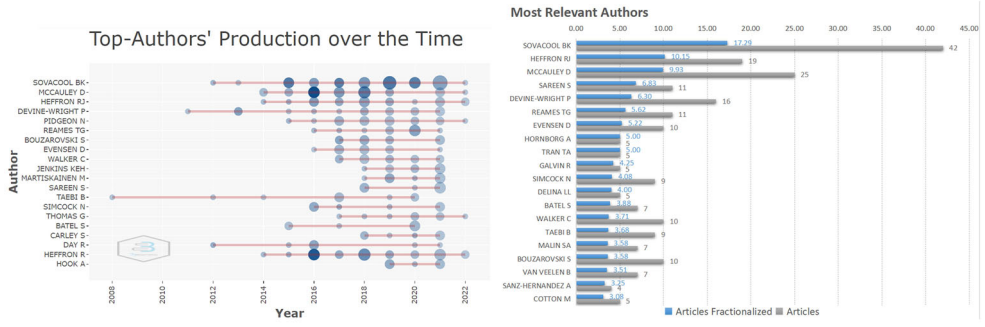
Only two are covered because they are too close to other entries (but both are in the central subset).

We notice that a few highly cited documents lie in the annular orbit away from the centre, the region where items that barely have connections with others in the network converged. Because of this phenomenon, we are able to explain the interdisciplinary attribute of EJ. After roughly browsing the research directions of the citing documents of the marginal documents, it can be found that they mainly concentrate on a particular aspect of energy or justice, such as environmental science, water resources, fuel, social issues, public administration, while rarely involving the discussion of EJ. It can be said that this is the charm and difficulty of interdisciplinary research. The knowledge of multiple disciplines can complement each other, but the objects of concern are numerous, so considerable energy is required to distinguish the key points.

4.4. Characteristic analysis of publication authors and countries/regions

In this subsection, we study the authors and countries/regions of selected publications to paint an overall picture of the most prolific, high-impact contributors and how they relate to each other without losing details.

There are many criteria used to determine an author's academic performance, the most basis of which is the author's number of published documents. In Figure 10 (a), we present the top 20 authors mainly by the total number of publications (while also considering factors such as citations, publication time, and coherence), highlighting their recent publication frequency. The sizes of the blue dots denote the NPs per year (in this case, from small to large corresponds to the values in the range of 1 - 11), and the depths of their colour denote the NCs per year (from light to deep corresponds to values in the range of 0 - 113). Quick note, the biggest point is shaped by the 11 documents Sovacool, B. K. published in 2021, and the darkest point is rendered by the 113 citations McCauley, D. received from the five papers published in 2016. Other points can be explained by referring to these two points. For example, although Taebi, B. has published EJ-related documents since 2008 and has gradually



(a) Frequency of recent publication **(b)** Fractionalized frequency

Figure 10. The performance of the top 20 prolific authors defined by distinct quantitative metrics.
Source: Authors' research.

accumulated as many as nine articles, the high-yield and high-cited eruption period is concentrated after 2016.

We are accustomed to adding up every document to count the author's publication volume, regardless of whether there are other co-authors. Because of this, we introduce the fractionalized frequency measure to compare the personal competencies of different authors. For co-authored articles, with the total number of authors as the denominator (n), each author gets a 1/n point (Cuccurullo et al., 2016). Unsurprisingly, the rankings in Figure 10 (b) versus (a) are inconsistent owing to this arithmetic modification. From top to bottom, the top 20 authors are sorted in descending order according to the number of fractionalized articles (NF, blue bars), and the corresponding NP (grey bars) of each author is given for comparison. Although more than half of the authors (12) belong to the first echelon on both metrics, there are indeed cases where the ranking of the other half of the authors fluctuates significantly. For example, Sanz-Hernandez, A. (R_{NF}: 19, R_{NP}: 67), Hornborg, A. (8, 37), and Cotton, M. (20, 41) appear in the top 20 list as new faces through a significant ranking increase. At the same time, Thomas, G. (15, 102), Heffron, R. (19, 98), and Hook, A. (20, 91) are significantly reduced in ranking and fall out of the list under the new algorithm.

High output can reflect scholars' professionalism and concentration, but their recognition and influence in the academic community require further discussion. Table 2 lists the top 15 authors according to their performances on the indicator NC and gives the corresponding data of other related indicators. Local Citations (LC) reflects the number of citations of an author in the current database (the 1,910 selected documents). As for the metric h-index, which evaluates both the author's academic productivity and the quality of their output (Zaorsky et al., 2020), it is the only measurement in the table beyond the scope of EJ publications.

