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The Interlinkage Between Renewable Energy Innovations and Sustainable Development Goals: Bibliometric Analysis and Future Research Agenda

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Abstract: The United Nations Sustainable Development Goals (SDGs) prioritise 17 goals, with SDG 7 focusing on affordable and clean energy, emphasizing the importance of renewable energy for achieving these goals. Therefore, the current study investigates the role of renewable energy innovation in fulfilling Sustainable Development Goals. The present study extracted the relevant literature from the Web of Science (WoS) database from 2019 to March 2024. During this timeframe, total 455 documents were extracted. This paper utilized content analysis, co-word analysis and bibliographic coupling for thematic analysis and the SDG Mapper tool to align renewable energy related publications with SDGs, providing a comprehensive overview of the research landscape. The findings reveal that 47.6% of RE research aligns SDG 7 (affordable and clean energy), SDG 13 (Climate Action), representing 14.7% and SDG 8 which focuses on Industry, Innovation, and Infrastructure, which is the third most prominent goal, accounting for 9.4%. Scientometric analysis identified various thematic clusters: Sustainable Economic-Energy-Environment Dynamics, Environmental Sustainability and Climate Metrics, Green Finance and Environmental Impact, Economic Energies: Pathways to Sustainable Development. The primary limitation of this study is its reliance on the Web of Science (WoS) database, which may not encompass all relevant literature on renewable energy innovation. Additionally, the analysis is limited to documents published between 2019 and March 2024, potentially overlooking earlier significant contributions. The study's findings have implications for policymakers and researchers aiming to advance sustainable energy practices and achieve the Sustainable Development Goals by 2030.

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Highlights

- Findings reveal that 47.6% of RE research aligns SDG 7 (affordable and clean energy), SDG 13 (Climate Action), representing 14.7% and SDG 8 (Industry, Innovation, and Infrastructure)
- Target 7.2 (increase RE significantly in the global energy mix by 2030) has the highest correlation among all targets
- Thematic Evolution reveals a evolution from foundational sustainability concepts to more specialized and actionable themes over time
- Energy efficiency improvement (SDG 7.3) and decreased footprint-to-energy ratio reduce footprint

1. Introduction

The Sustainable Development Goals (SDGs) can play a crucial role in promoting the development of renewable energy (RE) (Wang et al., 2022). Goal 7 of the SDGs emphasises the importance of providing affordable, safe, sustainable, and modern energy for everyone (He et al., 2022). This indicates that nations, corporations, and individuals are dedicated to advancing sustainable energy sources, including solar, wind, and hydropower (Schwerhoff & Sy, 2017). The goals were established in 2015 by the United Nations (UN) and outline an agenda for global action to foster peace, sustainable development, and social justice (Allen et al., 2018). The goals are rooted in fairness, collective responsibility, respect for human rights, and a commitment to safeguarding the environment and combating climate change (Pizzi et al., 2020). RE is unquestionably a clean and sustainable energy source that meets our energy needs (Pedersen, 2018). Its use is crucial as it significantly reduces the cost of electricity production, minimizes environmental impact, contributes to the battle against climate change, and offers clean, secure energy (Imaz & Eizagirre, 2020). Utilizing clean energy is essential for reducing carbon dioxide emissions in the atmosphere and playing a crucial role in combating climate change (Dahlmann et al., 2019). This is mainly because renewable energies do not release greenhouse gases, like carbon dioxide, when generating electricity (Wahab et al., 2022). This highlights the crucial importance of this type of energy generation in reducing global carbon dioxide emissions (Armin Razmjoo et al., 2022). RE offers many advantages that can help countries, companies, and individuals reach the SDGs (Cheng et al., 2022). These energy sources are known for their positive impact on the environment, reliability, and affordability, making them an excellent solution for reducing the harmful effects of burning fossil fuels (Omri & Belaïd, 2021). In addition, these energy sources are limitless and do not need to be refuelled like fossil fuels. Therefore, the SDGs can greatly expedite renewable energy advancement (Udemba et al., 2022).

However, there are still specific challenges that must be recognized and resolved to accomplish SDG 7 (Shyu, 2021). As per the previous studies, it is worth noting that approximately 13% of the world's population still does not have access to modern electricity, as stated in SDG 7.1 (Bruce & Vinuales, 2021). The rate at which the world's energy intensity has been reduced is much lower than anticipated, especially if the goal is to achieve net zero by 2050 (IEA, 2019). In addition, the current energy structure relies heavily on fossil fuels, contributing to approximately 80% of global greenhouse gas emissions (UN, 2019).

Currently, a limited number of studies advocate prioritizing and assessing the environmental impact of renewable energy sources (Ward et al., 2019). Such as examining the different categories and generations of solar photovoltaic (PV) technologies currently available (Obaideen, et al., 2022), connections between renewable energy and SDG 7 (He et al., 2022), concentrated solar power (CSP) role in achieving SDGs (Yousef, et al., 2024; Bhullar et al., 2025a; Bhullar et al., 2025b), roles of innovation in achieving SDGs (Dzhunushalieva & Teuber, 2024). However, it is crucial to understand the prevailing innovations in the current body of literature. Therefore, we embrace a comprehensive approach that considers innovation from a

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broader standpoint, allowing us to gain a more comprehensive perspective by studying how RE innovation contributes to fulfilling the SDGs. To accomplish this, the authors will investigate the following research questions:

RQ1. How are various renewable energy research patterns interlinked with SDGs and targets?

RQ2. Which journals, articles, authors, and countries produce this segment's most prominent and influential research?

RQ3. What are the primary research themes in this literature on the linkage of SDGs and renewable energy?

RQ4. Which emerging frontiers and untapped themes are expected to have a significant impact on future research in the field of SDGs and RE innovation?

