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Article

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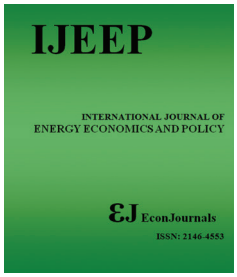

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New Trends in Green Projects Aimed at Clean Energy: An Analysis of the Scientific Literature

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ABSTRACT

In the search for global sustainability of energy production, green projects focused on clean energy have become a top priority internationally. Therefore, in order to understand current trends in this field, this bibliometric study has been developed. Through the analysis of scientific publications, key lines of research have been identified in the field of sustainable energy. The study used data from Scopus to analyze the trends of green projects focused on clean energy in the period between 2002 and 2024. The results obtained reveal a growth rate of 7.59% in scientific production in recent years, finding a total of 122 documents from 96 different sources and contributions from 344 authors. China is the country that leads in scientific productivity during the mentioned period, followed by India and the United States. The most prolific journals include Journal of Cleaner Production and Resources Policy, institutions such as IBN Tofail University and WSB University have been revealed as prominent contributors, and Taghizadeh-Hesary and Yoshino is listed as the main author found in the analysis. Finally, keywords such as "sustainable development," "renewable energy," "green projects," "renewable energy resources," "global warming," and "land fill" dominate the discourse, reflecting a global emphasis on sustainable energy solutions. The findings of this research serve as a guide for researchers, policymakers, green technology investors and project managers to formulate future solutions aimed at an effective energy transition on a global scale.

Keywords: Sustainable Development, Renewable Energy, Global Warming, Bibliometric Analysis, Green Projects
JEL Classifications: K32, Q42, Q54

1. INTRODUCTION

The severity of the climate problem has increased in the contemporary global environment, as demonstrated by extreme weather events that include longer droughts, stronger storms and record heat waves (AghaKouchak et al., 2020), representing obstacles that must be overcome to achieve sustainability and reduce the negative effects of energy generation on the environment (Al-Shetwi, 2022). Environmental problems are further exacerbated by the world's growing urbanization and population, which are placing additional pressure on infrastructure and natural resources (Ahmed et al., 2020).

The adverse consequences of environmental degradation on human health are increasing, including the impacts of extreme weather conditions, biodiversity loss, droughts, water scarcity, and soil pollution, all exacerbated by climate change (Sun et al., 2024). In response, efforts to combat climate change by addressing environmental pollution are being intensified. Various traditional factors, such as economic growth and energy consumption, have been criticized for their significant role in CO_2 emissions (Ulussever et al., 2023), the main contributor to climate change and environmental degradation. To limit the rise in global temperature, countries have begun to develop emission inventories and implement measures to reduce greenhouse gas (GHG) emissions. This has driven a global movement towards low-carbon economies and motivated several countries to invest in renewable energy, encouraging them to explore various tools and financial pathways (Zhao et al., 2023).

In this context, green projects focused on renewable energy have become increasingly important in the global conversation on

sustainability and climate change mitigation (Novoa et al., 2024). To reduce greenhouse gas emissions and lessen the harmful effects of climate change on the environment and society, these projects aim to encourage the adoption of clean technologies and renewable energy sources (Lu et al., 2020; Palma et al., 2023; Suman, 2021). In addition to their immediate effect on reducing carbon emissions, renewable energy initiatives can also foster social and economic advancement by creating jobs, advancing technology, and improving living standards in nearby areas (Novoa Pérez and Torres, 2023; Fang et al., 2022).