As you shall see, Sovacool, B.K., and McCauley, D. are outstanding in quantity and citations under various contexts, indicating that they have long delved into the EJ conundrum and made motivational contributions to the domain. Contrariwise, the research focus of Lubchenco, J., Martinez-Alier, J., and Broto, V. C. are not precisely located in the direction of EJ, judging from the imbalance in the levels of h-index,

Table 2. The top 15 most influential authors based on NC in EJ.

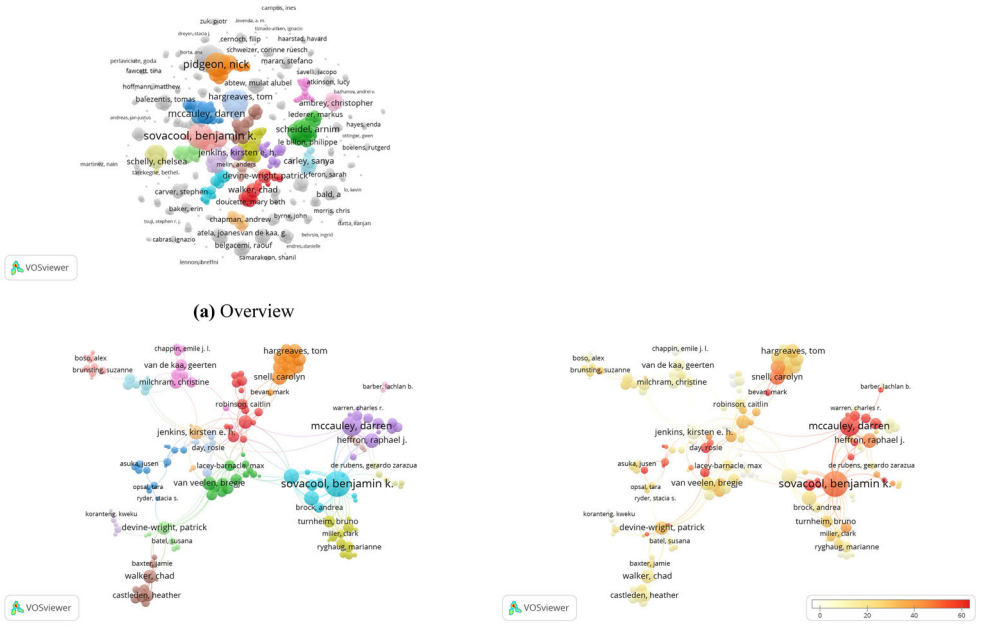
R	Author	NP	NC	AC	LC	H-index	Initial year
1	Sovacool, B. K.	42	2091	49.79	1053	65	2012
2	McCauley, D.	25	1672	66.88	1192	16	2014
3	Heffron, R. J.	19	841	44.26	565	14	2014
4	Jenkins, K.	6	733	122.17	563	11	2016
5	Lubchenco, J.	1	733	733.00	2	63	1998
6	Devine-Wright, P.	16	633	39.56	153	36	2011
7	Heffron, R.	7	623	89.00	435	14	2016
8	Day, R.	7	506	72.29	285	17	2012
9	Rehner, R.	4	503	125.75	381	8	2016
10	Gross, C.	2	479	239.50	129	1	2007
11	Stephan, H.	1	451	451.00	349	5	2016
12	Temper, L.	6	391	65.17	65	17	2016
13	Martinez-Alier, J.	8	367	45.88	53	37	2016
14	Broto, V. C.	4	364	91.00	45	27	2017
15	Scheidel, A.	6	358	59.67	64	13	2016

Source: Authors' research.

LC, and NP. But it must also be admitted that although they are not quantitatively dominant, the only existing documents have attested their high quality with soaring citations. It can be seen from AC that Rehner, R., Gross, C., and Stephan, H. also obtain relatively more citations with a small number of publications. Laying eyes on the time when the authors first published EJ-related literature, we can once again conclude that the high-level output in this field mostly erupted after the 2010s.