The subsequent sections of this article are structured as follows: Section. 2 Offers a detailed explanation of the sampling and methodology employed in this review. Section 3 Explains the relevant SDGs in this literature. Section 4 It is dedicated to performance analysis (major author groups and their contributions). Section 5 It is dedicated to co-authorship analysis. Section 6 Offers research fronts and future directions. Section 7 Presents the discussion of this study. Section 8 Provides detailed policy implications of this study. Section 9 Concludes the article.

2. Sampling and Methodology

Bibliometrics is used to analyze core archives, evaluate, explore documents, and identify scientific management libraries. Being well-versed in bibliometric studies allows researchers to lay a strong groundwork for groundbreaking advancements in their field. These analyses provide a centralized source of information, allowing scholars to understand the subject matter comprehensively. Additionally, they help identify knowledge gaps, sparking new ideas for future research. The two main bibliometric analysis methods are *performance analysis* and *science mapping*. Performance analysis measures the impact of research elements, while science mapping examines their relationships (Donthu et al., 2021; Singh et al., 2026). Therefore, this study uses this bibliometric review to examine article and journal performance trends, collaboration, and research constituents.

I. Search Criteria and Article Selection

The first step in Bibliometric Analysis is the selection of keywords utilizing Boolean logic, 'or' and 'and,' to combine keywords to locate relevant literature. The authors have used a combination of the PRISMA guidelines (Page, et al., 2021) and the workflow plan proposed (Zupic & Čater, 2015). The workflow plan has five main stages: (1) research design, (2) compilation of bibliometric data (using the PRISMA 2020 flow diagram), (3) analysis, (4) visualizing, and (5) interpreting, as you can see in

Figure **1**. The procedure began on 27 March 2024. To thoroughly review the relevant scientific literature, the authors have performed a search using the ISI Web of Science (WOS) databases (Aravindaraj & Chinna, 2022) by employing different types of keyword strings[1]. The chosen keywords encapsulate the direct nexus between RE innovations and SDGs and the initial outcome was (n = 826). After that, the authors applied the filters and (n = 68) records were removed based on the time-period of (2019-2024), and (n = 4) records

[1] (TITLE-ABS-KEY ("Renewable Energy" AND "SDG")) OR (TITLE-ABS-KEY ("Green Investment" AND "SDG") OR (TITLE-ABS-KEY ("Electric Energy" AND "SDG")) OR (TITLE-ABS-KEY ("Green Energy" AND "SDG")) OR (TITLE-ABS-KEY ("Green Finance" AND "SDG")) OR (TITLE-ABS-KEY ("Green Technology Innovations" AND "SDG")) OR (TITLE-ABS-KEY ("Green Energy Footprint" AND "SDG"))

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were removed because they were not articles and review articles. In the screening phase, (n = 754) records were assessed, with (n = 67) records cleaned by applying a [2] subject areas filter. Further screening is conducted on (n = 687) records, by selecting the relevant SDGs: SDG 01, SDG 02, SDG 6, SDG 07, SDG 8, and SDG 13, (n = 232) records were removed for not meeting criteria. No records are excluded based on language, as all remaining records are in English. In the inclusion phase, the final screening process concludes with (n = 455) records being considered eligible and included in the final analysis.

II. SDG MAPPER TOOL

To address RQ1, we employed a digital platform known as the "Knowledge Base for the Sustainable Development Goals," which incorporates the SDG Mapper tool. This portal functions as a central repository of information for European Union policies, indicators, and statistics about the SDGs. The SDG Mapper utilizes natural language processing (NLP) methods to identify the SDGs stated in the bibliometric records that have been submitted. (European Commission, 2021). After identifying references to the SDGs, machine learning techniques are used to analyze the data in the sample database and develop linkages between the bibliometric records and the applicable SDGs. This approach uses rule-based techniques to identify specific terms or phrases linked to each SDG.

III. Bibliometric visualization

Further analysis in this study was performed by VOS-viewer, a software that generates a visual representation of the database and graphs. It can be used to visualize hotspots and interconnected networks in the research field (Van Eck & Waltman, 2017). The authors used two VOS-viewer techniques: *co-authorship analysis* (RQ3) and *bibliographic coupling* (RQ4). Co-authorship analysis investigates the connections between researchers within a particular research field. This analysis is valuable in identifying. "[3]invisible collages" and the intellectual structure of the field (Crane, 1977). Bibliographic coupling is a scientific mapping approach that assumes that two articles that have shared references also have similar content (Kessler, 1963). The analysis focuses on categorizing publications into thematic clusters based on shared references and is most effective when used within a specific timeframe (Zupic & Čater, 2015).

3. Relevant SDGs [RQ1]

The authors have compiled a text file from the WoS database, a sample of 544 bibliometric records from 2019 to 2024. This database aims to identify the relevant SDGs and targets. It includes titles, keywords, and abstracts. The file was then uploaded to the SDG mapper tool to visually depict how much the literature on renewable energy innovation contributes to attaining the SDGs. Figure 2 shows a bar chart with each bar representing one of the 17 SDGs. The height of each bar and the accompanying percentage value show the proportion of literature aligned with a specific goal.

The primary SDG that is focused on in the literature on RE innovation is SDG 7 (Affordable and Clean Energy). This particular SDG accounts for approximately 47.6% (No. of occurrences 2631) of the literature. There is a clear emphasis in the field on developing energy solutions that are both economically accessible and environmentally sustainable. The second most frequently cited SDG 13 (Climate Action), representing 14.7% (No. of occurrences 817). This percentage signifies a notable level of research focus on the contribution of renewable energy in addressing climate change through mitigation and adaptation approaches. SDG

[2] Subject areas are: Environmental Sciences Ecology, Science Technology Other Topics, Energy Fuels, Engineering, Business Economics and Development Studies.

[3] The term "invisible collages" refers to the researchers collaborating on projects across different institutions.

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8, which focuses on Industry, Innovation, and Infrastructure, is the third most prominent goal, accounting for 9.4% (No. of occurrences 519) of all citations. This indicates a significant emphasis on integrating renewable energy innovations into industrial processes and infrastructure development.

