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Research Article

A bibliometric analysis of research on multiple criteria decision making with emphasis on Energy Sector between (2019-2023)

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ABSTRACT

In the present study, a bibliometric analysis of research works that have been conducted over the last five years in connection to Multiple Criteria Decision making (MCDM) and its application in the energy sector is presented. In the beginning, a statistical study of influential publications, journals, countries/territories, and authors was carried out. In the following step, an analysis was performed based on four distinct time periods to determine the evolving patterns of authors' cooperation structure and study themes. According to the findings, there has been a rise in the quality of collaboration between writers, as well as an increase in the number of publications and authors who have contributed to the study on MCDM during the last five years. Researchers should be able to successfully conduct investigations in linked domains with the assistance of the complete and scientific analysis of MCDM. It also concludes that there are more opportunities in the future in the field of energy applications with MCDM, and this can be encouraging for researchers from both fields, as well as those from the industrial and economic fields, to consider MCDM in their utilization of energy alternatives and to make decisions that are informed by such findings.

1. INTRODUCTION

In research, different technological phenomena have been introduced over the last few years, ranging from advanced utilization of Artificial intelligence tools, machine learning, generative AI, the Internet of things, big data, and many more [1]. Each of these technologies has its dependent utilization and integration with others to produce various solutions to many of the existing research problems faced nowadays [2]. Amongst these technologies comes an intelligent branch uniting operational research with a decision support system with what is known as multiple criteria decision-making analysis (MCDM) [3]. A systematic approach to complex decision-making scenarios, MCDM is utilized in numerous domains. The process entails weighing and choosing options according to several competing criteria. By taking a wide range of variables into account, including cost, risk, benefits, and restrictions [4], MCDM methods attempt to make optimal decisions easier to achieve. In complex decision-making environments, MCDM provides frameworks through quantitative and qualitative studies to help decision-makers make well-informed and resilient decisions [5]. MCDM also makes use of fuzzy multi-criteria decision-making, which Zadeh first introduced by incorporating the concept of fuzzy sets in order to handle information that is imprecise or ambiguous in making decisions [6]. In decision-making contexts, it takes into account subjective evaluations and uncertainty while simultaneously including a number of different criteria and alternatives. Many methods make use of fuzzy MCDM and their corresponding linguistic variables to model information that is ambiguous or qualitative, which helps with complicated decision analyses [7]. A more complex depiction of preferences and uncertainties is made possible by these approaches, which also make it possible for decision-makers to take into account a variety of views and imprecision during the decision-making process. In general, fuzzy MCDM offers a methodical framework that can be utilized to handle situations that involve uncertainty and ambiguity [8]. There have been several research areas and fuzzy types where fuzzy MCDM was applied [9, 10]. Since MCDM research has been carried out for an extended period, it has been applied in various case studies and applications [11], and it is still being applied to this day. At the same time, people interested in working with MCDM ought to understand its nature and how it was applied [12], at least within their domain of knowledge (e.g., medicine, industry, etc.). This will enable them to understand its requirements and utilization perspectives, which are needed for them to integrate and work on [4]. Towards

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that end, review works are distributed, and many discuss MCDM challenges in specific domains. However, due to the availability of many works, the presence of review works with a focus on bibliometric analysis is lacking, especially in domains like Energy [13]. Therefore, this work presents a review of works for MCDM applications within the energy domain in the last five years. Bibliometrics is used to analyze statistical processes in the many forms of communication media. As a result, academics have utilized bibliometrics, which is founded on mathematics and statistics, to conduct analyses of publications, citations, journals, and other types of publications across a wide range of academic topics and disciplines. It is possible to utilize the bibliometric method to analyze the number of publications in order to locate influential publications, authors, journals, organizations, and nations effectively. The mapping of social networks, such as co-word, co-authorship, and co-citation networks, is another way that bibliometrics can be used as an intuitive method to perform information analysis.

2. DATASET AND METHOD

As of October 2023, an extensive dataset search was conducted, and its results were obtained from the prestigious academic journals from ISI Web of Science (WoS) in order to carry out a complete bibliometric analysis. The dataset was carefully compiled by employing particular search parameters that included terms associated with "multiple criteria decision-making" and "energy" while simultaneously filtering content categories to include only reviews or articles. In addition, the search was improved by including indexes that were mainly derived from SSCI and SCI-EXPANDED resources. The purpose of this planned selection was to ensure that a precise investigation of scholarly works that are pertinent to the intersection of these areas would be carried out. It is possible to gain a sophisticated picture of the changing environment in this area of inquiry by doing an analysis that covers a predetermined period. This allows for the identification of the trajectory of research trends within this domain.