Only relying on the efforts of independent individuals cannot promote the vigorous development of the entire field permanently, so researchers with different strengths related to the field working together or collaborating across disciplines is strongly encouraged. In virtue of Vosviewer, we set the weight indicator of the co-authorship network composed of authors whose NP and NC are both not less than 2 to total link strength (TLS). It means that the larger the number of documents co-authored with other authors, the bigger the corresponding nodes in the web will be. In Figure 11 (a), the 175 clusters are numbered in ascending order according to the total number of as- sociated authors included in each cluster (Cluster 1 has 18 authors, and Clusters 92 to 175 have only one author each). One can easily infer that the authors involved in the network's dense grey clusters (Clusters 19 to 175) have relatively few collaborations with other scholars in the direction of EJ.

Hence, we pointedly zoom in on the largest sub-network with the most associations for closer observations in Figure 11 (b) (the location and colour of individual clusters have changed after regeneration by the software). Some of the shining performers in Figure 11 (a), such as Pidgeon, N. (TLS: 55, NC: 189), Scheidel, A. (26, 358), and Schelly, C. (16, 56), are not in the scope of extraction because they hold no connection to this sub-network. As it turns out, as leaders on the EJ side, Sovacool, B. K. (TLS:60, AC:49.8) and McCauley, D. (36, 66.9) are both aware of the importance of collaboration and actively expand their academic visions in the process. Among other authors in these 18 clusters, Snell, C. (21, 49.5), Milchram, C. (14, 10.8), and Turnheim, B. (13, 30.3) are also noteworthy scholars who have examined the dual metrics of TLS and AC. Figure 11 (c) with the AC indicator overlaid can also provide more information from an impact perspective.



(a) Overview

(b) The largest sub-network of connected items

(c) The overlay sub-network after superimposing AC

Figure 11. The authors' collaboration network based on TLS and AC.
Source: Authors' research.

Now that we have a rough understanding of how the cooperative relationship between authors is extended and distributed, it is time to think about what the venation should look like if the angle of view goes up to the national/regional level. The Corresponding Author's Country analysis function provided by bibliometrix records the NP of various countries/regions from two aspects, which are multiple countries publication (MCP) and single country publication (SCP). Combining these two indicators and adopting this as a basis shows the top 20 countries/regions in Figure 12. Overall, authors work independently or cooperate within the same country more often than they communicate across countries/regions, which is a crucial reason why the USA (MCP: 61, SCP: 443) and the United Kingdom (98, 241) are so far ahead of others in this analysis. Therefore, Denmark (6, 21) looks unusual from the rest due to its significantly higher MCP than SCP.

Considering the analysis data in Vosviewer, we then compile the comprehensive strength of the top 20 most predominant countries/regions in the field of EJ. Link refers to the number of other countries/regions with which a country/region has partnerships, and TLS is the total amount of collaborative documents it owns. Following the initial impression presented in Figure 12, Table 3 furnishes a more thorough representation of the dominance of the USA and England in EJ literature from various indicators of NP, NC, Link, TLS, etc. At the same time, we can recognize their pursuit of high-quality articles from the high AC values of Thailand, Switzerland, Denmark, Wales, and Scotland. Comparatively, Norway's performance on AC still needs to be improved, and perhaps more actively seeking cooperation with other countries/regions is one of the effective ways.

