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A comprehensive review of progress in sustainable development goals from energy and environment perspectives

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ABSTRACT

Given the increasing negative impact of environmental issues, mainly caused by high energy use, it is becoming increasingly important to focus on achieving the Sustainable Development Goals (SDGs). In light of these critical issues, this study comprehensively reviews the contemporary environment and energy-related literature from the point of view of SDGs so that the progress of the SDGs can be viewed from both environment and energy perspectives. Accordingly, the study undertakes a global scale by conducting a systematic review approach, identifying 2826 and 1917 articles in environment- SDGs and energy- SDGs areas in SCOPUS database. Through examination of these studies, the outcomes show that: (i) the number of SDGs-related studies has been increasing since 2015 and the number of environment-SDGs studies has exceeded the number of energy-SDGs studies; (ii) in the environment-SDGs studies, sustainable goals, renewable energy, and climate change are the basic themes, but it has changed from 2015 through 2022; (iii) in the energy-SDGs studies, renewable energy, sustainable development, and economic development terms have become motor themes after 2020; (iv) although climate action topic is in the niche theme before 2018, it is categorized as an "emerging or declining" theme after 2020; (v) most of the studies have been published by journals from Springer, MDPI, and Elsevier; (vi) the most prolific authors are from Tsinghua and Cyprus International Universities in environment-SDGs and energy-SDGs studies, in that order. This review assesses the emerging trends in the SDG-related environment and energy literature. Accordingly, policy implications and future research to support the achievement of the SDGs are discussed.

1. Introduction

In view of the increasing interest in climate change issues, which are mainly due to anthropogenic activities, achieving the SDGs has become one of the most important issues [1]. The basic building blocks of the SDGs are economic and environmental sustainability [2–7]. Environmental sustainability examines the ability of the ecosystem to cope with human activities, while economic sustainability focuses on the effective use of natural resources.

Among other factors, energy plays an important role in sustainable

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development [8–13]. While many years ago humanity met all of its energy needs from clean sources (e.g., using wind to power seagoing vessels and water to run watermills) [14], communities began to use more fossil fuels to meet needs (e.g., heating & cooling) due to increasing energy demand [15]. This change has led to an increase in carbon emissions and thus climate change.

Due to environmental concerns, countries have focused on increasing the use of clean energy [16]. SDG 7 (clean energy) is directly related to the use of affordable and clean energy to achieve sustainable development. SDG 7 aims to promote the use of clean energy sources, including renewable and nuclear energy sources. However, although SDG 7 intends to combat climate change through the use of clean energy, there are some barriers (e.g., energy poverty) to achieving this goal [17,18]. Through promoting clean energy, societies can reap the environmental benefits and contribute to the achievement of SDG 13 (climate action), which remains a focus for countries and stakeholders. Accordingly, various studies have analyzed the relationship between clean energy and carbon emissions. Some researchers have found that clean (renewable) energy is a carbon-mitigating factor (e.g., Ref. [19,20]), while some others have emphasized that it is not used effectively (e.g., Ref. [21]).

Given the enormous negative impacts of climate change, it is crucial to take timely action to prevent irreversible consequences [22]. Accordingly, various studies have examined the causes of climate change and environmental degradation in the context of the SDGs. While earlier studies used carbon dioxide (CO2) emissions as the main indicator of environmental degradation (e.g., Ref. [23]), much later studies have preferred to use other proxies, such as ecological footprint, load capacity factor, carbon intensity, carbon footprint, and material footprint as more comprehensive environmental indicators (e.g., Ref. [17,24]).

In line with the great importance of climate-related topics for the humanities, there is a rich literature on the SDGs from an environmental and energy perspective. Studies on the SDGs have been conducted on a large scale. While some of them have focused on the SDGs through empirical investigations (e.g., Ref. [25–28]), others have preferred to examine the SDGs in the form of a review of previous studies from different perspectives (e.g., Ref. [29–36]). In these studies, a small number of selected articles have been examined by the researchers using different approaches.

In recent years, some researchers have employed bibliometric analyzes to assess the SDGs (e.g., [5,37–45]). These studies have generally focused on examining the SDGs by covering a single domain in a limited number of articles. However, to make an assessment in a specific area of the SDGs, many more studies need to be considered. Therefore, there is a gap in the current literature in this regard. Considering this gap, the study conducts a comprehensive bibliometric analysis of the SDGs. It examines 2826 articles in the field of environment domain and 1917 articles in the energy domain. Therefore, it is possible to make a much more comprehensive analysis and draw a general picture of the progress of the SDGs, which is the main significance of this study with regard to the current studies in the current literature.

By applying a systematic review approach to the large number of articles in the areas of environment and energy domains of the SDGs, the study aims to conduct a comprehensive analysis. Therefore, the study makes the following contributions. First, the study is leading as it is the first time that environment and energy domains are together in the review of the SDGs. While previous studies have focused mainly on one domain, this study examines two domains together in a comparative approach. Second, the study examines almost 5000 articles in total, whereas previous review articles examined a smaller number of articles. Therefore, the study is quite comprehensive in terms of content. Third, in addition to the traditional parameters, the study considers load capacity factor, which is a recent environmental proxy, for the first time in a bibliometric study, which has not been used before. Based on these contributions, the study discusses a range of policy efforts to achieve the SDGs by 2030.

In the second part, which consists of four subsections, the selected methods and key words are presented. In the third part, the results are presented and discussed. The fourth part concludes with an assessment of the SDGs from energy and environmental perspectives.

2. Methods

2.1. Empirical approach

A six-step approach is followed in this systematic review and the proposed research framework is shown in Fig. 1.

The research methodology comprises a well-defined series of sequential steps that guide the systematic review. These steps are crucial to the research process and ensure the reliability and completeness of this study.

The first step is to carefully define the conceptual boundaries and scope of the research. This involves a comprehensive review of the existing literature. In this way, it is possible to precisely define the research's domain, which enables a targeted exploration of the chosen topics.

After defining the conceptual boundaries of the research, the second step is to identify and select keywords that play a prominent role in the pertinent academic discourse. The selection of these keywords is of central importance as they open up access to and evaluate the literature on the research domain. The selected keywords are refined by examining their prevalence in academic publications and their relevance to the thematic content of the research.

In the third stage, the identified keywords are systematically divided into distinct categories. This segmentation is carried out in order to differentiate between publications that pertain specifically to the domains of "Environment & SDGs" and "Energy & SDGs". This enables a targeted and selective search for relevant scientific material.

The fourth step consists of an extensive search for academic publications in the SCOPUS database, using the selected keywords. The chosen time period for data collection ranges from 2015/1 to 2023/9 and includes the most recent research contributions within the domain of this study.

The fifth step comprises an in-depth bibliometric analysis. This multi-layered analysis includes the evaluation of fundamental publication metrics, such as the number of publications and the average number of citations. In addition, this stage involves the identification of key authors and sources that have made significant contributions to the field. The most important sources that form the basis of scientific knowledge in the domain, are identified. Furthermore, temporal trends in research production and the productivity of authors are examined. Emerging research topics are discerned through a comprehensive trend analysis. Visualizations such as co-occurrence networks, co-citation analyzes, collaboration networks, and thematic maps are employed to gain deeper insights into the academic landscape.

The sixth and seventh steps of the methodological framework relate to drawing meaningful implications and conclusions from the collected data and bibliometric analyzes. These insights contribute to a refined understanding of the scope of the research and the academic environment.

2.2. Construction and keywords

The main reason for using the SCOPUS database, which is widely used for bibliometric analysis, is that it comprehensively covers various academic fields and represents research worldwide, providing a holistic view of the academic landscape [46,47]. SCOPUS provides high quality and reliable data, detailed citation information to assess the impact of scholarly works, advanced search and analysis tools, and author and affiliation data for insights into collaboration. SCOPUS also enables integration with other research analysis tools, provides longitudinal

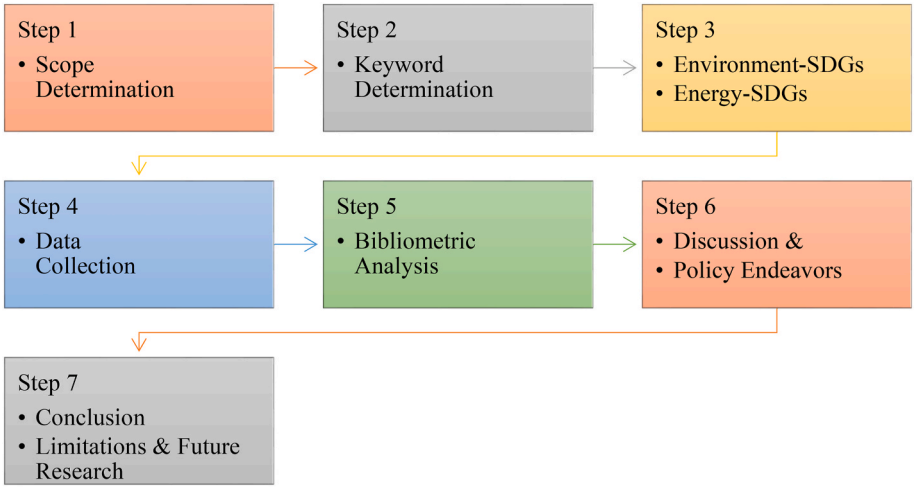

Fig. 1. Flowchart of the Methodology Adopted. This figure visually illustrates the seven separate steps used in the study and the sequence of the review strategy.

data to track trends over time, and offers access to full-text articles. SCOPUS is widely recognized in the academic world and is considered a reputable source for bibliometric research. It is also possible to consider the Web of Science database, as is the case for some recent studies (e.g., Ref. [48]). However, for the study based on the planned concept and keywords, SCOPUS provides more resources than the Web of Science database. Therefore, the SCOPUS database is used.