One thousand three hundred sixty-five publications spanning the years 2019 to 2023 were discovered because of the search. In the development of publications, the frequency with which articles on MCDM and Energy have been distributed over time is investigated. It reveals periods when research activity was remarkably increasing and identifies major turning points and milestones in the development of this diverse field of study. Within the scope of this study, the distribution of research contributions across the world is the primary focus. Particular attention is paid to the countries and regions that have made significant contributions to the development of our understanding of MCDM in relation to Energy. The findings of this analysis shed light not just on the geographic concentration of research activities but also on the potential networks of collaboration that could exist. The study investigates the most active authors, collaboration networks, and research clusters within the context of the MCDM and Energy research environment. A thorough examination of the patterns of collaboration that exist between researchers and institutions is necessary in order to gain an understanding of the dynamics of information flow in this sector. Furthermore, this research focuses on the literature that is cited the most frequently, identifying fundamental studies and notable authors who have had a significant influence on the development of MCDM applications in the energy sector since their inception. An analysis of citation trends is performed in order to determine the most significant contributions and theoretical foundations that have an impact on the relevant field. We discover and investigate novel research ideas that are present in the existing literature on MCDM and Energy. The objective of this section is to place an emphasis on novel applications, perspectives from a variety of disciplines, and potential future paths of research. A detailed examination of the results is presented in the following section.

3. RESULTS AND DISCUSSION

This section is meant to show the main points of discussion in this research. It will start with a discussion of the collaboration network and countries' Collaboration Networks.

3.1 Collaboration Network

Research efforts have been greatly accelerated by collaborative networks within the domains of Energy and MCDM, which has enabled the overcoming of intricate issues that are inherent in the creation of sustainable Energy. A deliberate effort that involves joint endeavors that transcend institutional boundaries, academic restraints, and geographical distances has been a defining characteristic of the development of research within this interdisciplinary domain. Through the creation of a nexus of multidisciplinary knowledge, the purpose of this concentrated attempt is to combine the insights and skills that are gathered from the fields of decision sciences, energy systems, and environmental sustainability. Through the synergy that exists between these several fields of study, an atmosphere is created that is favorable to the sharing of novel ideas, a variety of approaches, and the most effective practices. Through the facilitation of the interchange of ideas, approaches, and best practices, these networks build a collective intelligence that moves MCDM applications forward in the energy business, as seen in Figure 1.

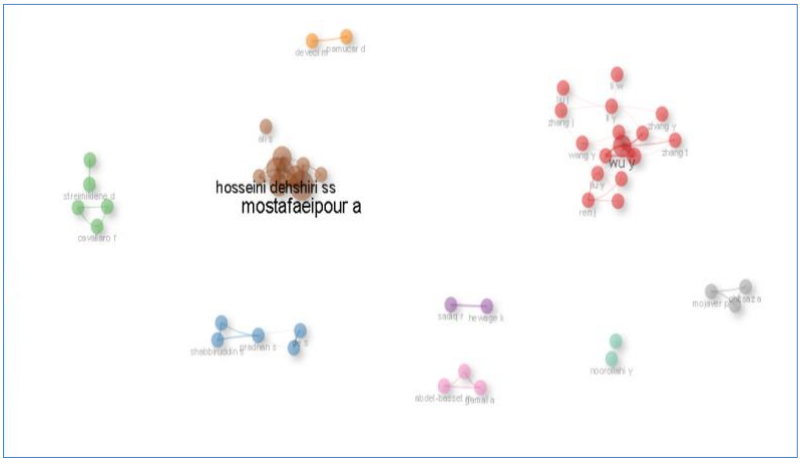

Fig. 1. Collaboration Network

The intricate patterns of co-authorship, institutional alliances, and international cooperation that are revealed by the collaboration landscape are used to illustrate the interconnected nature of the research activities that are conducted in this field, as seen where major works were collaborated between authors like Hosseini Dehshiri, Saraswat Mostafaeipour A, and many more. Figure 1 illustrates this interconnectedness. Increasing the robustness and relevance of frameworks for decision-making that promote sustainable energy transitions may be accomplished through the formation of collaborative networks among academics. These networks can make it easier to use a variety of perspectives and abilities.