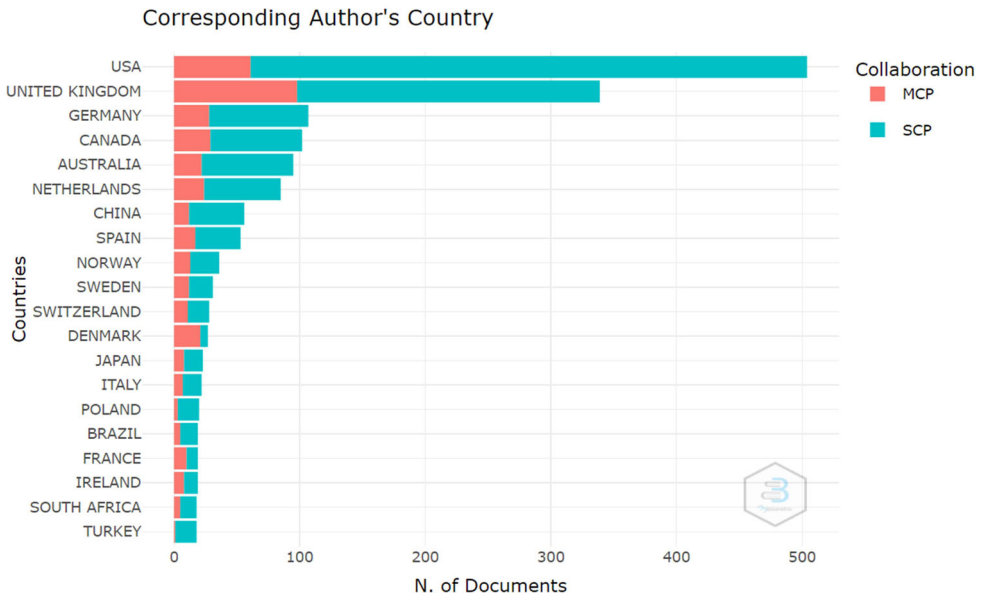


Figure 12. The top 20 most prolific countries/regions.
Source: Authors' research.

Table 3. The top 20 most influential countries/regions based on NC in EJ.

R	Countries/Regions	NP	NC	AC	Link	TLS	APY
1	USA	565	9423	16.68	54	249	2016.9
2	England	362	8987	24.83	60	358	2017.9
3	Scotland	85	2646	31.13	40	130	2018.0
4	Canada	138	2287	16.57	49	147	2017.8
5	Australia	114	2261	19.83	29	71	2018.4
6	Denmark	67	2221	33.15	40	140	2019.0
7	Germany	146	2164	14.82	38	144	2017.5
8	Netherlands	114	1965	17.24	47	136	2018.1
9	Wales	40	1280	32.00	26	62	2017.9
10	China	75	1262	16.83	44	94	2018.3
11	Switzerland	35	1235	35.29	33	57	2016.2
12	Spain	81	1112	13.73	39	101	2018.8
13	Sweden	46	963	20.93	35	85	2018.7
14	France	36	658	18.28	45	92	2018.4
15	Norway	51	572	11.22	22	47	2018.8
16	Italy	37	497	13.43	29	47	2017.0
17	South Africa	36	464	12.89	33	73	2018.8
18	Thailand	11	463	42.09	30	40	2017.3
19	India	25	442	17.68	40	68	2018.0
20	Ireland	23	440	19.13	26	45	2019.4

Source: Authors' research.

4.5. Characteristic analysis of published sources and institutions

As two elements closely bound up to literature publication and dissemination, the influence and promotion of sources and institutions on a given subject should be meticulously researched. Bradford's Law aims to intuitively portray the dispersion of documents in a field in different journals. Following its principles of it, Bibliometrix divides the sources into three zones containing an equal number of articles (in this

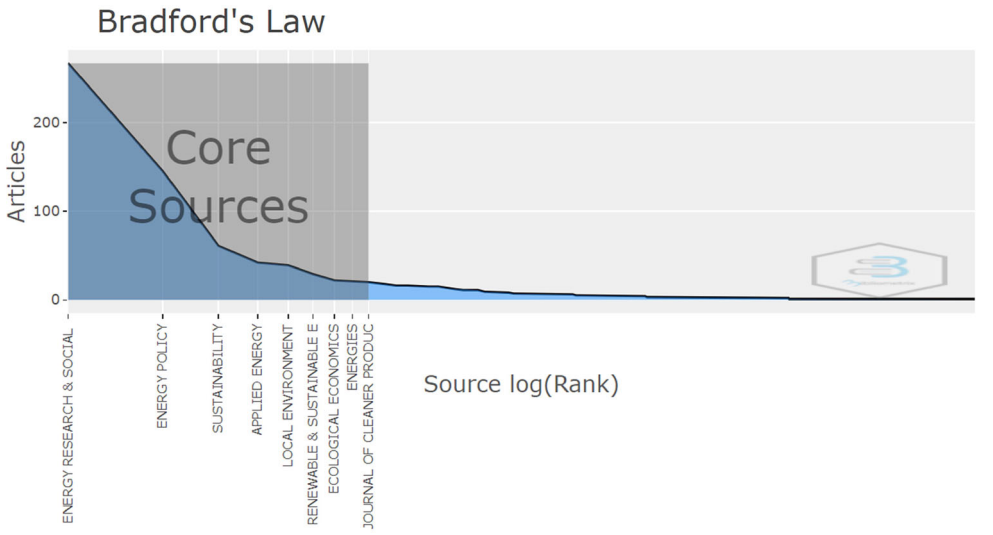


Figure 13. Source clustering through Bradford's Law.
Source: Authors' research.

case, it is 646: 634: 630), where the first zone is also regarded as the core zone consisting of journals with the most prominent and most concentrated publications (Borgohain et al., 2021). The area coverage changes in Figure 13 are steep, with just 9 out of 758 journals constituting the core source segment, which implies that Energy Research & Social Science (NP: 267), Energy Policy (145), Sustainability (61), Applied Energy (42), Local Environment (39), Renewable & Sustainable Energy Reviews (29), Ecological Economics (22), Energies (21) and Journal of Cleaner Production (20) have published about one-third of the literature in the EJ field.