The significance of targets is illustrated by bubbles in Fig. 3. The bubble size is calculated based on the percentage of keywords related to a specific goal out of the total number of keywords. The total number of keywords detected by the SDG mapper tool was 5524. Thus SDG 7 (affordable and clean energy) is the giant bubble among all, where target 7.2 (Increase renewable energy significantly in the global energy mix by 2030 has the highest (n = 1498 occurrences) among all targets, target 7.1 (Ensure universal access to affordable dependable, and modern energy services by 2030) has (n = 312 occurrences), 7.3 has (n = 338 occurrences) and lastly, target 7. a has (n = 10 occurrences), followed by SDG 13 (climate action) is second most prolific SDG with their target 13.1 has (n = 42 occurrences), target 13.2 has (n = 111 occurrences), and target 13. a has (n = 20 occurrences).

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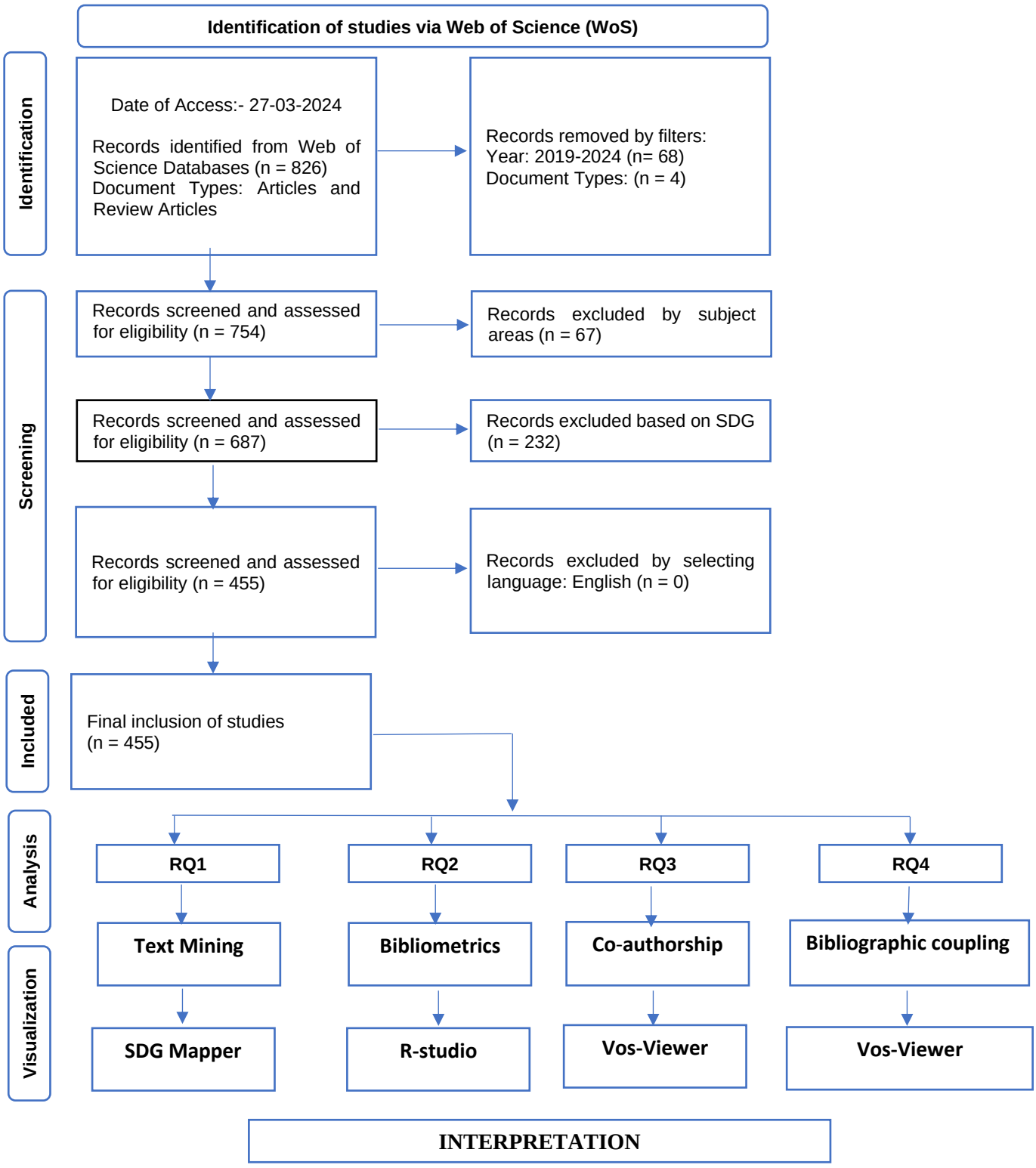