3.2 Average Citations Per Year

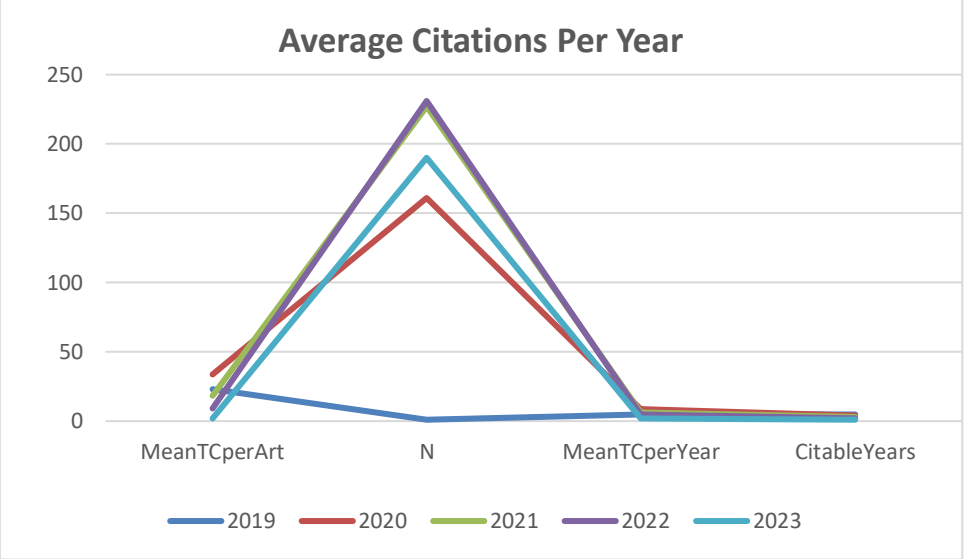

Fig. 2. Average Annual Citations Per Year

As seen in Figure 2, it provided presents an overview of the Mean Total Citations per Article (MeanTCperArt), the number of articles (N), the Mean Total Citations per Year (MeanTCperYear), and the Citable Years across different years from 2019 to 2023. These metrics offer insights into the impact of citations and the productivity of scholarly articles within a particular field or domain. The Mean Total Citations per Article (MeanTCperArt) column indicates the average number of citations received by individual articles in each respective year. There is a notable fluctuation observed across the years, with a peak in 2020 (33.71 citations per article) followed by a decline in subsequent years. This variability could signify

shifts in research focus, publication trends, or the impact of specific studies within the field. The column displaying the number of articles (N) showcases the volume of scholarly output for each year. There is a substantial increase in the number of articles from 2019 to 2023, peaking in 2022 with 231 articles. This surge in publication output could reflect an increasing interest or focus on the subject matter during these years. The Mean Total Citations per Year (MeanTCperYear) column signifies the average number of citations received annually across all articles published each year. Notably, the values fluctuate across the years, with the highest average citations per year seen in 2020 (8.43 citations per year) and a subsequent decline in the following years. This indicates variations in the citation impact of articles published in these years, potentially influenced by the changing dynamics of the field. Lastly, the column titled Citable Years illustrates the average number of years that articles from a particular publication year remain citable. The declining trend from 2019 to 2023 suggests that more recent articles tend to have a shorter citation period, possibly due to evolving research methodologies, rapid advancements, or shifts in scholarly practices. Overall, the table presents a dynamic landscape of citation impact, publication output, and the longevity of articles' relevance within the field across the years 2019 to 2023. The fluctuations observed in citation metrics and publication numbers highlight the evolving nature of research activities and scholarly contributions in this particular domain, indicating potential shifts in focus, research trends, or influential studies impacting the field's trajectory over time.

3.3 Thematic Map

The application of thematic mapping to Multiple Criteria Decision Making (MCDM) in the energy sector offers a visually informative depiction of the various aspects that impact decision-making procedures. These maps provide a thorough understanding of several criteria, including social concerns, economic viability, and ecological impact, across different geographic locations by combining spatial and thematic data. Figure 3 shows the thematic map in the context of energy planning and development; decision-makers can identify patterns, hotspots, and areas of particular importance by using theme maps, which highlight the spatial distribution of different decision criteria.