In the SCOPUS database, the words used in the query are searched for in the title of the study, in the keywords, and in the abstracts. By considering the most recent studies in the fields of energy and environment, two different datasets are generated from the SCOPUS database with the keywords listed in Table 1.

3. Results

3.1. Descriptive analysis

As part of the empirical investigation, the analysis begins with descriptive statistics, which include the main statistics, such as the number of documents and sources, the annual growth rate, and the average citations per document. Table 2 provides a comprehensive overview of research related to the SDGs in the domains of environment and energy.

There are 2826 documents and 838 sources in the area of Environment & SDGs, while there are 1917 documents and 557 sources in the area of Energy & SDGs. The annual growth rate in both datasets is also

Table 2
Main statistics.

Description	Environment & SDGs	Energy & SDGs
Documents	2,826	1,917
Sources	838	557
Annual Growth Rate	50 %	82 %
Average Citations per Document	17.7	19.6
References	162,192	111,778
Authors	10,289	6,127
Single-authored Documents	259	170
Average number of Co-Authors per Documents	4.8	4.2
International Co-authorships	43 %	47 %

Table 1
Keywords used.

Environment & SDGs			Energy & SDGs		
Environment		SDGs	Energy		SDGs
carbon dioxide	GHGs	sustainable development goal	energy access	renewable energy consumption	sustainable development goal
carbon dioxide emission	Greenhouse gas emissions	sustainable development goals	energy conversation	non-fossil energy	sustainable development goals
CO_2	Nitrous oxide	SDG	energy generation	non-fossil energy consumption	SDG
CO_2 emission	Nitrous Oxide (N_2O)	SDGs	energy infrastructure	solar energy	SDGs
CO_2 emissions	Methane	SDG13	energy input	wind energy	SDG7
carbon emission	Methane (CH4)	SDG 13	energy intensity	hydro energy	SDG 7
ecological footprint	carbon				
footprint	SDG-13	energy investments	waste energy	SDG-7	
biocapacity	carbon				
intensity	climate action	energy ladder	wood energy	affordable and clean energy	
load capacity factor	carbon efficiency		energy needs	biofuel energy	
particulate matter	material footprint		energy poverty	biomass energy	
particulate matter 2.5			energy savings	geothermal energy	
greenhouse gas			energy security	natural gas consumption	
greenhouse gas emission			energy transition	natural gas	
Greenhouse gas			renewable energy		

Based on the search with the above-mentioned keywords in the period between 2015/1 and 2023/9, which is the most recent data available at the time of writing, a total of 2826 and 1917 documents, which are either research or review articles, are found on the topics “Environment & SDGs” and “Energy & SDGs” respectively.

impressive. Studies on Environment & SDGs have grown at a remarkable rate of 50 %, while studies on Energy & SDGs have seen a significant growth of 82 %, indicating a growing interest in both areas. Documents on environment and SDGs are cited 17.7 times on average, while documents on energy and SDGs are cited 19.6 times, revealing that research on energy and SDGs is cited more widely. In terms of references, 162,192 citations are identified in the research documents on environment and SDGs, compared to total of 111,778 citations in the research documents on energy and SDGs. This indicates that external sources are used much more frequently in environmental and SDG research.

The results also reveal that Environment & SDGs includes a larger community of 10,289 authors, indicating broader participation, while Energy & SDGs research involves 6127 authors. Looking at the documents written by individual authors, it can be seen that there are 259 authors in Environment & SDGs, compared to 170 in Energy & SDGs. This means that more authors are involved in research on the environment and SDGs. The average number of co-authors per document is 4.8 and 4.2 for Environment & SDGs and Energy & SDGs, respectively. This indicates a collaborative nature in both areas. International co-authorship is also remarkable in both areas. In Environment & SDGs, 43 % of the documents have international co-authors, while in Energy & SDGs, 47 % of the research has international co-authors. Further preliminary statistics are presented in Figs. 2 and 3

The annual number of documents shows a remarkable upward trend, especially after 2019. By September 2023, the number of documents reaches 830 in Environment & SDGs and 604 in Energy & SDGs. Both categories exhibit fluctuations in average citations per year, with a peak in 2019, Fig 4 and 5 when Environment & SDGs recorded 9.1 citations and Energy & SDGs 11.5 citations. In addition, Bradford's Law can be used to show that 10 journals publish around 35 % of the documents in all the collections used for the study [49]. The top three journals are Environmental Science and Pollution Research (ESPR), Sustainability, and Journal of Cleaner Production in Environment & SDGs while ESPR, Energies and Sustainability in Energy & SDGs.Fig 6

The statistics on author productivity calculated on the basis of Lotka's law, which describes the frequency of publications by authors in a given field, are taken into account [50]. The resulting data show that 85.3 % of the authors in the Environment & SDGs dataset have written only one scientific paper. This ratio is similar in the Energy & SDGs dataset, at 85.5 %. After examining the productivity of the authors, the most relevant affiliations are also examined. The top three affiliations are Tsinghua, Beijing, and Zhejiang University in the Environment & SDGs dataset, while Cyprus International University, International Institute for Applied Systems Analysis, and İstanbul Gelişim University are the most prolific in the Energy & SDGs dataset.

China is the leader in the number of articles published in the Environment & SDGs dataset with 526 articles. It has an almost evenly split between publications from one country (53 %) and publications from multiple countries (47 %). The United States (USA) has the second highest number of articles with 202. The majority of its publications are single-country publications (65 %). India is the third largest contributor with 154 articles. India also has the highest percentage of single-country publications among the top countries at 67 %. In contrast, China has the most articles in the Energy & SDGs section (320), indicating a high output of scientific publications. However, the proportion of publications from a single country is relatively low (48 %), indicating that a significant part of China's research output comes from international collaboration. India has the highest proportion of publications from a single country at 71 %. This means that the vast majority of articles originating from India are written by researchers or institutions in that country itself.

3.2. Analysis of the Studies on Environment & SDGs nexus

The bibliometric dataset on environment & SDGs contains maps on co-occurrence, collaboration network and thematic (evaluation) maps by using RStudio software. Fig. 7 shows the co-occurrence network map for the keywords used by the authors.

The co-occurrence map is created on the basis of two fundamental concepts: Betweenness centrality and Closeness centrality. The term "betweenness centrality" is a concept that helps identify nodes that play a crucial role in maintaining network connectivity and efficient communication by acting as bridges or intermediaries between other nodes. In addition, the term "closeness centrality" measures how central a node is in the network by quantifying its closeness to all other nodes. Nodes with high closeness centrality are well-connected and can efficiently disseminate information or influence the rest of the network.

The result of the analysis of the Co-Occurrence Network Map identifies three main clusters (or themes). The first cluster is characterized by carbon dioxide, carbon emission, environmental economics, and economic and social impacts. The second cluster is characterized by the terms of sustainable development, environmental protection, greenhouse gasses, and gas emissions. The terms controlled study, particulate matter, and agriculture are the three most important terms in the last cluster.

Fig. 8 shows the thematic map of three clusters obtained from the co-occurrence analysis. The x-axis represents the centrality, which can be seen as a measure of importance, while the y-axis represents the density, which can be seen as a measure of the development of the theme.

The keywords "article, human, and humans" belong to the niche theme, while "sustainable development, sustainable development goal, and climate change" belong to the basic theme. Finally, "carbon dioxide,

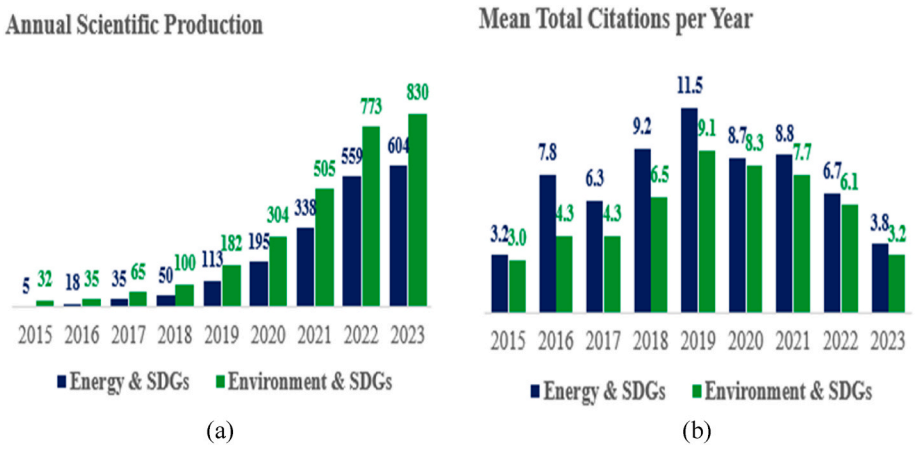

Fig. 2. Annual Scientific Production and Mean Total Citation per Year. The figure shows that the number of publications in the field of energy, environment and SDGs has increased over the years, but the average citation frequency of articles has decreased per year.