Around the world, numerous technologies and methods are used in clean energy initiatives, such as biomass, geothermal, hydroelectric, solar and wind. Each of these technologies has its own benefits and drawbacks, and a variety of circumstances, including the availability of natural resources, the state of infrastructure at the time, government regulations, and social acceptability, have an impact on their adoption and development (Elavarasan et al., 2020; Androniceanu and Sabie, 2022). However, despite these variations, the goal of all clean energy sources is the same: to reduce dependence on fossil fuels and promote a more robust and sustainable energy system (Holechek et al., 2022). Clean energy initiatives therefore provide an opportunity to modernize energy systems and promote global sustainability, in addition to serving as a vital substitute for highly polluting conventional energy sources (Kalair et al., 2021). Moving towards a cleaner, healthier and richer future for current and future generations can be achieved by supporting the widespread adoption of and investing in renewable energy projects.

In light of this, it is more crucial than ever to understand current developments, technological trends and effective sustainable energy practices. Research and development in the field of clean energy has been accelerated by the rapid pace of technological advancement, growing environmental awareness, and the demand from governments and civil society to reduce carbon emissions (Tan et al., 2021). Consequently, to determine the most pertinent topics of study, the most promising developments, and the most successful management techniques in this field, it is imperative to thoroughly and methodically examine all the academic material that is currently available (Martínez et al., 2024).

To achieve this objective, this research has carried out a bibliometric analysis to determine the main study topics, the most recent advances and efficient management strategies in the field of sustainable energy (Ampese et al., 2022). The evaluation of the state of the art in this analysis has focused on identifying both consolidated areas and those that are still promising to advance more environmentally friendly energy solutions (Kontogianni and Alepis, 2020). In this way, this research aims to present a comprehensive assessment of the trends and achievements in the clean energy industry using data collected from Scopus (Li and Wong, 2021).

Using bibliometric techniques to map and visualize scientific production in the field of sustainable energy, the state-of-the-art analysis was carried out with a rigorous and methodologically sound approach (Borre et al., 2023). Special attention was paid to identifying the most influential journals, leading institutions, and notable authors in this field. To gain a deeper understanding of the emphasis areas and research objectives in the field of clean energy, the most relevant keywords and developing trends in the academic literature have also been investigated (Ramirez et al., 2023).

In summary, the ultimate goal of this bibliometric study is to stimulate an informed debate on how to achieve an effective energy transition towards cleaner and more sustainable energy sources and offer solid advice for strategic decision making. The results of this study should be of interest to researchers, policymakers, green technology investors and project managers. They could also serve as a basis for future research and cooperation in the field of sustainable energy. Ultimately, it is anticipated that this research will help pave the way toward an energy future that is both equal and sustainable for both current and future generations.

2. METHODOLOGY

This study focuses on current trends in green projects aimed at clean energy, a critical area for global sustainability and minimization of environmental impact. By analyzing the scientific publications produced in recent years, the main lines of research, technological innovations, and management strategies in the field of sustainable energy have been identified (Ramírez-Duran et al., 2023). The objective is to map the state of the art, highlighting both established and emerging areas that promise to move towards more sustainable energy solutions.

By virtue of everything previously explained, the following variables with their descriptors have been proposed (Table 1).

Based on the identification of these elements, the following search equation is proposed in the Scopus database (TITLE-ABS-KEY [“green projects”] OR TITLE-ABS-KEY [“sustainable projects”] AND TITLE-ABS-KEY [“clean energy”] OR TITLE-ABS-KEY [“alternative energy”] OR TITLE-ABS-KEY [“renewable energy”]). With the data obtained from Scopus, a data analysis process is carried out with the support of the R Studio software in its Bibliometrix package and the VOS VIEWER software (Table 2).

The previous table (Table 2) identifies the general elements associated with the scientific production of the area of knowledge, where a growth of 7.59% is observed in recent years, in a total of 122 sources with 344 authors present in said publications.

3. RESULTS AND DISCUSSION

The growth of scientific production can be seen more clearly in Figure 1; Of this, the years 2020 (16), 2022 (23) and 2023 (26) stand out, articles each year, in which there was a notable growth in publications related to the research topic, 53 are concentrated in these years, 28% of all research carried out.

Next, the most relevant sources are shown based on the frequency of publication on the topic and through the percentiles shown through Bradford’s law; this law classifies journals into three

performance zones, each with an increase in the number of journals and a similar proportion of articles (Sudhier, 2020).