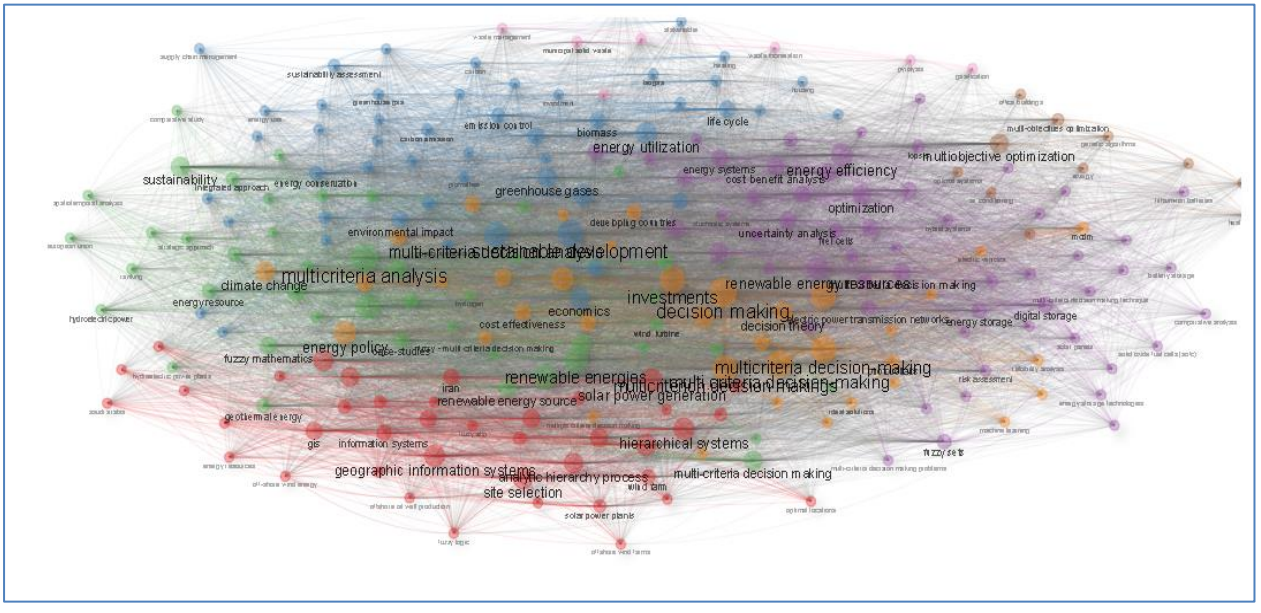

Fig. 3. Thematic Map

As seen from Figure 3, various criteria and visualizations are presented, ranging from criteria utilized in energy efficiency, energy sources, site selection, and many more. These criteria have been utilized within the context of MCDM, Energy, and their associated areas in various MCDM energy research. Selecting the best energy alternative that is enabled by the various geographical effects with a diversity of energy resources is made easier with the help of this visual method. Policymakers, academics, and stakeholders can benefit significantly from thematic mapping as it helps them better comprehend the spatial dynamics present in the intricate decision-making processes pertaining to energy resources and infrastructure. Further details on the thematic mapping are presented in the following Figure 4.