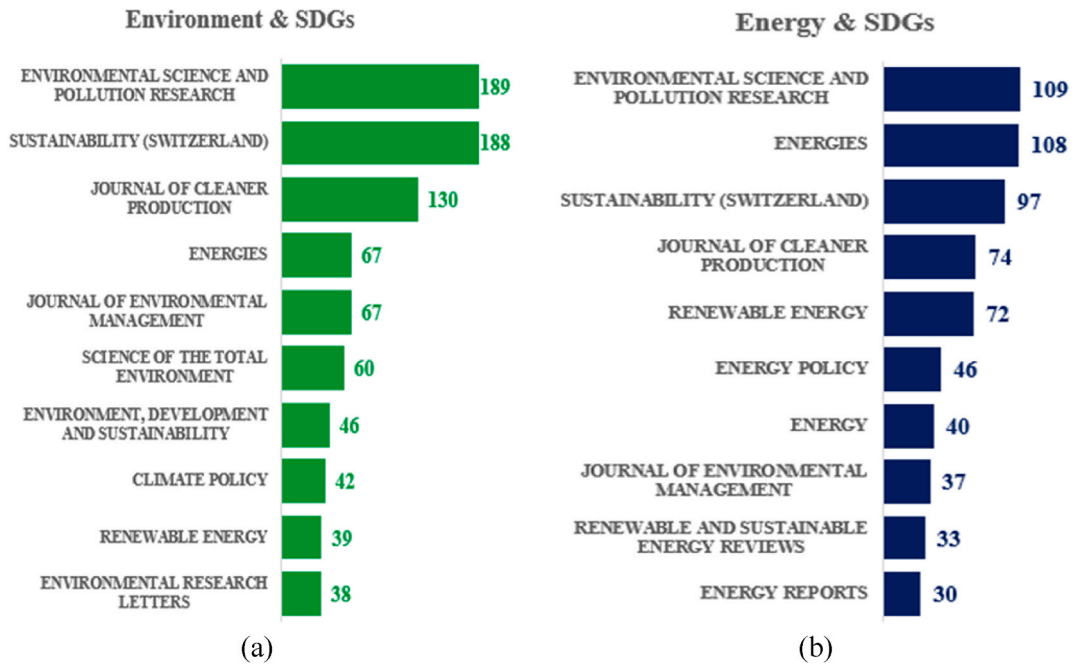

Fig. 3. The Most Relevant Journals. The figure shows the most published WOS-indexed journals in the field of environment, energy and SDGs.

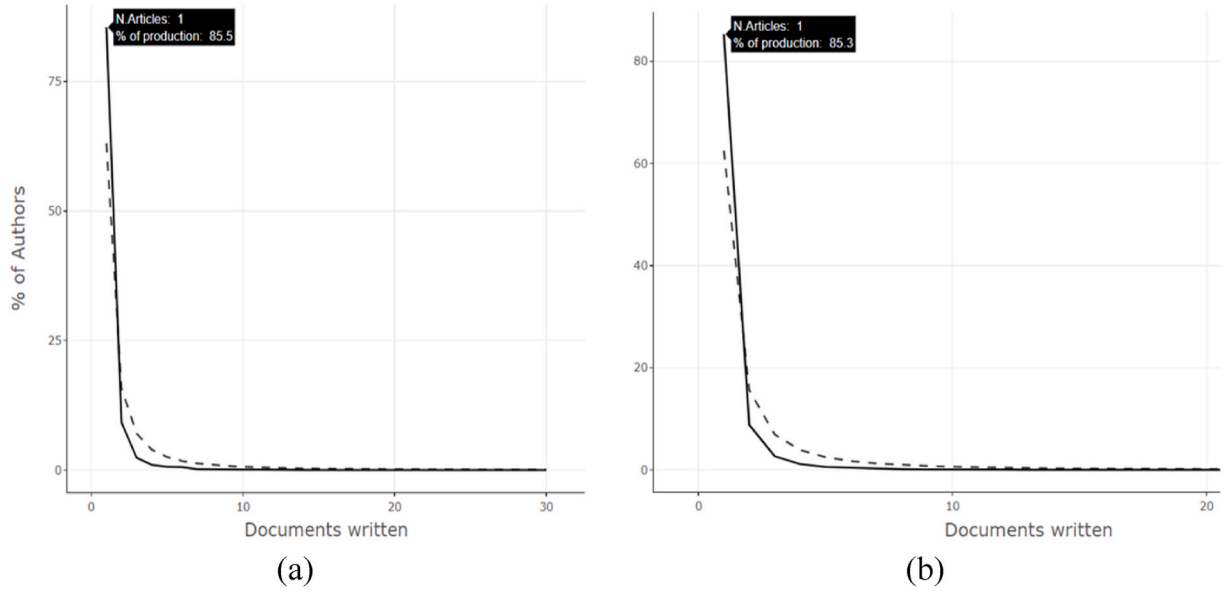

Fig. 4. Author Productivity through Lotka's Law. The figure presents the relationship between articles written and the productivity of authors.

carbon emission, and economic development" are right in the middle of all four themes.

Fig. 9 represents the evaluation of the author's keywords in the Environment & SDGs dataset over time. The time intervals are decided based on the frequency distribution of the published articles and the productivity analysis of the authors.

It can be seen that there are two groups of keywords that were frequently used before 2017. Between 2018 and 2020, the number of keywords has decreased, but three different keywords stand out: Sustainability, Climate Change, and Paris Agreement. It can be seen that the keywords that were used between 2015 and 2017 as Paris Agreement, climate governance, climate, and climate policy are grouped under the title of Paris Agreement between 2018 and 2020. The second group of keywords such as sustainability, agriculture, greenhouse gas, carbon emission, and China are collected under the main heading of climate change in 2018–2020. After 2020, these keywords are grouped under three headings: SDGs, Climate Change, and SDG13: Climate Action. Before 2018, the topics of climate change, sustainable development, climate policy, and mitigation were categorized as basic themes, while the topics of sustainability and carbon footprint were categorized as motor themes. After 2020, however, the targets for renewable energy and sustainable development have become motor themes. To summarize, climate action topic was a niche theme before 2018, while it is categorized as an emerging or declining theme after 2020. The author's collaboration network map for Environment & SDGs is given in Fig. 10.

There are six clusters, which are visualized in different colors. Adebayo T.S., Abbas S., Ullah S., Pata UK., and Kirikkaleli D. generally work together. Similarly, Bekun F.V., Alola A.A., Sarkodie S.A., and Hossain

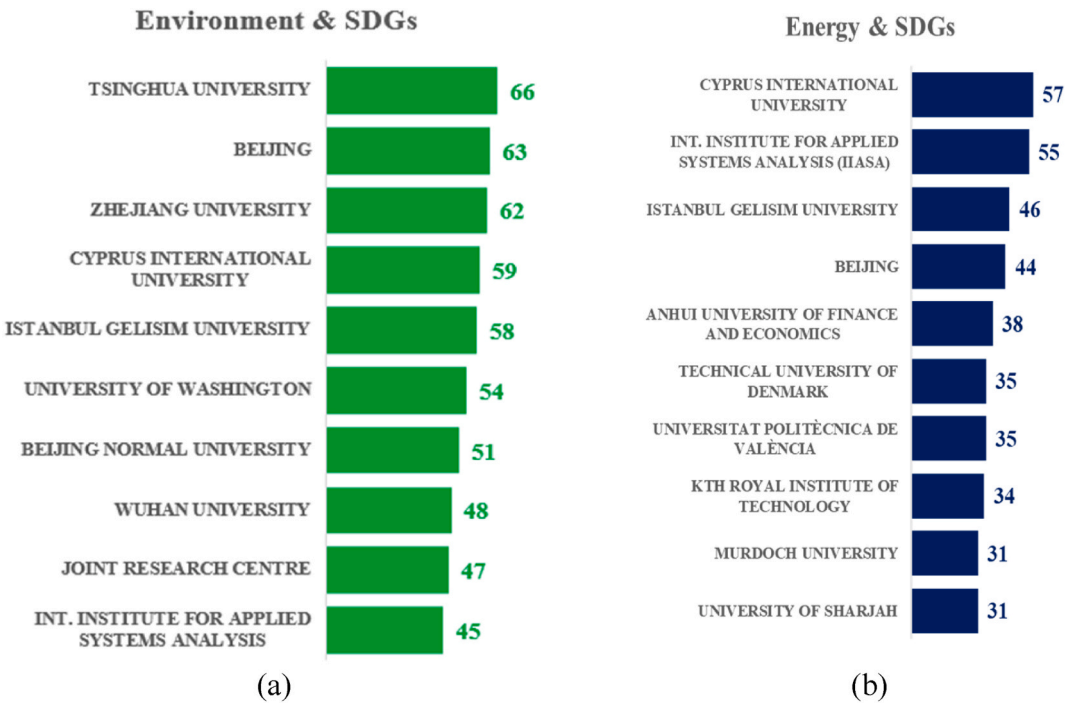

Fig. 5. The Most Relevant Affiliations. The figure presents the affiliation weights of researchers working on energy, environment and SDGs.