Figure 1: PRISMA flow diagram*. Sources: Author's Compilation*

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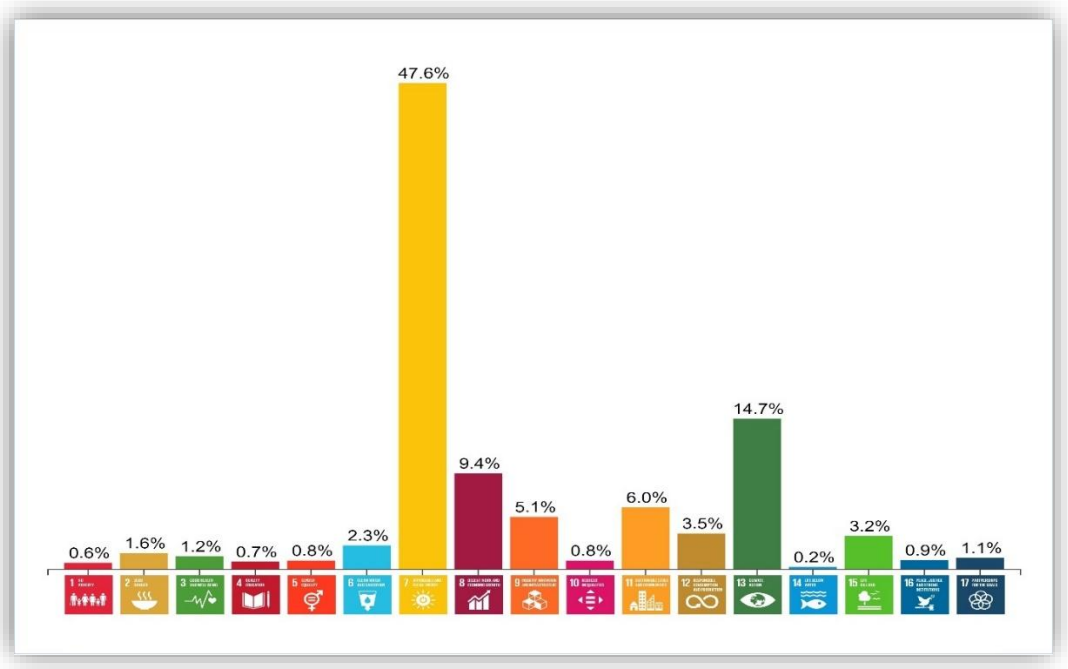


Figure 2: Relevant SDGs; Source: Figure created by the authors using SDG Mapper tool *(European Commission, 2021).*

The most detected keyword that accounted for (n = 1003) is 'renew energy'—followed by 'climate change' (n = 370 occurrences), where the detected SDG target was 13.0, emphasizing the focus on climate change issues. Further, it firmly covers energy-related topics, with terms like "energi consumpt," "sustain Citi," "econom growth," "clean energi," "R&D," and "technolog innov" correlating to different SDGs and highlighting a diverse range of subjects like energy consumption, sustainable urban development, economic growth, clean energy initiatives, research and development, and technological innovation. The prevalence of SDG 7-related terms further supports this finding.

4. Performance Analysis [RQ2]

Figure 4 Displays the annual production of scientific articles in renewable energy from 2019 to 2024. There has been a noticeable increase in production over the years, with the number of articles starting at 24 in 2019 and reaching a peak of 162 in 2023. However, there is a projected decline in 2024, with the number of articles expected to decrease to 42. There seems to be a pattern of varying interest or investment in renewable energy research during these years. Notably, over the last three years (2022, 2023, and 2024), article production has accounted for 71.22% (307 articles) of the total output.

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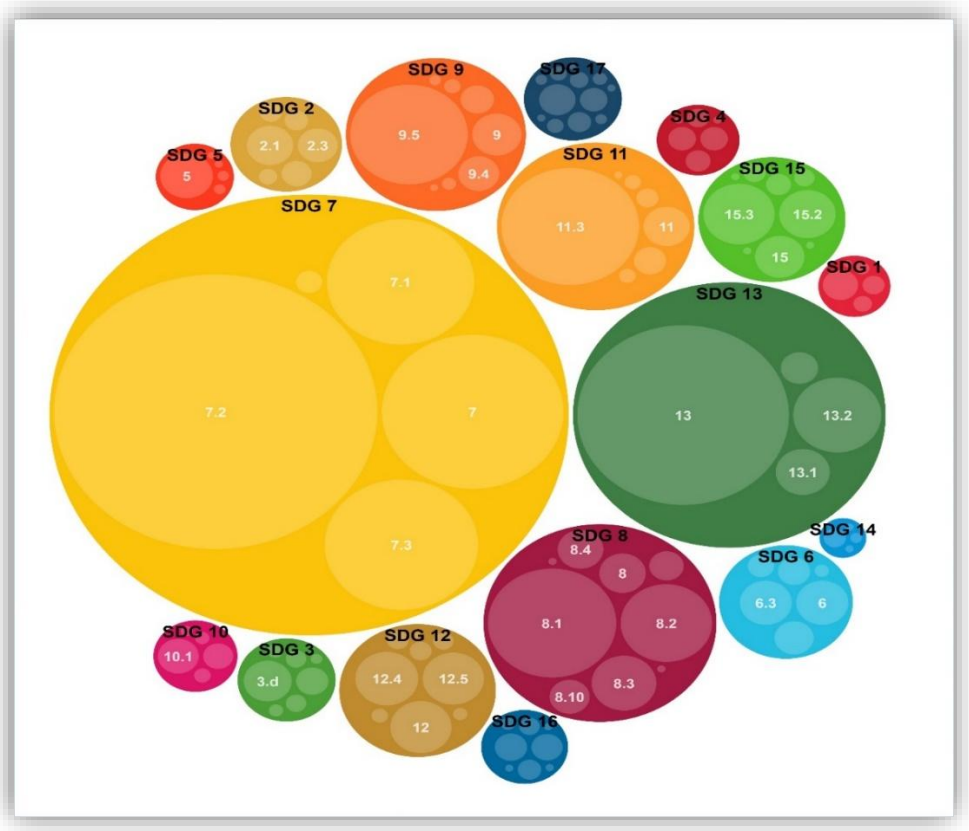


Figure 3: SDG targets are based on the percentage of corresponding detected keywords—
Source: *Figure created by the authors using SDG Mapper tool (European Commission, 2021).*