Table 1: Keyword standardization

Keywords	Descriptors
Green projects	*Green energy *Sustainable projects
Clean energy	*Clean energy *Alternative energy *Renewable energy

Table 2: Main information of the data obtained from scopus

Main information about data	
Timespan	2002:2024
Sources (Journals, Books, etc.)	96
Documents	122
Annual growth rate %	7,59
Document average age	5,12
Average citations per doc	20,93
References	5334
Document contents	
Keywords plus (ID)	781
Author's keywords (DE)	399
Authors	
Authors	344
Authors of single-authored docs	22
Authors collaboration	
Single-authored docs	22
Co-authors per doc	3,02
International co-authorships %	24,59
Document types	
Article	83
Book	1
Book chapter	6
Conference paper	25
Note	2
Review	5

Table 3: Bradford's law

Zone	No. journals	No. titles	Percentages
Zone 1	15	41	33.61
Zone 2	41	40	33.61
Zone 3	40	40	32.79

Table 3 and Figure 2 show the percentages corresponding to each Zone of Bradford Law. It should be noted that zone 1 is the one that concentrates the most publications with 33.61% (41) titles in 15 journals. In this same sense, Figure 4 shows the most representative magazines according to this law.

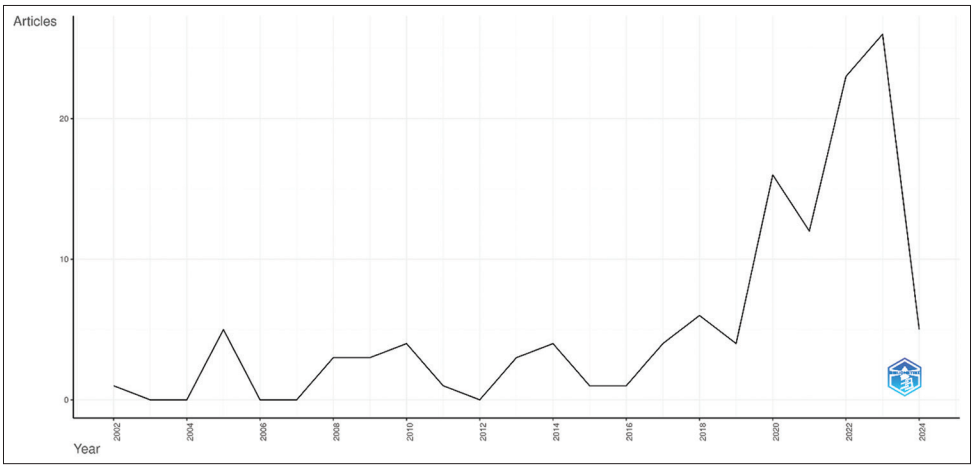
In accordance with the above, Figure 3 shows how the Journal of Cleaner Production, and Resources Policy, leads the area with 5 publications each, followed by Energy Policy, Environmental Science and Pollution Research and Sustainability (Switzerland) with 4 publications each one.

In the case of one of the most relevant sources found, Journal of Cleaner Production is an international transdisciplinary journal that focuses on cleaner production, environmental and sustainability research and practice. On the other hand, in terms of countries, it is observed that China is the greatest exponent in terms of scientific productivity with 50 contributions, followed by India with 28, the United States with 26, Italy with 16, Portugal with 16, Malaysia with 12, Indonesia with 12, among others, this can be seen in Table 4.

As can be seen, publications from China represent 14.66% of the total found. Recent studies show that investment in green industries has been increasing and that the nation is now the world's leading destination for green investments. According to them, China has committed to achieving carbon neutrality by 2060, which requires significant investments in environmentally friendly projects (Polzin and Sanders, 2020). However, due to financial constraints that may seriously impede their ability to invest in green technology, Chinese companies are limited in their green innovation capacity (Yu et al., 2021).