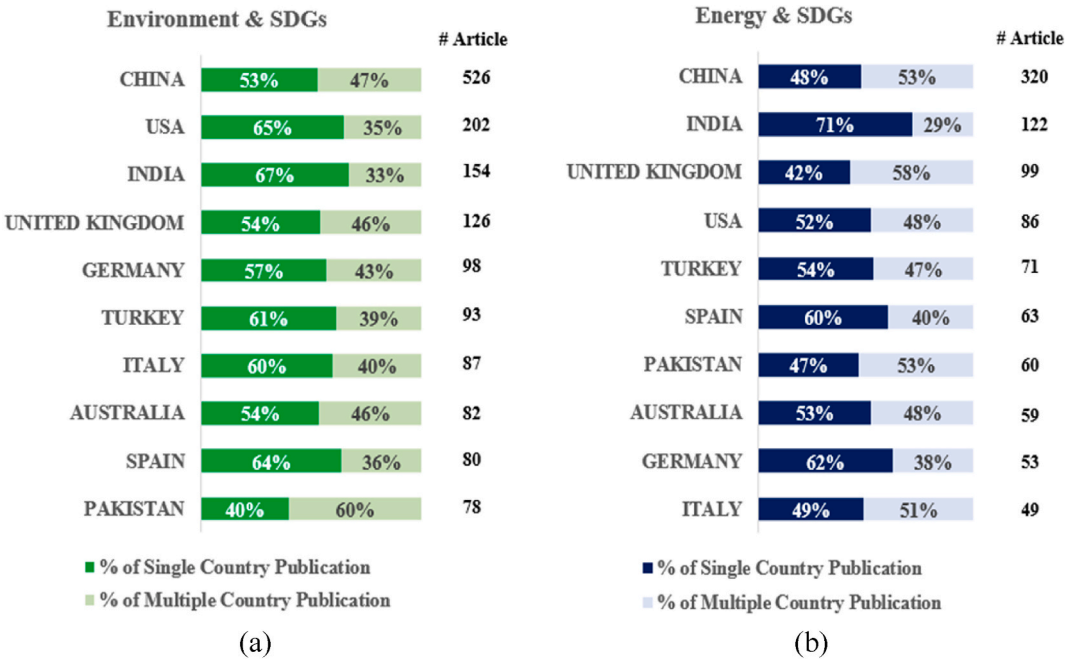

Fig. 6. Corresponding Author's Countries. The figure shows the country weight of researchers publishing in the fields of energy, environment and SDGs.

M.E. generally collaborate. Among the third group of authors, Wang Y. stands out. Fig. 11 shows the institutional collaboration network map for the Environment & SDGs.

Cyprus International University and İstanbul Gelişim University stand out in the network map of institutional cooperation for Environment & SDGs. However, the authors of Tsinghua University collaborate with many institutions, which is shown in yellow. Fig. 12 visualizes the country collaboration network map for Environment & SDGs.

Two clusters emerge with centers are China and the USA. In addition, authors from China, India, Pakistan, Türkiye, and Malaysia frequently collaborate in the first cluster, while authors from the USA, Germany, Italy, Spain, and Japan also frequently collaborate in the second cluster.

3.3. Analysis of the studies on energy & SDGs nexus

The bibliometric dataset on energy & SDGs contains maps of co-occurrence, the cooperation network, and thematic maps. Fig. 13 shows the co-occurrence network map of the keywords used by the authors.

The results of the analysis of the Co-Occurrence Network Map show that there are three main clusters. The first cluster is characterized by the terms planning, renewable energy sources, and energy policies. The

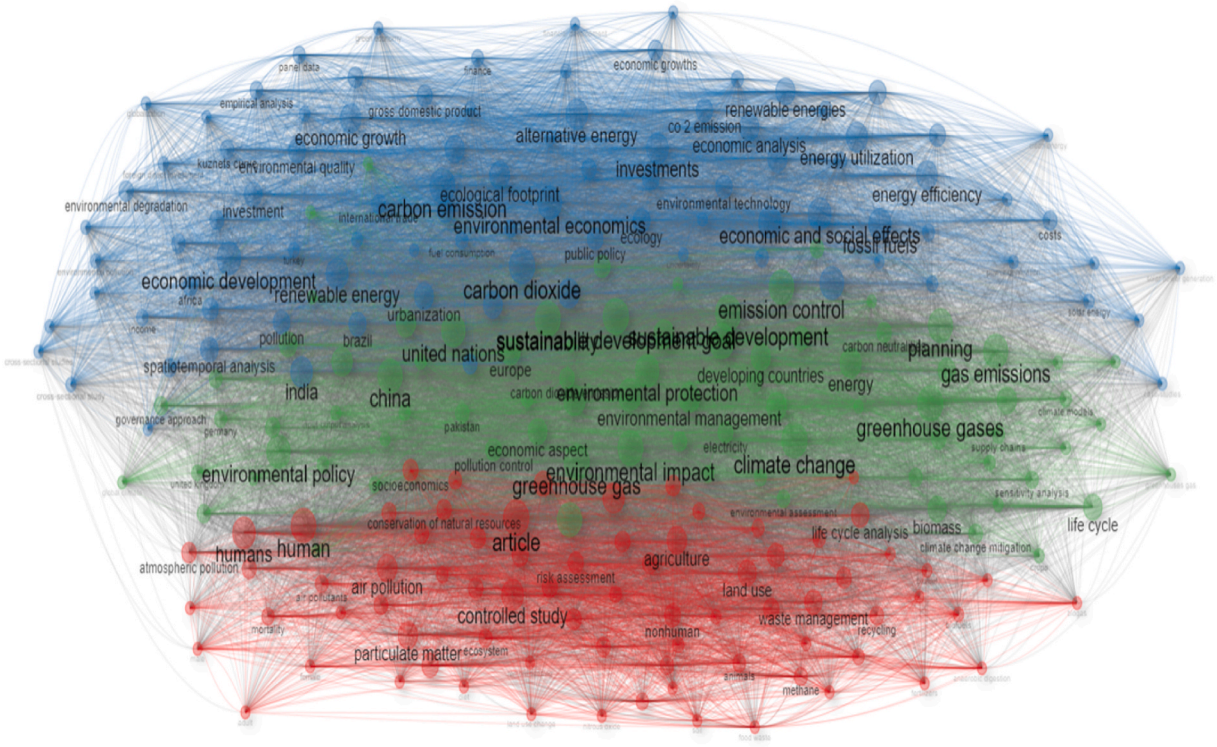

Fig. 7. Co-Occurrence Network Map of Keywords for Environment & SDGs. The figure visually presents the keywords used most by the studies examining the environment & SDGs link with a network map.

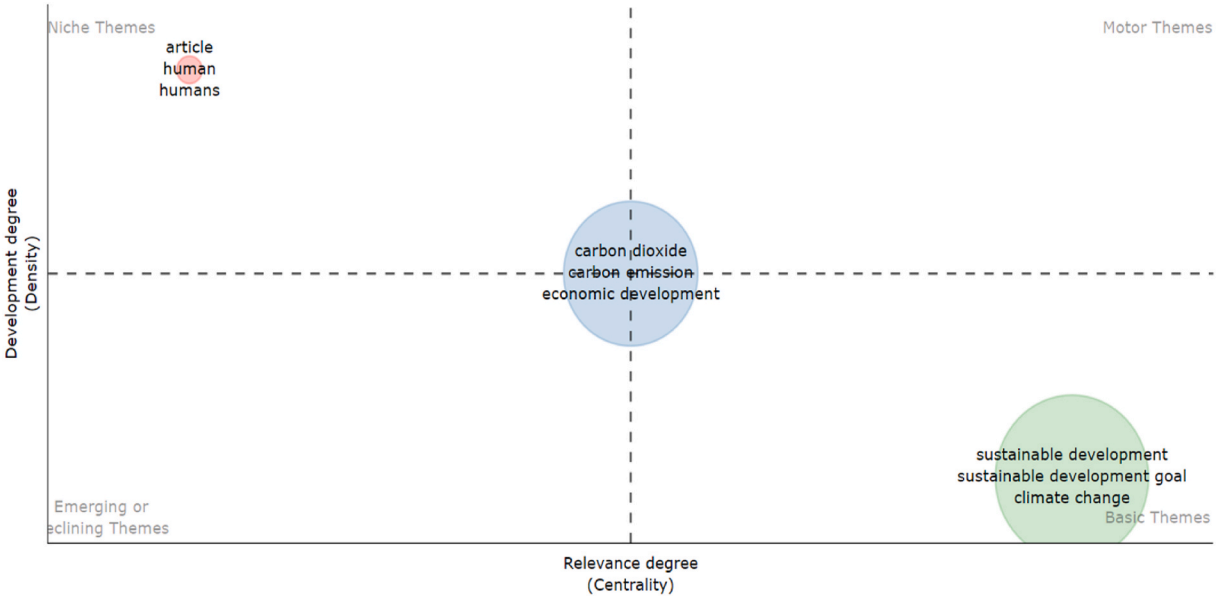

Fig. 8. Thematic Map for Environment & SDGs. The figure uses a thematic map to show that the concepts of carbon dioxide, carbon emission and economic development stand out in the environment & SDGs relationship.

second cluster is characterized by the terms of sustainable development, sustainable development goal, and renewable energies. The terms alternative energy, carbon dioxide and economic development are the three most important terms in the last cluster.