I. Annual Scientific Production

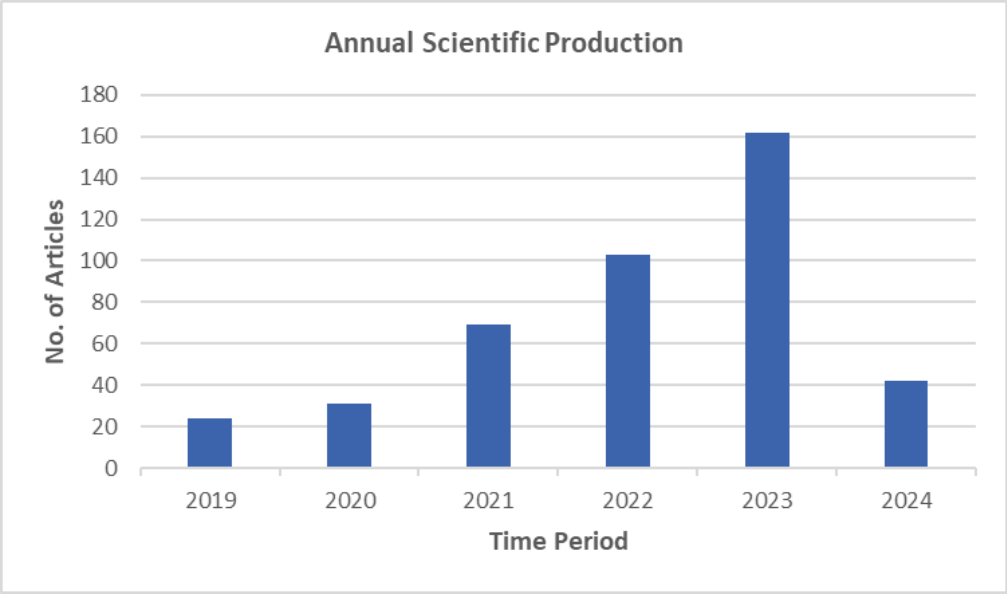


Figure 4: The Publication Trend (2019-2024)

<Insert Table 1: Top 10 Most Prolific Authors>

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<Insert ***Table 1*** It presents a mosaic of academic excellence worldwide, each tile signifying a scholar's research path and commitment to the SDGs and RE innovation. Leading the way in academic achievement is Tomiwa Sunday Adebayo, whose commitment to research at Cyprus International University and depth of work have garnered significant acclaim (he has 714 citations in 20 publications). Avik Sinha follows closely after, with 16 papers and 1170 citations demonstrating the effect of his work at the Goa Institute of Management on academic circles. Renowned scholar Festus Victor Bekun of Istanbul Gelisim University makes a lasting impression with 431 citations and 11 publications. Sunway University's Arshian Sharif adds colour with 668 citations spread over eight articles. Ahsan Anwar, who has received 379 citations from 8 publications, skillfully integrates information from the National College of Business Administration and Economics. From their different universities, Mohammad Ali Abdelkareem, Enas Taha Sayed, Rajesh Sharma, Pradeep Kautish, and Rajvikram Madurai Elavarasan each make a substantial contribution that will shape the future of academia. Collectively, these academics create a mosaic of intellectual accomplishment that enhances scholarly conversation and opens doors for upcoming researchers.

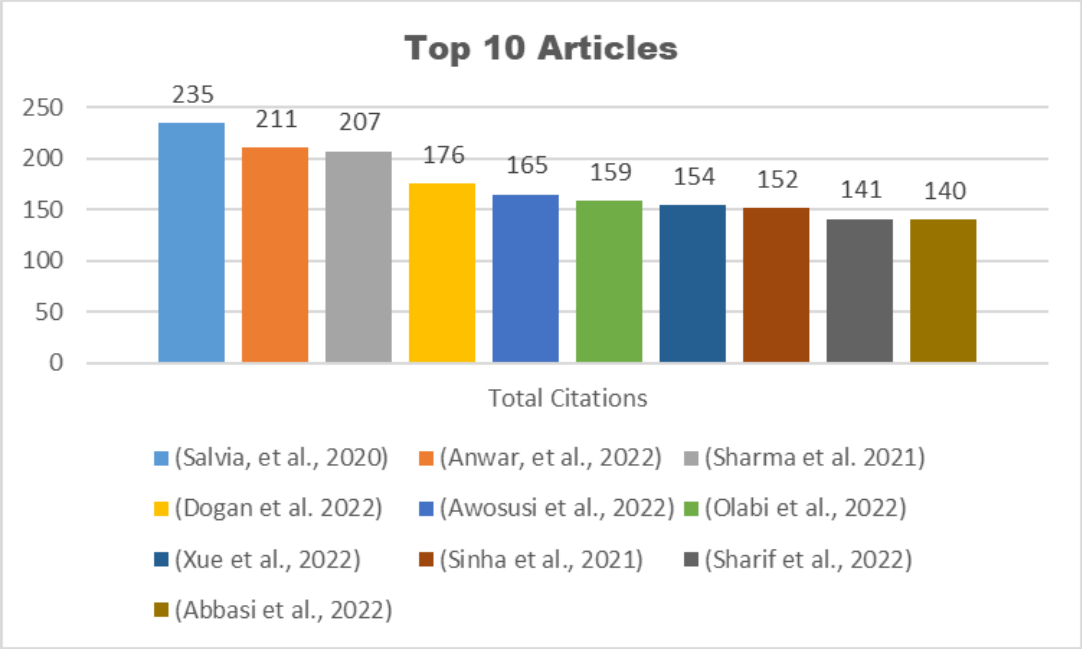


Figure 5: Top 10: Most Impactful Articles (*Source: Authors Compilations)*

Figure 5 presents a collection of influential articles published in renewable energy innovations, explicitly focusing on their contribution to achieving the SDGs between 2019 and 2024. The authors have uploaded the top 10 articles individually into the SDG mapper tool. The article written by (Salvia et al., 2020) is highly regarded, having received 235 citations. It focuses on SDG 13 (climate action) with a significant relevance of 88.7%. This indicates a strong emphasis on researching the role of renewable energy in combating climate change through mitigation and adaptation strategies. The main target of this article is 13.2, with a relevance of 38%. (Anwar, et al., 2022) received a significant number of citations, totalling 211. Their primary focus is SDG 7, which accounts for 55% of their research. The specific SDG targets they address are (7.2, 7.3, and 7.1.) where the most influential target is 7.2, with 51% relevance.