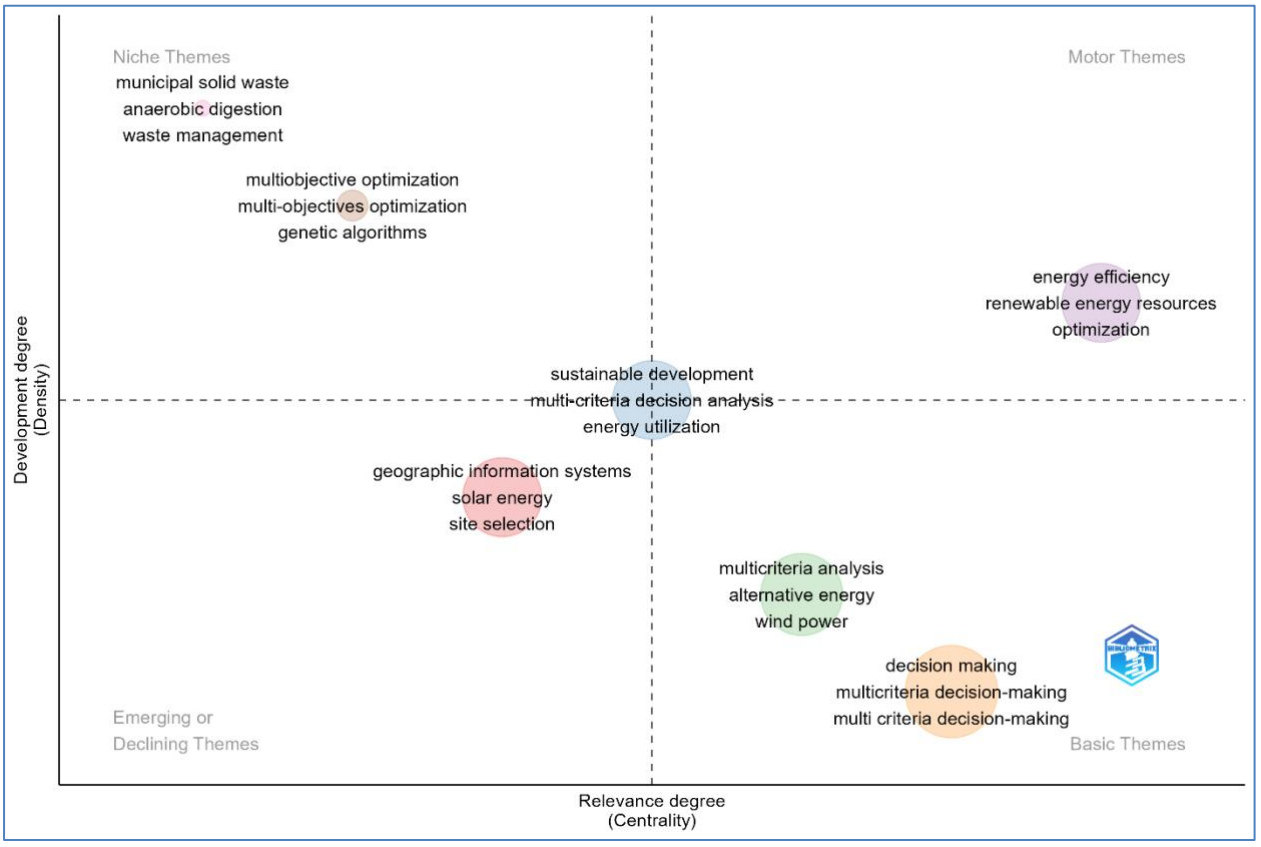

Fig. 4. Thematic Map

The MCDM and energy research fields are characterized by an environment that is constantly moving. Within this context, a variety of rising and decreasing themes have evolved, which represent changing priorities and problems. Some of the emerging themes include the utilization of life cycle analyses for the purpose of conducting an all-encompassing evaluation of various energy alternatives, the growing emphasis on resilience and adaptability in the face of the unpredictability of climate change, and the incorporation of artificial intelligence and machine learning techniques in order to enhance decision-making procedures. In addition, there is a rising interest in researching the socioeconomic implications of energy choices, taking into consideration topics such as participation in the community, equity, and accessibility. When, on the other hand, the profession grows to realize the importance of more comprehensive and interdisciplinary methods, specific traditional topics, such as simply economic-centric evaluations or decision models based on a single criterion, are becoming less popular. This transition underlines the development of MCDM in the energy sector, which is occurring as a result of the growing recognition among academics of the importance of adopting a more comprehensive set of criteria and methodologies in order to address the complex and interconnected challenges associated with the generation of sustainable Energy. Across the four main themes presented in the previous Figure 4, the NICHE theme includes a focus on areas where MCDM and Energy collide, including municipal solid waste and waste management. For the motor theme, the main areas discussed included renewable energy sources and clean Energy. Declining themes, on the other hand, were concentrated on things like geographical information systems, and basic themes included alternative Energy and wind power.

3.4 Co-Occurrence Network

Co-occurrence network analysis is a technique that is utilized in a wide variety of areas to discover the connections that exist between the components that make up a dataset. Through the construction of networks that graphically illustrate the relationships between entities, it focuses on determining the frequency with which entities occur together. The purpose of this approach is to uncover hidden patterns, essential features, and theme frameworks that may not be obvious through standard research. This method is utilized in a variety of fields of study. With the use of co-occurrence networks, one may discover insights, support decision-making, and investigate emerging patterns. This is accomplished by translating data into network representations and analyzing the attributes of these representations. When everything is said and done, this

method provides a vital way of comprehending convoluted relationships and gleaning significant information from complex datasets. See Figure 5.