Apart from this, we have listed the top 15 sources in Table 4 based on their NC values and employed Journal Citation Reports (JCR) partition and Impact Factor (IF) to emphasize their quality and status. There are comprehensive and solid sources that focus on the quantity and quality of articles, such as Energy Research & Social Science and Energy Policy. Also, highly rated journals are dipping superficially into the EJ field, which has gained many recognitions with only a few articles, such as Science, Journal of European Public Policy, and Agricultural Sustainability. As an intersection of multiple disciplines, the EJ literature is bound to involve sources classified to various fields. However, h-index, IF, and some other metrics are not appropriate for horizontal comparison between different disciplines. Hence, we only pick one of them (IF) to simply examine the absolute strength of the journals themselves in the list. For instance, Science and Nature Energy's excellence has been self-explanatory, with high IF values of 63.714 and 67.439, respectively.

In contrast, JCR evaluates sources on the premise of being classified, which makes it easier to measure various journals on a large scale. Taken together, more than half of the sources here are subsumed into Quartile 1 (Q1) under all categories they belong to, while the rest are also doing well, demonstrating their solid strength as the head. The seemingly exceptional category bar involves only 15 different disciplines because Environmental Studies (six times), Energy & Fuels (four times),

Table 4. The top 15 most contributive sources based on NC in EJ.

R	Source	NP	NC	Categories	JCR partition	IF2021
1	Energy Research & Social Science	267	4697	Environmental Studies	Q1	8.514
2	Energy Policy	145	4533	Economics; Energy & Fuels; Environmental Sciences; Environmental Studies	Q1; Q2; Q1; Q1	7.576
3	Applied Energy	42	1330	Energy & Fuels; Engineering, Chemical	Q1; Q1	11.446
4	Science	1	733	Multidisciplinary Sciences	Q1	63.714
5	Sustainability	61	721	Environmental Sciences; Environmental Studies; Green & Sustainable Science & Technology;	Q2; Q2; Q3	3.889
6	Nature Energy	15	658	Energy & Fuels; Materials Science, Multidisciplinary	Q1; Q1	67.439
7	Renewable & Sustainable Energy Reviews	29	642	Energy & Fuels; Green & Sustainable Science & Technology	Q1; Q1	16.799
8	Ecological Economics	22	582	Ecology; Economics; Environmental Sciences; Environmental Studies	Q1; Q1; Q1; Q1	6.536
9	Global Environmental Change-Human and Policy Dimensions	11	373	Environmental Sciences; Environmental Studies; Geography	Q1; Q1; Q1	11.160
10	Goodrum	13	353	Geography	Q1	3.926
11	Journal of Environmental Planning and Management	5	319	Development Studies; Regional & Urban Planning	Q2; Q3	3.371
12	Journal of European Public Policy	1	316	Political Science; Public Administration	Q1; Q1	4.366
13	Geographical Journal	4	300	Geography	Q2	3.384
14	International Journal of Agricultural Sustainability	1	281	Agriculture, Multidisciplinary; Green & Sustainable Science & Technology	Q1; Q4	3.506
15	Wiley Interdisciplinary Reviews-Climate Change	15	276	Environmental Studies; Meteorology & Atmospheric Sciences	Q1; Q1	10.072

Source: Authors' research.

Environmental Sciences (four times), Green & Sustainable Science & Technology (three times), Economics (two times) appear on several occasions. The popularity of the several mentioned disciplines hinds us that although EJ incorporates knowledge from diverse disciplines with different focuses, it still pays a lot of attention to environmental issues.

In the last part of the visual analysis, we focus on the publication organizations. The 20 institutions presented in Figure 14 are aligned in descending order of NP from top to bottom. Though the University of Sussex still has a clear lead in the first position, the distribution of EJ literature in institutions is relatively more even than in sources. Among the countries where they are subject, England alone possesses eight prolific institutions in total, providing a tangible boost to the progress of EJ. The rest also includes the United States and Scotland with 4 and 2 institutions respectively, plus Denmark, Wales, the Netherlands, Spain, Australia, and Germany with one institution each.