< Insert Table 2: Top 10 Most Impactful Countries>

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< Insert **Table 2** Displays the most impactful countries in the field of RE innovations fulfilling SDGs in the time frame of 2019-2024. China is at the forefront with 125 publications and 3,179 total citations, highlighting its strong commitment and pioneering role in renewable energy innovation. India closely follows with 86 publications and 2,573 citations, showcasing its dedication to sustainable development and energy security. Turkey's publication count may be lower than others, but its citation count of 2,413 demonstrates the high quality and impact of its research in the field. Notable contributors worldwide, such as Pakistan, England, Malaysia, Saudi Arabia, Italy, Russia, and Japan, have shown different levels of involvement and interest in RE Innovation in fulfilling SDGs. This highlights the importance of shifting towards cleaner and more sustainable energy sources.

< Insert Table 4: Most Impactful Sources (Journals)>

Error! Reference source not found. Shows the most prominent and impactful journals publishing articles in the field of RE innovation fulfilling SDGs. "Environmental Science and Pollution Research" has 44 publications and 690 citations. Followed "Energies" holds the second position with 32 articles with a substantial count of 404 citations. "Renewable & Sustainable Energy Reviews" is the most qualitative journal in this field; a few articles, i.e., 27, have been produced by this journal, but this journal has produced the most impactful articles because this journal has 1036 citations count. Overall, these top 10 journals are critical in influencing the research landscape of RE innovations and promoting scholarly exchange and progress in the field.

5. CO-AUTHORSHIP ANALYSIS [RQ3]

The first step in scientometric analysis is co-authorship analysis. The criteria for selecting the sample for co-authorship analysis is having at least three connections with three authors per document and 50 citations. This threshold leads to 6 significant clusters with at least four authors in one cluster. The authors are ranked in each cluster based on their DC (degree of centrality). DC refers to the number of links connected to other authors in a network (Donthu et al., 2021). < Insert ***Table 3*** reports a summary of the co-authorship analysis table. TP denotes total publications, tc denotes total citations, dc denotes the degree of centrality, and APY denotes the average publication year.

< Insert Table 3: Major author groups in RE innovation in fulfilling SDGs field >

I. Innovative Energy Solutions And Environmental Dynamics

Cluster 1 is led by author Tomiwa Sunday Adebayo, the most prominent and impactful author in this cluster and in this study with 29 DC. This author has 20 publications and leads the way in academic excellence. He also adds color to his publications with 714 citations. APY, i.e., 2019.86, makes him the oldest and most renowned author in this cluster. This cluster comprises nine authors, and their APY is 2022.03, which shows that most of the authors in this cluster have worked recently and are engaging in research about RE and fulfilling SDGs. The main thematic focus of this group is on innovative energy solutions and environmental dynamics, which are part of SDG 7 (climate action). The authors in this cluster mainly work on themes such as eco-innovations, clean energy trade dynamics, energy investment, ecological footprint and bio-capacity, wind and solar energy, and environmental degradation. TC of his cluster is 2170, the highest among all other clusters.

II. Green Economic Policies And Technological Impact

Author Arshian Sharif leads cluster 2 with 13 DC, which makes him the most prominent author in this cluster. He also has eight publications and 668 citations, and his APY is 2022.38, which shows that this author has published recently and is contributing his research towards fulfilling SDGs. This

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cluster's main thematic focus is on green economic policies and technological impact, with APY 2022.74 representing this cluster as the latest than cluster 1. Author Ahsan Anwar is another prolific author in this cluster as he has eight publications, but due to his lower 6 DC and 379 citations count, he stands at fifth position in this cluster; in fact, this author also stands at fifth position in the top 10 most prolific authors in this field, this author can collaborate with other authors in future and so that he can increase his link strength and citations count by producing impactful articles and move to the top position in this field. The themes untapped by these authors are green innovation, technological innovations, UN policies about green energy, and reducing energy wastage. The total citation count of this cluster is 1889, which shows that this cluster has produced very impactful articles.

III. Government Taxation And Economic Structural Transformation

Cluster 3 is led by author Ilhan Ozturk, the most connected author with 8 DC and five publications, 251 TC, an average of 50 citations per document, and an APY of 2022.06, making him the most productive author in this cluster. The most prolific author in this cluster is Umer Shahzad, with the highest citation count of 483 and 4 publications. This cluster comprises six authors with an APY 2022.18, and the total citation of this cluster is 1781. The main thematic focus of this cluster is government taxation and economic structural transformation. The authors have untapped various significant themes in this cluster, such as G7 countries' strict taxation against the consumption of C02, which aims to fulfill SDG 7 (affordable and clean energy) and SDG 13 (climate action) and increasing investment in renewable energy also are working on structural transformation of green energy efficient usage for achieving SDGs.

IV. Global Energy Solutions And Climate Solutions

Cluster 4 is led by author Mohammad Ali Abdelkareem, who stands first with 25 connected links and publishes eight articles with 295 citations, and APY is 2022.88. This cluster comprises six authors, which are the most connected; every author has more than 14 DCs, making this the most prominent cluster in this field of RE innovations fulfilling SDGs. This cluster's main thematic focus is global energy and climate solutions. These authors are working on themes like the role of green hydrogen, the role of green ammonia, the role of wind energy, and the role of ground source heat pumps and pre-combustion carbon capture technologies in achieving SDGs. Every author in this cluster has published a single factor that helps achieve SDGs. Methodologically, this cluster's primary focus is on SDG 7 (affordable and clean energy) and SDG 13 (climate action). The APY of this cluster is 2022.88, representing that this cluster's authors have published recently, and the TC of this cluster is 1252.

6. RESEARCH FRONTS AND FUTURE DIRECTIONS [RQ4]

The criteria for selecting the sample for bibliographic coupling analysis is an article that pertains to a minimum of 55 citations in the sample period of 2019-2024; only 40 articles meet these criteria, and after refining, only 26 articles were included in this analysis, and these articles are divided into major 4 clusters. Authors review these clusters to find their central themes. < *insert* ***Table 4*** Displays the summary of these research fronts. Propositions show future avenues for these clusters. APY denotes the average publication year, and TC denotes total citations.