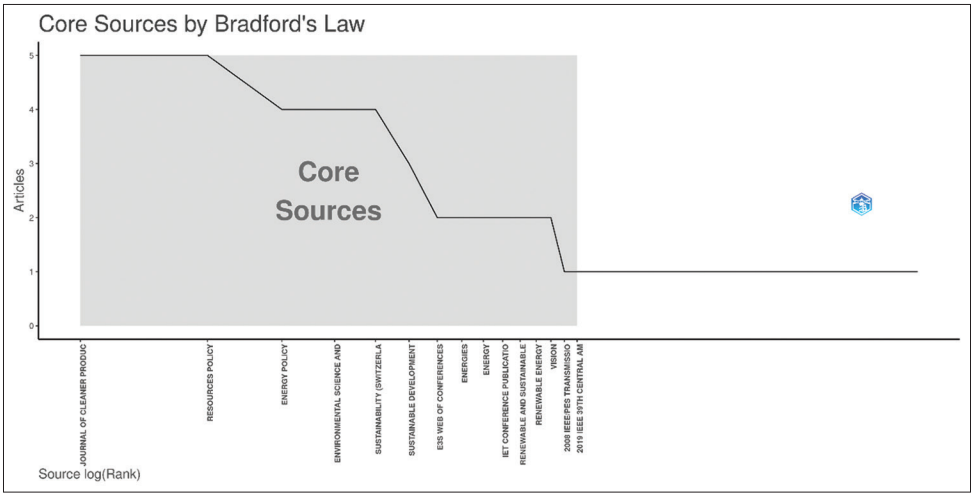
Following this order of ideas, Figure 5 shows the institutions that have made the most contributions on the topic of study are IBN Tofail University and WSB University with six (6) contributions each, Kassel University, Southwestern University of Finance and Economics and University Technical University Of Athens with five (5) contributions each; These contribute 9.78% of all publications, taking into account that there are co-authored works among them.

Figure 1: Annual scientific production



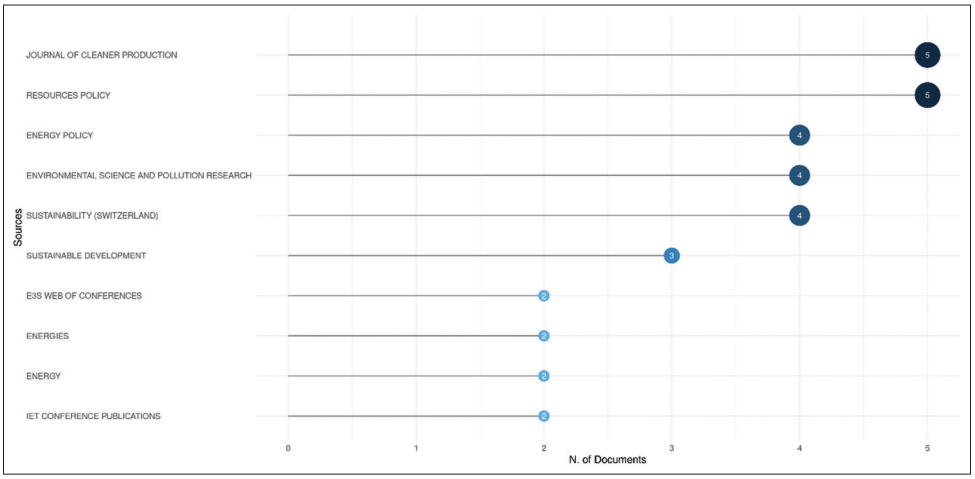
Source: Author based on information from scopus (2024)