Bibliographic coupling analysis, a standard citation analysis, is based on the overlap degree of the references of two documents to identify the correlation between each other (Habib & Afzal, 2019). In Vosviewer, we use TLS, which would increase with the number of shared references between two items, as a weight indicator to sketch the bibliographic coupling network of 137 institutions with documents and citations not less than 5 and 20, respectively. Although the web of relationships looks

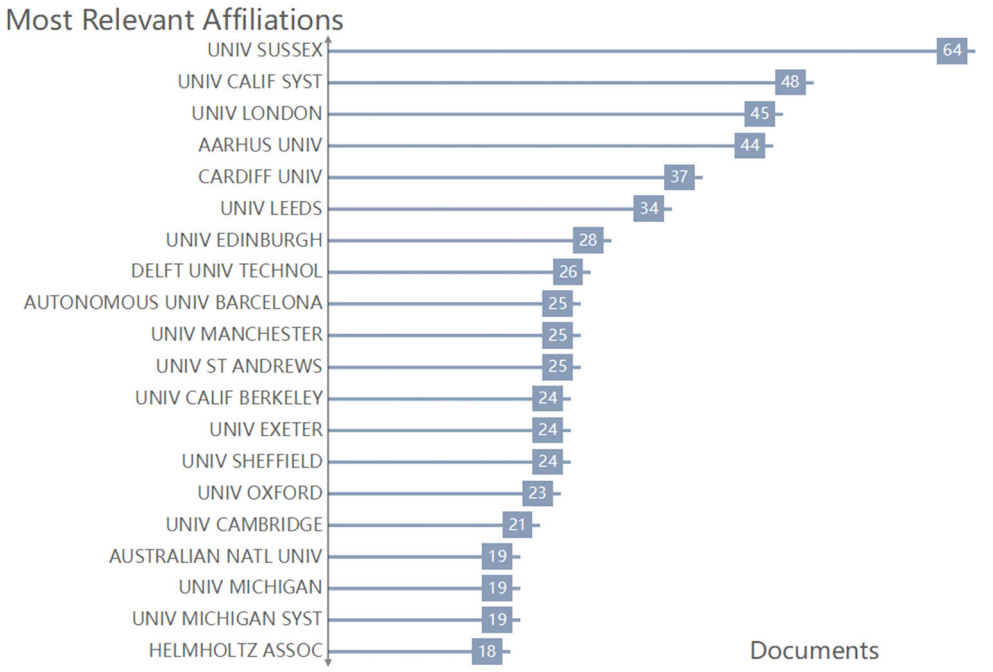


Figure 14. The top 20 most productive institutions in EJ publications.
Source: Authors' research.

intricate and large at first glance, the seven clusters with different colours can be easily distinguished. The representative organizations of these clusters, that is, the ones with the highest TLS in each cluster, are Lund University (red, TLS: 20,842), Delft University of Technology (green, 27,639), Cardiff University (navy blue, 42,339), University of St Andrews (yellow, 32,395), University of Leeds (purple, 29,055), Universitat Autònoma de Barcelona (sky blue, 15,023) and University of Sussex (orange, 80,440). Three of them also come from the top 10 list of the co-authorship network above, illustrating the benefits of cooperation from the side again. It can be said that many coupling relationships with various other institutions suggest that the research direction of this institution coheres with the prevailing trends in the field. Keeping a close eye on these outstanding affiliations' academic dynamics and enthusiastically seeking out collaboration opportunities serves us to be exposed to the scientific frontier and obtain inspiration. (Figure 15).

5. Discussion

A comprehensive bibliometric analysis of 1,910 EJ documents allows us to grasp the performance of the literature in this field in terms of annual publication trends, popular research themes distribution, citation structure and major contributors. Previously, the results of each analysis have been interpreted separately. In this section, we hope to further discuss the overall characteristics of the EJ literature as revealed in the quantitative analysis from the following three perspectives.