< insert Table 4: Major Research Frontiers RE Innovations & SDGs here >

Cluster I. Sustainable Economic-Energy-Environment Dynamics

The largest cluster formed by bibliographic coupling in RE innovations and SDGs focuses on exploring the complex relationship between economic growth, energy

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consumption, technological innovation, and sustainability in different socio-economic frameworks and geopolitical contexts through thought-provoking questions. (Sharma, et al., 2021) Analyzed the effects of per capita income, renewable energy, life expectancy, and population density on the ecological footprint, both in the long run and the short run. They found that a 1% rise in population density leads to a 0.139% expansion in the ecological footprint. Both (Doğan et al., 2022) and (Shahzad, et al., 2020) examine the effects of an environmental tax on carbon emissions in various nations, and factors influencing emissions, including energy consumption, economic complexity, natural resources lease, and economic growth. (Doğan et al., 2022) study reveals that implementing rigorous environmental tax regulations enables businesses to transition towards more environmentally friendly production methods. (Shahzad, et al., 2020) Highlights the importance of synchronizing and improving decision-making at the bureaucratic level for energy mix and overall economic policies. Legislators and policymakers must exercise caution and ensure the effective implementation of environmental regulations. This cluster studies examine aspects such as agricultural output (Chopra, et al., 2022), trade, income (Adedoyin et al., 2021), the association between human development and ecological footprint (Kassouri & Altıntaş, 2020), and policy tools like environmental taxes. Overall, the research within this cluster offers a nuanced perspective on the challenges and strategies for achieving sustainability within diverse economic systems and policy frameworks. Once these policies are implemented, nations can make significant strides toward achieving the goals of SDG 13 (climate action), SDG 14 (life below water), and SDG 15 (life on land).

Cluster II. Insights and Innovations in Emerging Economies

The second cluster in RE innovations and SDGs highlights the essential link between the use of renewable energy and other aspects of sustainable development, such as economic growth, technical advancement, urbanization, and control of ecological impact. Studies by (Saint Akadiri et al., 2023) and (Xue et al., 2022) contribute valuable insights into the interplay between economic complexity, nonrenewable energy, and the ecological footprint. Both studies highlight the captivating potential of renewable energy in promoting environmental sustainability within the complex landscape of economic factors. Studies by (Abbasi et al., 2022) and (Hossain et al., 2022) explore how clean energy can contribute to sustainable economic development and reduce emissions. (Anwar et al. 2021) By focusing on SDG 9 (Industry, Innovation, and Infrastructure), this study examined the influence of technological innovation and infrastructure development on sustainable practices central to building resilient industries and fostering innovation. (Agboola et al. 2019) Moreover, (Ramzan et al., 2022) investigate the interconnectedness of income, agriculture, communication technologies, and energy consumption, suggesting that renewables can be crucial in achieving an environmentally sustainable economy. Their primary focus is on SDG 7, SDG 13, and SDG 12. The policy implications derived from these studies are: Encouraging renewable energy investment can lead to cleaner production methods and reduced emissions, advancing SDGs 7, 9, and 13. Fiscal and regulatory incentives can stimulate job creation in new sectors, promoting SDG 8. Integrating renewable energy solutions in urban planning can improve quality of life and contribute to SDG 11. Innovation policies supporting clean energy technologies can foster sustainable industry practices, impacting SDGs 9 and 12. International cooperation in technology transfer and financial support for renewable projects can help achieve SDGs 7 and 13.

Cluster III. Green Finance and Environmental Impact

Cluster third revolves around "Green Finance and Environmental Impact." Studies

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in this cluster thoroughly analyze the complex connections between different financial mechanisms and their impact on environmental outcomes, explicitly emphasizing CO2 emissions. The study conducted by (Anwar et al., 2022) explores the intricate relationship between financial development and renewable energy, specifically focusing on its effects on carbon emissions in Asian countries. On the other hand, (Yoshino et al., 2021) examine how structural economic changes influence the distribution equality of renewable energy. (Liu et al. 2022) Through empirical investigation, explore the relationship between financial inclusivity, green financing, and energy efficiency within the FinTech sector. Findings conclude that green financing is the most suitable and supportive tool for energy efficiency among the three options. (Wu et al. 2023) offer a theoretical perspective on the potential impact of investment decisions influenced by SDGs on optimizing energy portfolios. Finally, (Zhao et al., 2022) examine the diverse effects of urbanization on different socio-economic aspects, such as renewable energy usage and financial development, and their role in contributing to CO2 emissions. The integration of this cluster studies emphasizes how the financial sector's growth and technological progress in finance can either help or hinder environmental sustainability. This significantly impacts achieving SDG 7, SDG 9, SDG 11, and SDG 13.

Cluster IV. Economic Energies: Pathways to Sustainable Development

Cluster 4th, however, is known for its emphasis on " Economic Energies: Pathways to Sustainable Development." The articles in this cluster closely examine the relationship between energy consumption, economic growth, and environmental sustainability. (Adebayo et al. 2023) Examine the effects of various energy sources, such as hydroelectric and natural gas, on economic growth and carbon emissions over time and across different frequencies. (Elavarasan et al. 2020; Elavarasan et al. 2021) discuss two studies in this cluster: one focuses on understanding the factors that promote or hinder renewable energy development, while the other explores the significant effects of the energy sector on sustainability progress. Both studies emphasize the significance of comprehending the factors that drive and hinder the acceptance of renewable energy in the context of a country's progress. (Hinson et al., 2019) provide a comprehensive analysis of how FinTech can contribute to attaining SDGs in sub-Saharan Africa, emphasizing the advantages of technological advancements in sustainable development financing. Finally, another study (Zhao et al., 2022) examines the durability of renewable energy, considering the political implications and stakeholder attitudes toward policy adoption. Overall, this cluster collectively illustrates a thematic synergy of incorporating sustainable energy practices into a larger framework of environmental and economic policies. Therefore, the cluster contributes to advancing SDG 7, SDG 9, and SDG 13.