Fig. 14 shows the thematic map, which uses a co-occurrence keyword network to plot in a two-dimensional map the typological themes of a domain, in three clusters obtained from the co-occurrence analysis [51]. The x-axis represents centrality, which can be seen as a measure of importance, while the y-axis represents density, which can be seen as a measure of the development of the theme.

There are four different areas: Niche Themes, Motor Themes, Emerging or Declining Themes, and Basic Themes. In addition, the size of the bubbles is proportional to the occurrence of the cluster words. The topics "alternative energy, carbon dioxide, and economic development" are in the middle between motor and niche themes, while "planning, renewable energy resources, and energy policy" are also in the middle between niche and emerging themes. Finally, "sustainable development, sustainable development goal, and renewable energies" are the basic

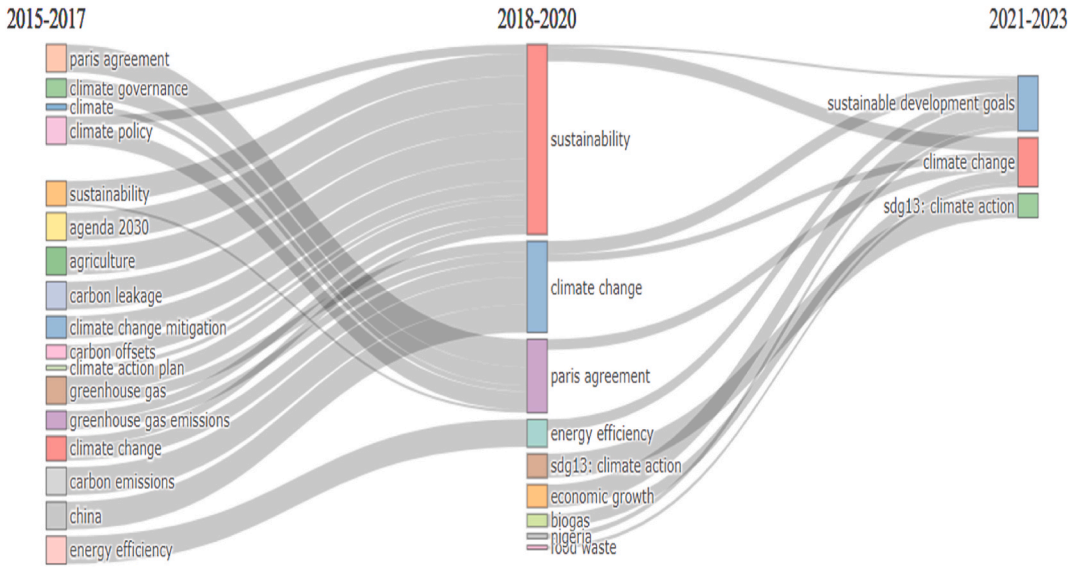

Fig. 9. Thematic Map Evaluation for Environment & SDGs. This figure indicates which terms are frequently used in the Environment & SDGs relationship in three different periods.

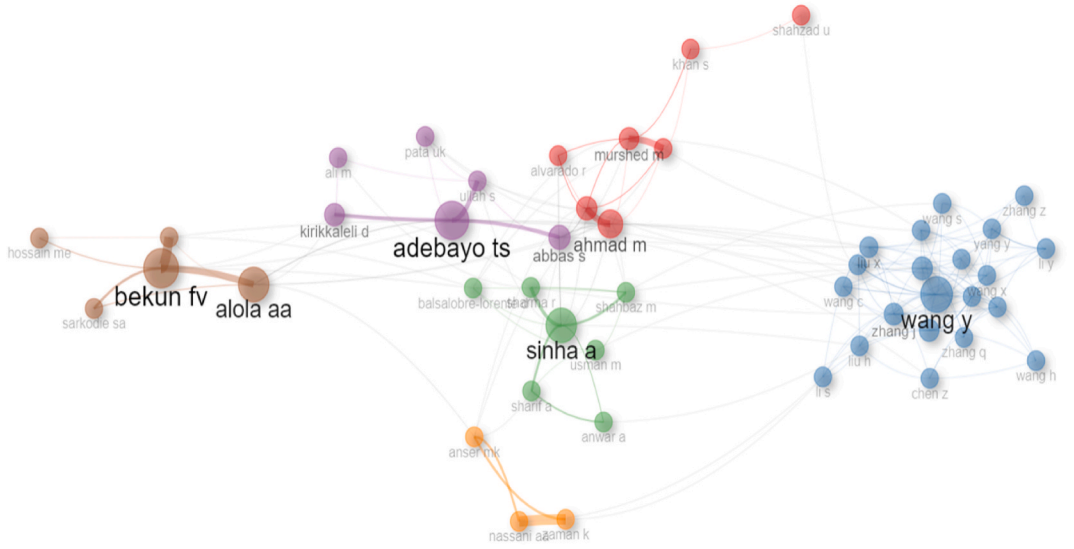

Fig. 10. Author Collaboration Network Map for Environment & SDGs. This figure represents the collaborations of the most published researchers in the field of Environment & SDGs.

themes.

Fig. 15 represents the evaluation of the author's keywords in the Energy & SDGs dataset over time, referred to as Thematic Map Evaluation. The time intervals are determined based on the frequency distribution of published articles and the authors' productivity analysis.

It can be seen that there are two groups of keywords that were frequently used before 2017, while the number of keywords used in scientific papers. Between 2018 and 2020, the number of keywords has increased, but four different keywords stand out: renewable energy, energy access, China and hybrid energy system. It can be seen that the keywords used between 2015 and 2017, such as energy access and energy transition, are grouped under the title of energy access between 2018 and 2020. The second group of keywords such as energy, life cycle assessment, SDG, renewable energy, and energy consumption are summarized under the main heading of renewable energy in the period 2018–2020. After 2020, these keywords are grouped under three headings: SDGs, renewable energy, and life cycle assessment. Before 2018, energy consumption and life cycle assessment topics were categorized as niche themes, while the energy transition was categorized as a noteworthy topic. After 2020, however, renewable energy, sustainable development, and economic development have become motor themes.

The map of the author network for Energy & SDGs, which depicts the collaboration between an author and other authors in a dataset, can be seen in Fig. 16.

There are seven clusters, which are visualized in different colors. It can be said that Adebayo T.S., Abbas S., Irfan M, Ullah S., Akadiri S.S., Kirikkaleli D., and Agyekum E.B. generally work together. Similarly, Sinha A., Usman M., Shahbaz M., Shah M., Sharma R., and Anwar A. generally work together. Among the authors of in third group, Alola A. A., and Bekun F.V. stand out. Fig. 17 shows the map of the institutional cooperation network for Energy & SDGs.