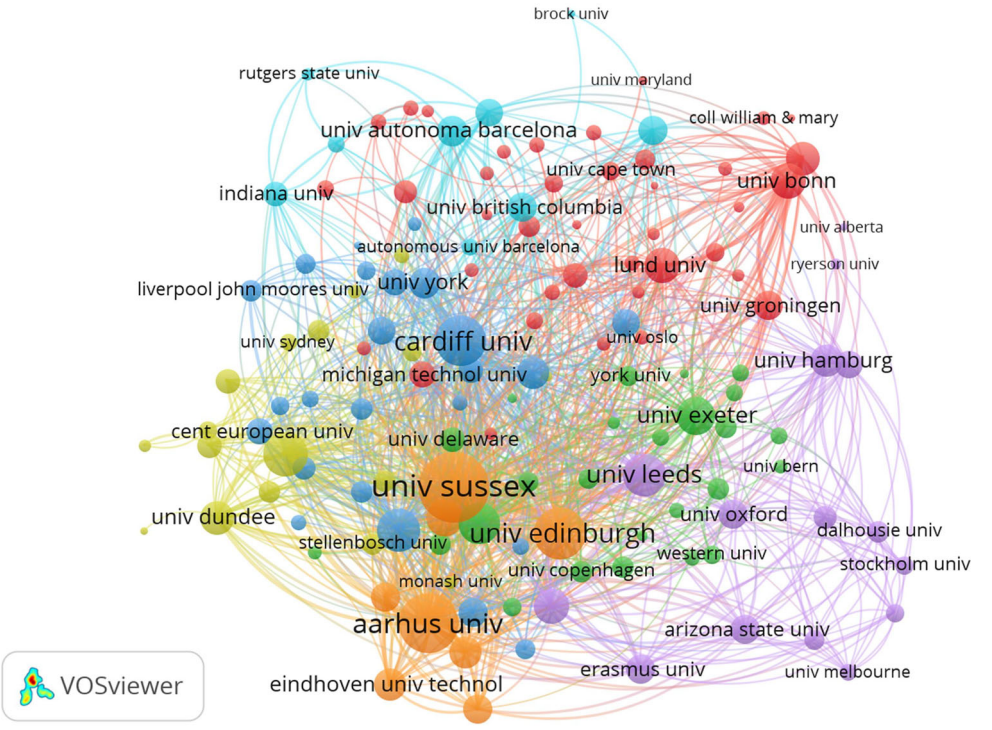


Figure 15. The institution bibliographic coupling network based on TLS.
Source: Authors' research.

5.1. Rapid growth of energy justice literature in recent years

In a number of analyses including the time factor, it is clear that EJ has attracted a great deal of attention in recent years, which leads to an impressive increase in the volume of literature and the publications of widely recognized high-quality research results. In the context of the growing importance attached to energy, the world has developed a distinct attitude and philosophy towards energy usage and management than in the past. The depletion of natural resources is urging us to develop alternative green energy sources as soon as possible to achieve the transition to sustainable development.

However, equity and justice in energy activities are inherently difficult to maintain and guarantee due to multiple factors such as geography, economics and social system. The pressing energy transition makes this situation even more intractable and unpredictable. Apparently, the reality has given EJ research the sustenance to flourish and has spawned a large body of academic achievements that seek to provide solutions for breaking the dilemma. The surge in EJ literature is bound to continue for a long time.

5.2. Research hotspots closely related to the renewable energy transition

Progress in any discipline is driven by practical challenges and is ultimately aimed at serving actual needs. The low carbon transition, one of the most daunting and urgent

key tasks currently shared globally, has had a significant impact on almost all academic fields, not to mention the field of EJ, which is built on energy activities. As an emerging intersecting subject, EJ is still in the process of being explored in terms of its theoretical framework and applications. Hence, the energy transition as a massive global project with a wealth of data and practical opportunities are able to provide a great platform for EJ research.

Moreover, energy transition has exacerbated inequalities in certain energy activities at this stage, leaving vulnerable groups in a more difficult situation, which highlights the significance and urgency of developing systemic guarantees of justice. Unlike ameliorating existing inequalities already caused by rising industrial levels and rapid economic development, such as energy poverty, there is a greater need for EJ scholars to shift their thinking to pre-emptive prevention and control. For example, developing a system of indicators to measure equity and a theoretical framework to guide a just transition. The uncertainties associated with the energy transition are enormous, and the way forward for EJ is also bound to be constantly adjusted to the actual transition situation.