Figure 2: Bradford's law



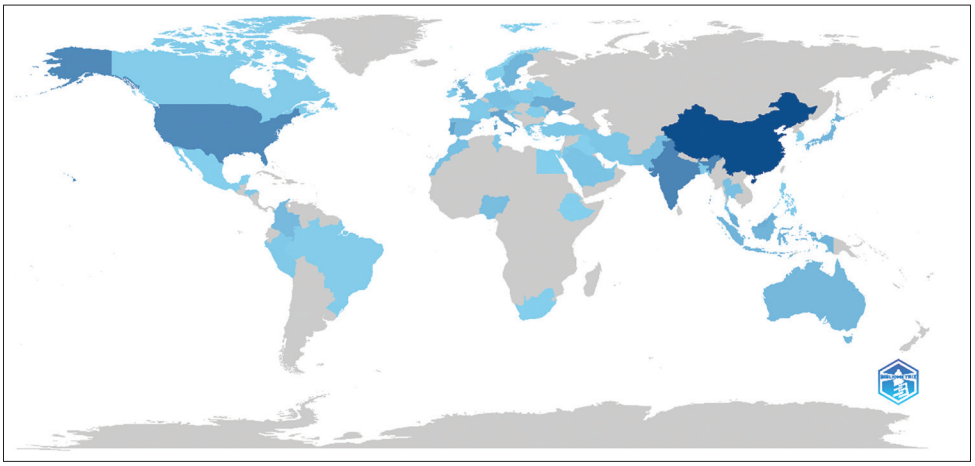
Source: author based on information from scopus (2024)

Figure 3: Most relevant sources



Source: Author using R software based on information from Scopus (2024)

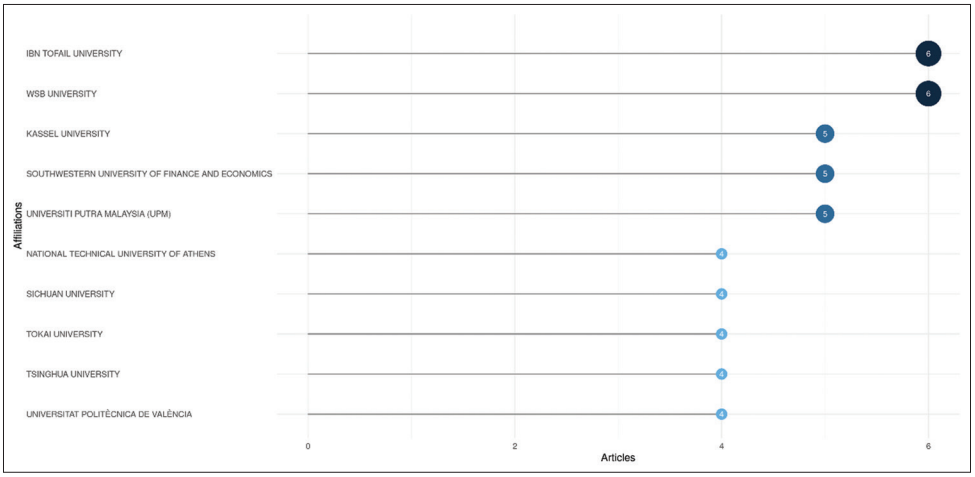
Figure 4: Scientific production between countries



Source: Author based on information from Scopus (2024)