Cyprus International University and İstanbul Gelişim University stand out in the network map of institutional cooperation for Energy & SDGs. However, there are only a few small groups on the map such as

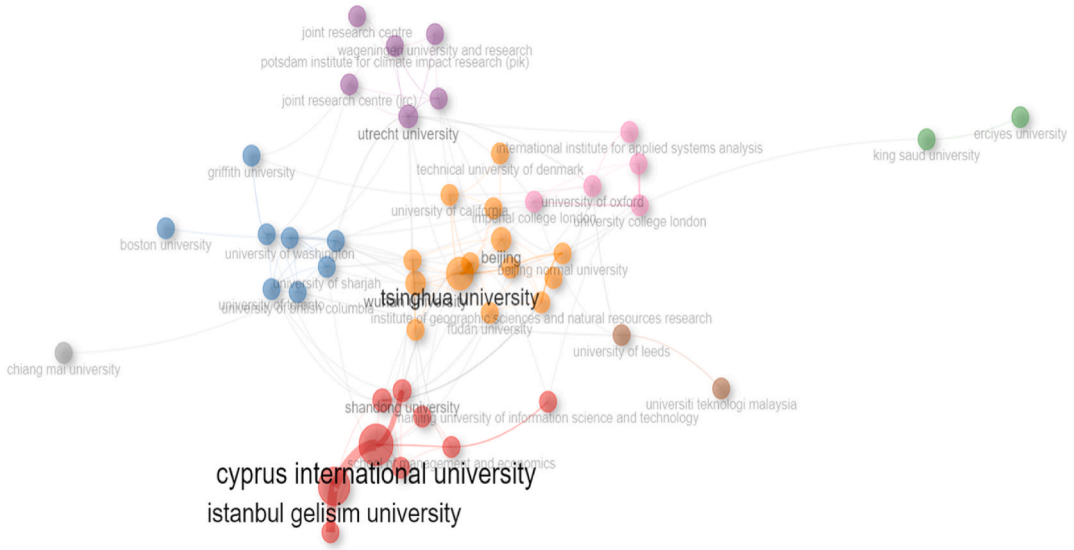

Fig. 11. Institution Collaboration Network Map for Environment & SDGs. This figure shows inter-institutional collaborations in the field of Environment & SDGs relationship.

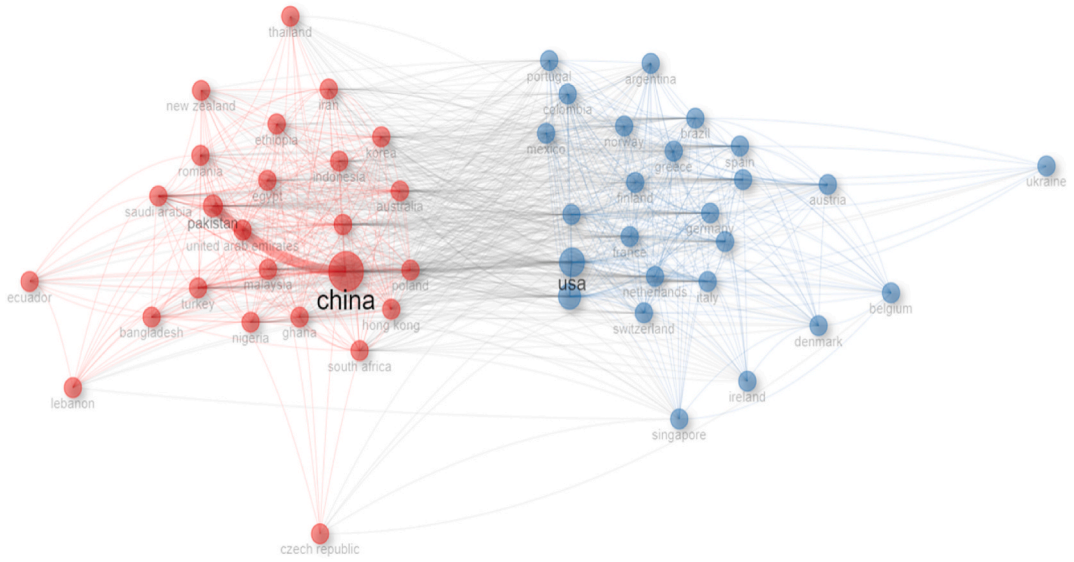

Fig. 12. Country Collaboration Network Map for Environment & SDGs. The figure shows that the countries that publish the most in the field of Environment & SDGs are China and the USA.

Imperial College London, the International Institute for Applied System Analysis, and Utrecht University. Authors from King Abdullah of Science and Technology, the University of Oxford, and the University of Cape Town also collaborate.

In addition to the map of the cooperation network of authors and institutions for Energy & SDGs, this study also shows the map of the cooperation network of countries for Energy & SDGs (see Fig. 18).

It can be seen that there are two clusters, centered on China and the UK. In addition, authors from China, Türkiye, India, Pakistan, and Australia frequently work together in the first cluster, while authors from the UK, the USA, Germany, Spain and Canada also frequently work together in the second cluster.

3.4. Discussion and policy endeavors

The study uses a systematic review to evaluate the progress of SDG-related literature around the world. The study applies a bibliometric investigation to analyze how SDGs-related literature has evolved over time at the global level by considering the latest available studies and focusing on two key areas (i.e., the environment and energy domain).

The review approach demonstrates that the number of SDGs-related studies has been increasing since 2015, with the number of environment SDGs studies exceeding the number of energy SDGs studies. The keywords: "sustainable goal", "renewable energy", and "climate change" are the basic themes, but this has changed from 2015 to 2022. Moreover, “renewable energy”, “sustainable development”, and “economic development” have become the main themes of energy SDGs after 2020. Although climate protection was a niche topic before 2018, it is classified as an “emerging or declining” theme after 2020. Furthermore, most of the studies were published by Springer, MDPI, and Elsevier. The main affiliation is Tsinghua University for environment-SDGs and Cyprus International University for the energy- SDGs.

The approach assesses emerging trends in SDG-related environmental and energy literature. Thus, the study presents insights into how

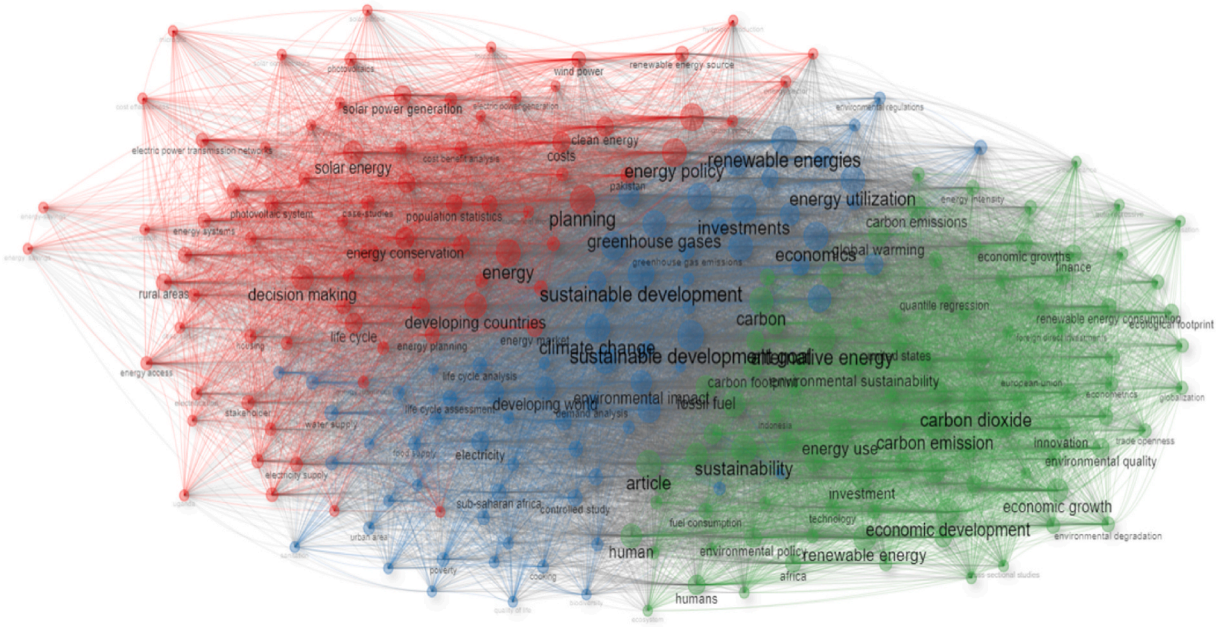

Fig. 13. Co-Occurrence Network Map of Keywords for Energy & SDGs. The figure visually presents the keywords used most by the studies examining the energy & SDGs link with a network map.