5.3. Relatively concentrated distribution of prominent contributors in the field

We have noticed that the outstanding contributors (authors, journals, countries/regions, etc.) in the field are very concentrated. It is convenient for more non-senior researchers in the field to grasp the main content of EJ quickly, but also implies the concern of lacking diversity in research content and directions. That is why we have analysed and demonstrated the cooperation between items in various dimensions. Meanwhile, we call for richer results to be obtained through collaborations between different authors, institutions, disciplines, and fields to promote the healthy development of EJ. Especially today's realistic challenges are often constrained by a complex multiplicity of factors, while a single perspective will not be conducive to seeing the problem for what it is and offering solutions that balance the demands of all parties.

6. Conclusion

Inspired by the global attention to energy issues and the swift growth of the cross-cutting field of EJ in this context, we have systematically reviewed and analysed the existing results in this paper focusing on EJ's literature. It is not easy to show the intertwined EJ knowledge system in an orderly manner because this discipline is rooted in multiple social sciences, such as environmental justice, climate justice, and social justice. Moreover, energy research has diverse attributes and demands. Therefore, we have targeted aspects that can be depicted as comprehensively as possible within a limited space.

Combining the results of the quantitative analysis of the literature in this field, we have mapped the knowledge landscape of EJ in four main areas: basic quantitative features, distribution and evolution of topics within the field, citation structure and the results of the work of researchers at different levels in this field. On this basis, we have further underlined and discussed the key characteristics shown in the process,

including the rapid development trends of recent years, the distribution of research hotspots closely linked to the energy transition and the current relative concentration of contributors to the field.

While this vigorous growth has accelerated progress in the field, it may also lead to the emergence of duplicative and ineffective research. The results of this study will help to present the overall strengths and weaknesses of EJ-related research at this critical moment, and provide inspiration and ideas for researchers in the field to take the next step forward.

6.1. Theoretical and practical implications

The results of the bibliometric analysis have yielded us with important insights. The first thing to point out is that a salient feature runs through the entire quantitative analysis process. The EJ literature did not begin to emerge in large numbers until recent years, specifically after about 2015. Consequently, under the appearance of owning quite a few related studies, there are characteristics of dispersion and superficiality that cannot be avoided during the growth period. In the next step of the research program, the development should be aimed at portraying the features that distinguish EJ from other justice models and sculpting its functions as a practical tool beneficial for decision-making.

Secondly, through the analysis of research trends on keywords, etc., we have felt that the transition to renewable energy occupies the most spotlights at this time node. Ensuring justice and equality for various groups during the shift, especially marginalized communities, has become one of the top priorities for EJ to explore in-depth and deliver solutions. Furthermore, there is still a long way to go before we reach the destination of energy transition, and the process may cause new forms of inequity. This urges EJ researchers to develop 1) a common system of measurement indicators, and 2) a forward-looking theoretical framework to provide policy makers and practitioners in the energy sector with references for policy making and implementation. While taking measures to prevent exacerbating existing inequities or creating new ones, we should also pay close attention to the practical process of transformation and adjust the research emphasis in time.

In a nutshell, the young EJ is showing momentum full of motivation, yet we cannot neglect to reflect in time for sustainable and meaningful outputs. In this paper, we hope to achieve this purpose and then bring enlightenments to the readers.

6.2. Limitations

Even though we have attempted to build this study on the strengths of bibliometric analysis as much as possible, there are still unavoidable flaws in the process:

1. The operating rules or algorithms of various tools are distinct and generally difficult to unify, which may cause discrepancies in the results of the same analysis on different software packages. When it is unfeasible to understand and modify the default parameter settings of the program in compelling ways, we can only

rely on upon subjectively picking the apposite tool according to the degree of adaptation to the analysis.
2. Even putting aside the divergences between software packages, each of them may not be able to reproduce the information in the literature with complete accuracy, and present it in a specific form. In particular, it takes a certain amount of time from data collection to the final presentation to the viewer, during which actual data changes in related literature may occur. But it is guaranteed that within the selected range, the relative relationship between items is comparatively reliable and has reference value in reflecting the overall situation and direction.
3. The data used in this study is obtained only from the WoS Core Collection, which lead to a certain lack of richness and comprehensiveness in the results of our analysis. This paper mitigates the potential negative impact of this shortcoming by including as much of the extensive literature related to the topic of EJ within this database as possible, and we will further improve the way in which data is collected in future research.

For the above three reasons, we recommend that researchers view and use this series of quantitative analysis results dialectically in conjunction with the further active study. We will also try to explore EJ in more depth and detail from a more specific perspective in our future work.

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