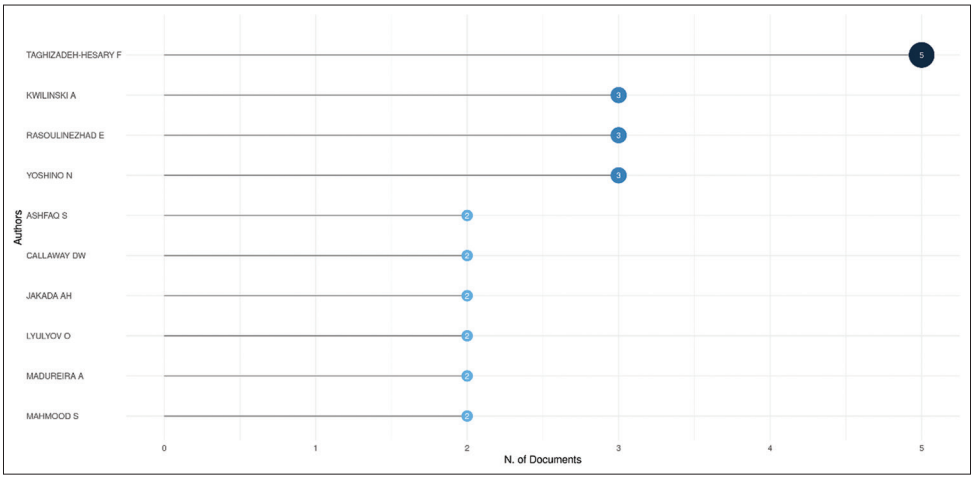
To measure productivity per researcher, the frequency index is taken as a reference; on which Figure 6 shows the leadership of Taghizadeh-Hesary and Yoshino all with five (5) contributions, followed by Kwilinski et al. with three (3) contributions each. For the purposes of this research, Lotka's law allows mapping the production curve on the N of authors to more clearly understand

Figure 5: Most relevant affiliations



Source: Author based on information from Scopus (2024)

Figure 6: Most relevant authors



Source: Author using R software based on information from scopus (2024)

Table 4: Scientific production by country

Country	Frequency
China	50
India	28
USA	26
Italy	16
Portugal	16
Malaysia	12
Ukraine	12
Indonesia	10
Japan	10
Sweden	10

the impact of authors on the area of knowledge (Kushairi and Ahmi, 2021).

Regarding this, Table 5 shows how 94.8% of the authors have made a single contribution, followed by 4.10% who have made at least two, followed by 1.20% who have made more than 3. From the above it can be inferred that the majority of authors who investigate this topic are transitory.

Table 5: Lotka's law

Written documents	N. of authors	Proportion of authors
1	326	0.948
2	14	0.041
3	3	0.009
5	1	0.003

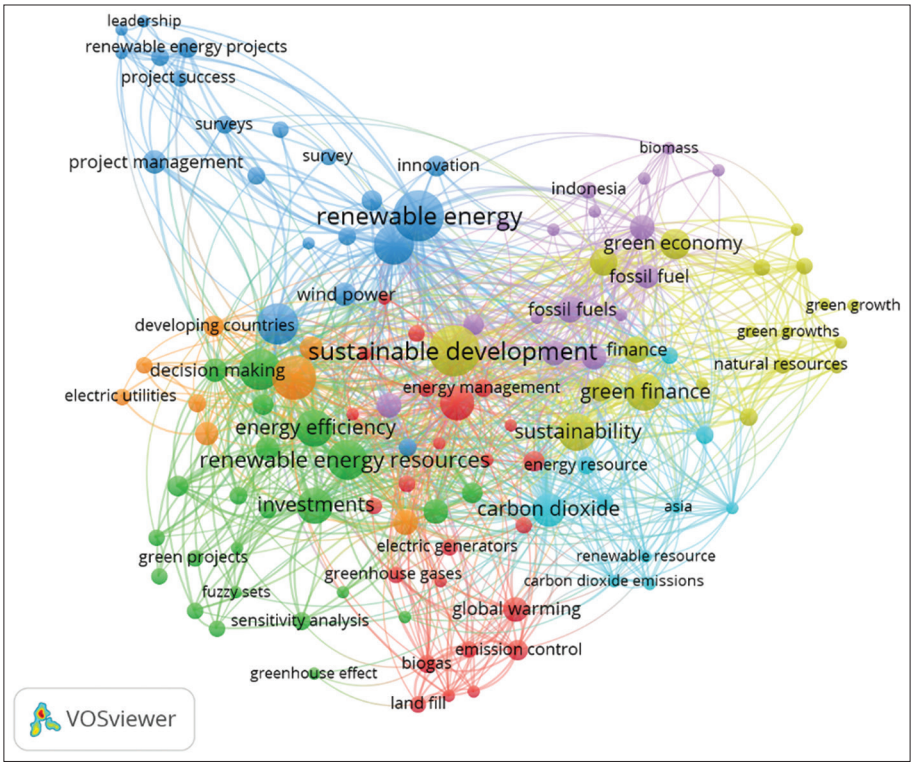
On the other hand, Table 6 shows the twenty-four articles related to the study topic that have the most citations. The three most representative are: Yu et al. (2021) in Energy Policy; Taghizadeh-Hesary and Yoshino (2020) in Energies; and Rasoulinezhad and Taghizadeh-Hesary (2022) in Energy Efficiency.