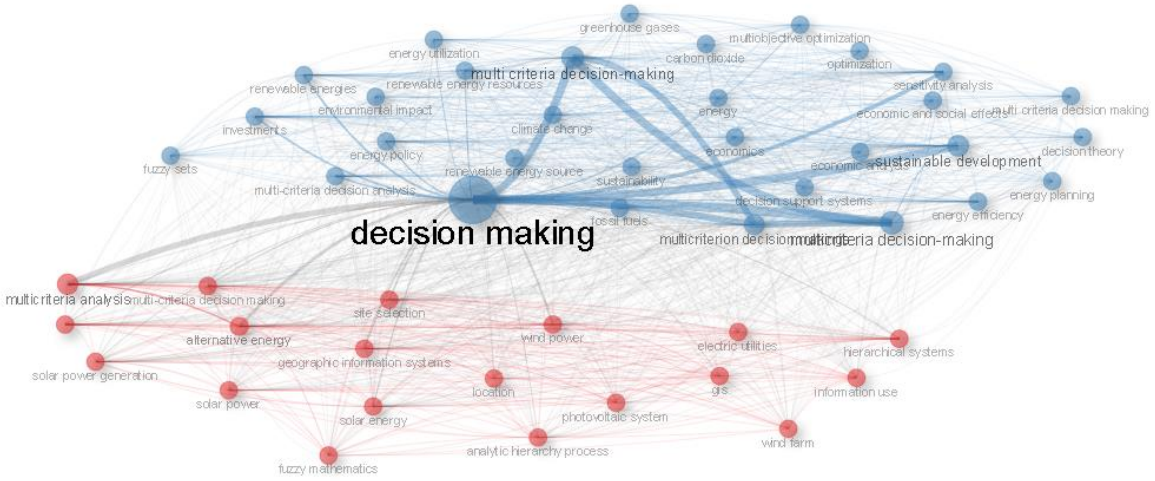

Fig. 5. Co-Occurrence Network

Constructing and analyzing co-occurrence networks in the context of Energy and MCDM offers significant perspectives into how essential ideas, themes, and techniques relate to one another, as shown in Figure 5. These networks have nodes that reflect concepts or keywords that can be found in academic publications and edges that show how frequently these terms appear together. Through the process of mapping, scholars are able to discern the most fundamental and impactful ideas, uncovering correlation patterns and emphasizing the conceptual framework within the field of study. From the figure, it can clearly be seen that amongst the most notable network co-occurrences comes site selection for energy-related devices. Wind power, electric utilities and many more followed this. Other options included in this network were concerned with wind farms, solar Energy, and Alternative Energy. As for the upper part of the discussion on network co-occurrences, the discussion was meant and focused on fuzzy sets, fossil fuel, and many other forms of MCDM utilization in such a case study. It is seen that co-occurrence networks can identify new trends, transdisciplinary connections, and possible deficiencies in research by providing a visual depiction of the links between different MCDM and energy-related factors. By helping academics and professionals navigate the intricate web of interconnected ideas and encouraging a more integrated and cooperative approach to decision-making in the energy sector, the analysis of these networks improves our understanding of the knowledge landscape.

4. CONCLUSION

In this research, we used bibliometrics and social network approaches to analyze many publications that were linked to MCDM and Energy and published over the past five years. Bibliometric analysis was used to take into consideration and assess a wide range of factors, including the trend of publications that were published as well as many other characteristics. Additionally, the dynamics of collaboration among authors and research hotspots in the MCDM energy sector were examined by establishing social networks across four distinct periods. This was done in order to understand the topic better. Applications of MCDM to handle energy-related issues and problems have also garnered attention, particularly in a variety of applications and fields of study. The limits of such a study cannot be denied; there is no way around it. To begin, no other papers or reviews from the ISI World of Science are included in our dataset. On the other hand, there are a significant number of publications concerning MCDM and Energy that have been published in other journals that are not included in the ISI WoS retrieval system. Specific terms have the same meaning on co-word networks, but they are displayed as words that are similar to one another. In the future, we intend to finish our dataset by adding contents from other databases, pre-processing the words by employing text mining techniques, and carrying out research from a variety of perspectives in order to produce a ranking of authors and journals that is more precise. Additionally, it is our aim that our research will be of use to other researchers working on the subject of MCDM as well as other relevant disciplines.

Conflicts of Interest

The authors declare no conflicts of interest

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