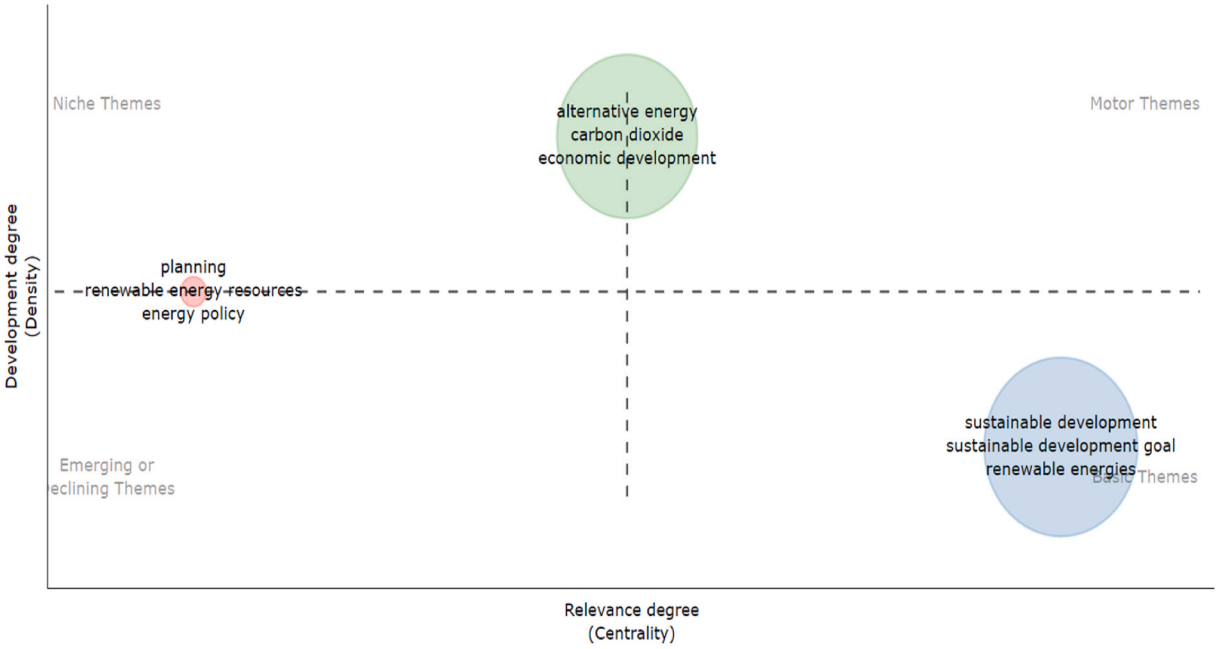

Fig. 14. Thematic Map for Energy & SDGs. The figure uses a thematic map to show that the concepts of alternative energy, energy policy, and renewable energies stand out in the energy & SDGs relationship.

SDG-related literature in key areas such as environment and energy has evolved at a disaggregated level and what critical interventions are needed to accelerate progress and ensure the achievement of the SDGs in 2030 by capitalizing on the defined new trends.

The outcomes collected in this research are consistent with studies, such as Adebayo and Kartal [52], Anser et al. [53], Kirikkaleli [54], and Bekun [55], which highlight the importance of the environment as well as Ulussever et al. [56], Pata et al. [57], and Ramzan et al. [58], which reveal the significance of energy in achieving the SDGs.

Taking into account the basic characteristics of the studies from 2015/1 and 2023/9 as well as the results of the comprehensive systemic review, it is possible to discuss various policy aspirations, which are presented below.

a) Following up closely on the direction in which the literature progresses.

Based on the outcomes, it is clear that the studies on the possible causes of recent climate-related issues (e.g., environmental degradation, global warming, climate change) and the possible solutions to these issues are steadily increasing, while the negative impacts on humanity are becoming greater and greater. In this context, knowledge has constantly

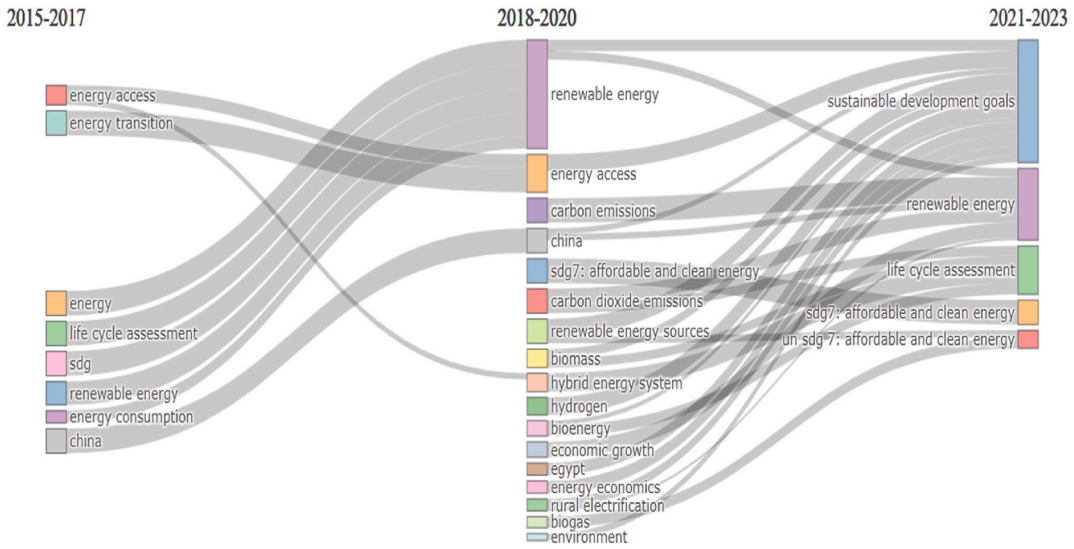

Fig. 15. Thematic Map Evaluation for Energy & SDGs. This figure indicates which terms are frequently used in the Energy & SDGs relationship in three different periods.

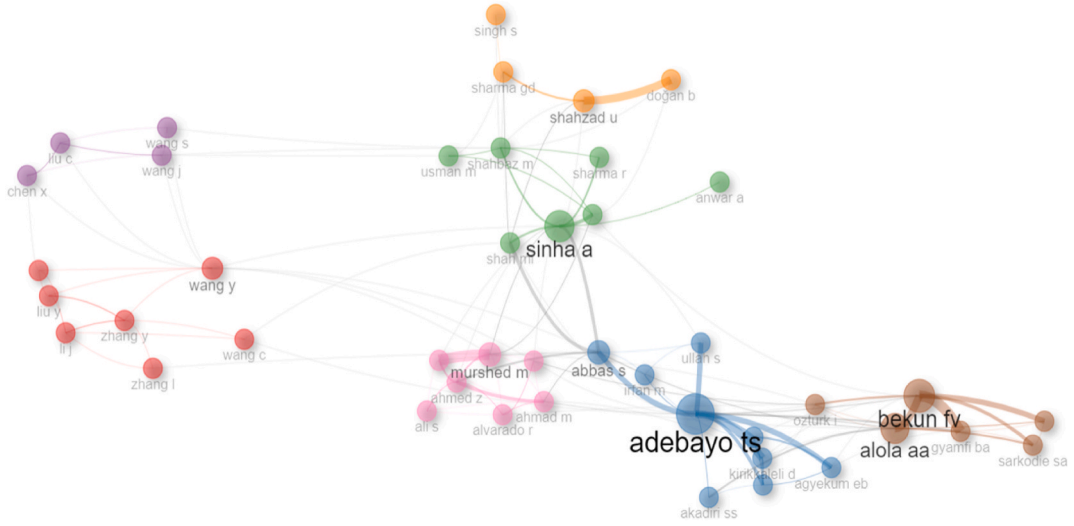

Fig. 16. Author Collaboration Network Map for Energy & SDGs. This figure represents the collaborations of the most published researchers in the field of Energy & SDGs.

evolved and the literature base has been developed with the presentation of new findings and novel insights. Therefore, it is crucial for policy makers at the global or national level to take into account the latest developments, findings, and information when formulating policies to achieve the environment and energy-related SDGs (i.e., SDGs 7, and 13).

b) Recent studies in journals

The results of the systematic review show that Springer is the leading publisher, followed by MDPI and Elsevier, respectively. Moreover, ESPR, Sustainability, Journal of Cleaner Production, Energies, and Journal of Environmental Management, published by these publishers, have a pioneering role in Environment & SDGs domain, while ESPR, Energies, Sustainability, Journal of Cleaner Production, and Renewable Energy are the pioneers in Energy & SDGs domain. Based on this finding, it is important that policymakers, regulatory stakeholders, and academics consider the publications of these journals and publishers when expanding the current state of knowledge. This will enable them to take the latest information into account when developing policies to achieve the environment and energy-related SDGs.

c) Collaborating with scholars from China and Cyprus to support the development of the literature.

Collaboration between scientists is extremely important for the further development of knowledge. Based on the results of the systematic review, it is found that Tsinghua University from China and Cyprus International University from Türkiye are the leading institutions in the fields of Environment & SDGs and Energy & SDGs domains, in that order. In line with this finding, it is clear that these institutions are at the forefront of advancement in their respective fields by expanding current knowledge. Therefore, it is crucial that related parties, including policymakers, both benefit from their better efforts and bring them together to achieve many useful outcomes in policy development.

d) Continuing support to new research to uncover the unexplored aspects

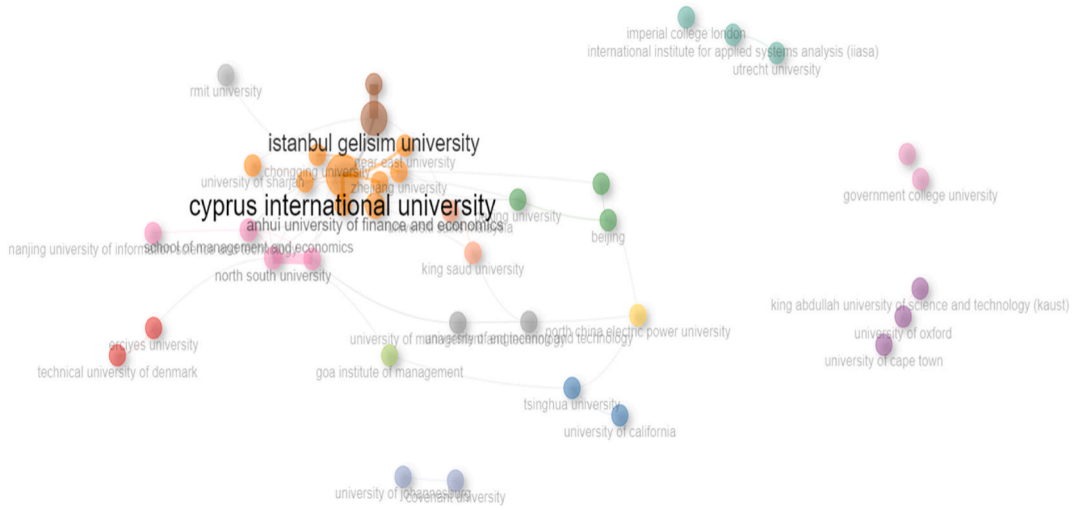

Fig. 17. Institution Collaboration Network Map for Energy & SDGs. This figure shows inter-institutional collaborations in the field of Energy & SDGs relationship.