Finally, the cluster analysis through VOS VIEWER, Figure 7 reveals the terms with the greatest impact grouped by co-occurrence, where it is observed as keywords such as "sustainable development," "renewable energy," "green projects," "renewable energy resources," "global warming," "land fill" are several of the key terms associated with the area of knowledge of new trends in green projects towards clean energy.

Table 6: Most cited articles

Articles	DOI	Total Citations	References
Yu et al. (2021), Energy Policy	10.1016/j.enpol. 2021.112255	413	(Yu et al., 2021)
Taghizadeh-Hesary and Yoshino (2020), Energies	10.3390/en13040788	237	(Taghizadeh-Hesary and Yoshino, 2020)
Rasoulinezhad and Taghizadeh-Hesary (2022), Energy Efficiency	10.1007/s12053-022-10021-4	222	(Rasoulinezhad and Taghizadeh-Hesary, 2022)
Yoshino et al. (2019), Economic Modelling	10.1016/j.econmod. 2018.11.018	107	(Yoshino et al., 2019)
Mngumi et al. (2022), Environmental Science and Pollution Research	10.1007/s11356-022-19839-y	104	(Mngumi et al., 2022)
Sureeyatanapas et al. (2018), Journal of Cleaner Production	10.1016/j.jclepro. 2018.04.206	95	(Sureeyatanapas et al., 2018)
Halliru et al. (2020), Journal of Cleaner Production	10.1016/j.jclepro. 2020.124247	95	(Halliru et al., 2020)
Shang et al. (2023), Resources Policy	10.1016/j.resourpol. 2023.103359	89	(Shang et al., 2023)
Liu et al. (2020), Energy Policy	10.1016/j.enpol. 2020.111709	80	(Liu et al., 2020)
Strielkowski et al. (2020), Economic Research-Ekonomska Istraživanja	10.1080/1331677X.2020.1734854	71	(Strielkowski et al., 2020)
Zhang and Umair (2023), Environmental Science and Pollution Research	10.1007/s11356-023-27870-w	62	(Zhang and Umair, 2023)
Farinelli et al. (2005), Journal of Cleaner Production	10.1016/j.jclepro. 2004.12.013	57	(Farinelli et al., 2005)
Gu and Zhou (2020), Ecosystem Health and Sustainability	10.1080/20964129.2020.1747947	56	(Gu and Zhou, 2020)
Guild (2020), Journal of Sustainable Finance and Investment	10.1080/20430795.2019.1706312	51	(Guild, 2020)
Kwilinski et al. (2023), Land	10.3390/land12020511	49	(Kwilinski et al., 2023)
Gong et al. (2020), Energy Policy	10.1016/j.enpol. 2020.111687	40	(Gong et al., 2020)
Du et al. (2023), Energy Economics	10.1016/j.eneco. 2023.106595	37	(Du et al., 2023)
Zaman et al. (2022), Energy Policy	10.1016/j.enpol. 2022.112793	37	(Zaman et al., 2022)
Wang et al. (2022), Environmental Science and Pollution Research	10.1007/s11356-021-16441-6	34	(Wang et al., 2022)
Olaofe (2018), Energy	10.1016/j.energy. 2018.07.185	31	(Olaofe, 2018)
Siri et al. (2021), Handbook of Environmental Chemistry	10.1007/698_2020_635	28	(Siri et al., 2021)
Domenech et al. (2015), Renewable and Sustainable Energy Reviews	10.1016/j.rser. 2015.06.017	26	(Domenech et al., 2015)
Moussa (2018), Ain Shams Engineering Journal	10.1016/j.asej. 2018.09.001	25	(Moussa, 2018)
Lange et al. (2018), Marine Policy	10.1016/j.marpol. 2018.01.008	23	(Lange et al., 2018)