7. Discussion

In their 17 SDGs, the United Nations aims to end extreme poverty, hunger, water scarcity, pollution, and energy insecurity by 2030. Innovations in renewable energy (RE) contribute to a lessening of air pollution, global warming, and emissions of greenhouse gases. Developing countries' access to modern, sustainable energy services is the end aim of SDG 7, which aims to strengthen infrastructure and technology in this area. Developing biofuels from microalgae might change the course of history for poor nations like Africa, which suffer from extreme heat and a lack of fresh water. According to Acheampong et al. (2017), there is hope for large-scale microalgae production even on barren land. Governments may improve energy security and invest in education, health, and infrastructure by switching to renewable energy sources like solar, wind, and hydropower, which are both affordable and environmentally friendly. Sustainable energy creates employment, which benefits

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society and helps to decrease inequality. This makes it more difficult to use renewable energy footprints as a criterion for environmental friendliness, unlike carbon or fossil energy footprints. Our methodology lays the groundwork for reliable evaluations of the global impact of renewable energy usage. Ecological, monetary, and social sustainability are all part of RE (Jianjian et al., 2022). Overall this study highlights the importance of integrating RE with SDGs to improve sustainability. Regulatory frameworks with national targets, tax cuts, low-interest loans, research and development grants, and educational programmes are all ways in which governments could encourage RE. Partnerships between the government, businesses, and nonprofits, as well as refunds and cuts to tariffs, green investment support, and other measures, are crucial. Last but not least, to embrace and implement RE, public awareness initiatives on its role in SDGs are essential.

8. Policy Implications

The study has significant theoretical and practical implications. The study deepens our understanding of scientific research exploring SDGs and renewable energy. In addition, researchers can use the research to determine the leading institutions and geographic locations for research residencies and collaborative projects related to the studied subject matter. In addition, it allows researchers to establish connections with other researchers if they wish to collaborate on research projects or organize conferences related to the subject being studied. In addition, this study allows academics to identify the leading journals and publishers through which they can share their research findings. In addition, authors can identify the primary theoretical sources that shape their research. In addition, it allows authors to gain a deeper understanding of the interdisciplinary aspects of the topic being studied and to recognize existing and future research areas that may need further exploration. By doing so, they can make a meaningful impact on the progress of sustainable development goals (SDGs) and the adoption of renewable energies. Deficiencies in examining renewable energy and the SDGs can be found in various aspects of sustainability, including technological, financial, social, environmental, and governance dimensions.

9. Conclusion and Limitations

At the midpoint of the Agenda 2030 program, scientists are increasingly focused on innovative solutions to bridge gaps in achieving the UN's Sustainable Development Goals (SDGs). This study, motivated by this shift, examines the interlinkage between renewable energy (RE) and SDGs using bibliometric analysis. Drawing from 455 articles sourced from the Web of Science (WoS) database, the study reveals a significant increase in relevant publications from 2019 to 2024.

Through text mining and the SDG mapper tool, it was discovered that a considerable amount of literature, 47.6%, is centred around SDG 7 (Affordable and Clean Energy). This suggests a prominent research emphasis on creating sustainable and easily accessible energy solutions. In addition, 14.7% of the literature focuses on SDG 13 (Climate Action), emphasising the significant efforts made towards addressing climate change through various strategies and technologies. This distribution highlights the commitment of the academic and research community to promoting energy sustainability and taking action on climate change. This connection exists because switching to renewable energy sources helps lower emissions of greenhouse gases, which in turn slows the rate of climate change. An ideal strategy to promote the usage of renewable energy sources could be the execution of the SDGs. Solar and wind power are two examples of alternative energy projects that can help accomplish this goal by producing electricity in an environmentally friendly and long-term sustainable manner.

The second research question involves performance analysis, highlighting Tomiwa Sunday Adebayo as the most prolific author with 714 citations in 20 publications. The

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most cited article, "Will climate mitigation ambitions lead to carbon neutrality? An analysis of the local-level plans of 327 cities in the EU" by Salvia et al. (2020), focuses on SDG 13 with 88.7% relevance. Leading journals include "Renewable & Sustainable Energy Reviews," "Environmental Science and Pollution Research," "Energies," and "Sustainability." China leads in publications (125) and citations (3,179), reflecting its commitment to renewable energy innovation.

When it comes to bibliographic coupling, this analysis also reveals four significant clusters: "Sustainable Economic-Energy-Environment Dynamics," "Insights and Innovations in Emerging Economies," "Green Finance and Environmental Impact," "Economic Energies: Pathways to Sustainable Development" three out of four clusters have an average publication year of 2021, while the remaining cluster has an average publication year of 2022. Cluster four demonstrates the pathway for achieving SDGs (Elavarasan et al., 2020; Elavarasan et al., 2021). Two studies in this cluster focus on understanding the factors that promote or hinder renewable energy development. At the same time, the other explores the significant effects of the energy sector on sustainability progress. Both studies emphasize the significance of comprehending the factors that drive and hinder the acceptance of renewable energy in the context of a country's progress and addressing SDGs.

There are a few limitations to the study. Firstly, it only focused on Web of Science databases without considering other databases like Scopus. Furthermore, the analysis solely focused on renewable energy as a pathway to accomplish the SDGs, disregarding the potential of different innovations to broaden the scope. Additionally, it is essential to consider that the selection of keywords could have potentially restricted the scope of the search. The specific search terms used to gather data may influence the study's findings. Despite our diligent efforts, we may have overlooked essential articles that utilized unique or specialized terminology that was not accounted for in our literature search. Therefore, there is always the possibility of conducting further searches using supplementary keywords. Finally, there may be a delay in choosing articles from 2019-2024 as we have not yet selected any earlier publications. Some specialized subjects or up-and-coming areas may not have enough recent publications, which can restrict the extent of our analysis.

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