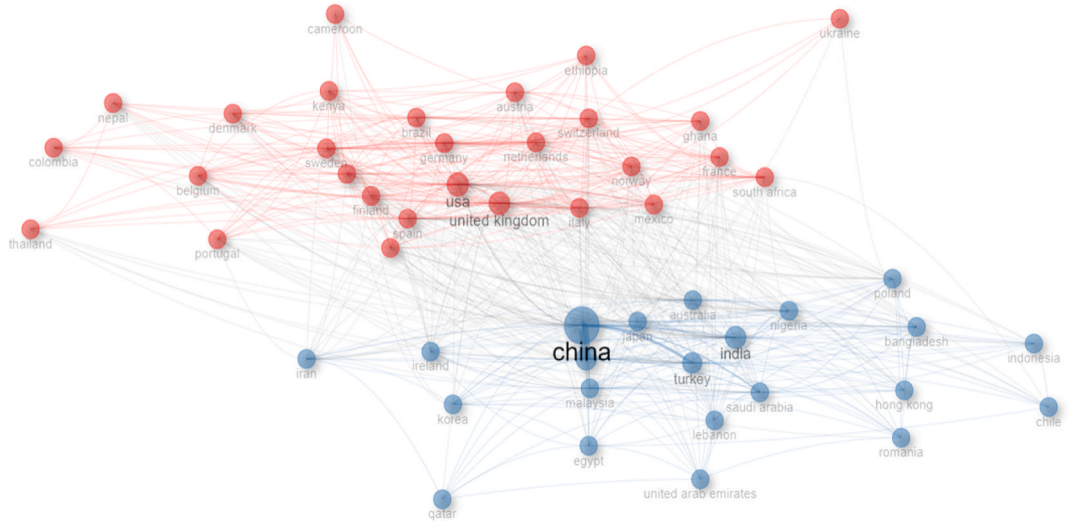

Fig. 18. Country Collaboration Network Map for Energy & SDGs. The figure shows that the countries that publish the most in the field of Energy & SDGs is China and the UK.

The outcomes show that the number of SDGs-related studies has increased in both areas, reaching 830 and 604 in the environment and energy domain, respectively. The studies have focused intensively on CO_2 emissions in the area of environment & SDGs domain and researched alternative energy in the area of energy & SDGs domain. Furthermore, the studies have shifted their theme from different focal points to new focal points over time. Therefore, it is not only important that policymakers consider the emerging trends, but also that new research is conducted to uncover the unexplored aspects of the SDGs in both the environment and energy domains. In this way, future studies can provide new insights.

e) Considering the key areas that the research has focused on.

The outcomes of the present study shows that the literature is evolving. In this context, while there are various indicators for both the environment and energy domain, some basic points are of much greater interest. In environment & SDGs domain, researchers have focused on CO_2 emissions rather than other environmental indicators (e.g., ecological footprint & load capacity factor). In energy & SDGs domain, researchers have often focused on alternative energy rather than fossil fuels, which have been intensively analyzed in previous studies. Policymakers and other stakeholders should therefore consider the latest theoretical developments when choosing among the possible options in re-formulating their policy mix with regard to the SDGs, in particular SDGs 7 and 13.

f) Monitoring progress of each SDGs by using high-frequency data.

The literature indicates that many studies similar to the regulator use low frequency (e.g., yearly) data in different countries to monitor what progress is being made on each SDGs. However, one year is a relatively long period of time in which a lot of time elapses. As described in recent studies, competent authorities should instead monitor progress using much higher frequency data (e.g., quarterly, monthly, daily) in order to take timely action without causing delays, which is crucial in tackling climate-related issues related to SDGs 7 and 13.

g) Consideration of multiple methods simultaneously to benefit from their different characteristics.

Researchers use different analytical methods to examine the progress

of the various SDGs. There are two main streams in the literature: econometric approaches and machine learning approaches. These two main streams have different pre-requirements and characteristics. Therefore, each of them offers various benefits in case of usage. Accordingly, policymakers should consider using various methods from both main streams to support each other and thus compensate for any shortcomings of the methods. Thus, policymakers can gain much more robust insights and refine their policy mix in all of the valued models.

h) Evaluation of recent methods to be used for forecasting.

New methods are developed almost every year. New methods enable decision-makers to analyze from various perspectives and with different properties. For example, wavelet-based methods allow the time and frequency dimension to be considered, Fourier-based methods provide the ability to consider smooth structural shifts, and quantile-based methods allow the nexus to be examined across various levels (i.e., quantiles). Therefore, all stakeholders should attend to emerging methods and assess whether these new methods can lead to insights about their focus areas in achieving the SDGs.

4. Conclusion, limitations, and future research

4.1. Conclusion

Global climate change becoming as a major challenge. In this context, there is more focused interest in environment as well as the role of energy, which is one of the main causes of environmental degradation. The fight against such environment-related issues has therefore been a priority issue in recent decades. In line with this goal, the SDGs proposed in September 2015 aim to make economy more environmentally friendly. Considering that 2023 is the halfway point of the SDGs since the announcement and the 2030 achievement date, the study undertakes a systematic review to comprehensively examine the progress of the SDGs, with a focus on the environment (SDG 13) and energy (SDG 7) domains on the globe at a disaggregated level. In this context, 2826 and 1917 studies on Environment & SDGs and Energy & SDGs published in the SCOPUS database between 2015/1 and 2023/9 are determined, in order.

This study uses a systematic review approach to outline the progress and emerging trends in the current literature on Environment & SDGs and Energy & SDGs domains. In line with the outcomes, the study discusses various policy endeavors to contribute to the SDGs in 2030: (i) closely monitoring the direction in which the literature is progressing; (ii) considering recent studies in reputable journals published by leading publishers; (iii) collaborating with leading scientists to support the development of the literature; (iv) supporting new research to uncover unexplored aspects; (v) consideration of key areas on which research has focused; (vi) monitoring the progress of each SDGs through the use of high frequency data; (vii) simultaneous consideration of multiple methodologies to benefit from their different characteristics; and (viii) evaluation of current methodologies that can be used for forecasting.

Overall, this research makes various contributions to the both theoretical and practical areas. From a theoretical point of view, the study makes a comprehensive examination of both environment and energy domains together for the first time within the review of SDGs. In doing so, by differentiating from many current studies, the study considers almost 5000 articles. Furthermore, to the best knowledge, load capacity factor is used for the first time in a study of this kind. From a practical perspective, the study clearly highlights the leading authors and institutions in both domains (i.e., environment- SDGs & energy-SDGs). Therefore, to ensure the achievement of the SDGs (especially SDGs 13 and 7, which relate to environment and energy) in 2030, it is crucial that these authors and institutions work together. That is why these are pioneering ones and they have a high level of expertise and knowledge in these areas. Therefore, they can provide important input to expedite the achievement of the SDGs in the coming period.

4.2. Limitations and future research

Although this study attempts a systematic review approach, there are still some drawbacks. The first limitation is that the study only focuses on two main domains when analyzing the SDGs: Environment (SDG 13) and Energy (SDG 7). Therefore, new studies can consider the remaining SDGs for further investigation. Secondly, the study uses the SCOPUS database as the leading database in the both environment and energy domains. However, new research should also work with the Web of Science database. Third, the study uses some selected keywords to determine the scope (i.e., the published studies). Therefore, new studies might consider using some other keywords to determine the scope of their studies from different perspectives. Further studies in this direction would bring new value to the current state of knowledge.

Disclosure statement

The authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Availability of data and materials

Data will be made available on request.

Ethics approval and consent to participate

Not applicable.

Consent for publication

The authors are willing to permit the Journal to publish the article. Not applicable.

CRediT authorship contribution statement

Mustafa Tevfik Kartal: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **M. Santosh:** Writing – review & editing. **Talat Ulussever:** Writing – review & editing. **Ugur Korkut Pata:** Writing – original draft, Writing – review & editing. **Serpil Kılıç Depren:** Formal analysis, Methodology, Software, Validation, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Not applicable.

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