Figure 7: Co-occurrence of keywords using VOS viewer software based on information from Scopus



4. CONCLUSION

The bibliometric analysis developed in this research reveals important trends and patterns in the research of green projects focused on clean energy. Of the 122 articles analyzed in this bibliometric study based on the information obtained from Scopus on new trends in green projects towards clean energy, the shared conclusions can be established in the following paragraphs.

The highest peaks of publications occur in the years 2020, 2022 and 2023, where 53.28% of the total published works are concentrated, evidencing a growing interest in the field, reflecting the global urgency to find sustainable solutions. In turn, the scientific production analyzed in the period from 2002 to 2024 shows a growth rate of 7.59%, attesting to the dynamism and continued relevance of this topic in the scientific community.

The geographical distribution of the publications highlights the prominence of countries such as China, India and the United States, leaders in clean energy research, concentrating 68.90% of all the publications found. On the other hand, the journals that publish the most on the subject are, such as the Journal of Cleaner Production and Resources Policy, leading the area among the three with 5 publications each, followed by Energy Policy, Environmental Science And Pollution Research and Sustainability (Switzerland) with 4 publications each, the rest of the publications are dispersed among different journals, underlining the importance of these platforms in the dissemination of knowledge in the field of energy sustainability.

The institutions that have made the most contributions on the topic of study are evidence that the institutions that have made the most contributions on the topic of study are IBN Tofail University and WSB University with six (6) contributions each, Kassel University, Southwestern University Of Finance And Economics and Universiti Technical University Of Athens with five (5) contributions each; These contribute 9.78% of all publications. The role of these academic institutions in generating knowledge about clean energy is notable, demonstrating their commitment to research and innovation in this area.

The authors with the most published articles are Taghizadeh-Hesary and Yoshino, all with five (5) contributions, followed by Kwilinski et al. with three (3) contributions each; This is taking into account that 3.02% of the researchers in this field have international co-authorships. Finally, the keywords most related to the topic of study are "sustainable development" "renewable energy" "green projects" "renewable energy resources" "global warming" "land fill," which reflect the central themes in the field of clean energy, highlighting the importance of aspects such as climate change and natural resource management. All of this data provides a reference point for future research and collaborations.

This bibliometric study provides a solid foundation for future research on renewable energy. It is advisable to focus on certain topics, such as the use of cutting-edge technology, the evaluation of energy regulations and the investigation of the financial sustainability of environmentally friendly initiatives. Furthermore, by tracking patterns over time, longitudinal research can detect important changes in objectives and methods. To accelerate the global transition towards cleaner and more sustainable energy, two important facets that need to be investigated are international collaboration and interdisciplinarity.

The future implications of this study are significant for policy formulation, investment in clean technologies, and academic research. In terms of policy, the findings suggest the need to promote closer international collaboration and develop policies that incentivize the adoption of sustainable technologies.

For investors, the importance of investing in emerging technologies that can offer innovative solutions to current environmental challenges is highlighted.

Regarding future lines of research, it is recommended to further explore the long-term impact of clean energy projects on both the environment and society. It is also crucial to investigate new renewable energy technologies, such as marine energy and carbon capture and storage, which have not yet been fully explored. Additionally, the use of mixed methodologies combining quantitative and qualitative analysis is suggested to provide a more comprehensive view of the trends and challenges in this field.

However, the study presents certain limitations. One of the main limitations is the exclusive reliance on the Scopus database, which could exclude relevant research published in other databases or in languages other than English

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