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Unveiling Research Trends on the Sustainable Development Goals: A Systematic Bibliometric Review

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ABSTRACT

Sustainable Development Goals advocated by the United Nations in 2015 focus upon five major crucial areas of concern by 2030 i.e., people, planet, prosperity, peace, and partnership. Through a bibliometric analysis, the present study intends to examine the trends, development, and prospects of the Sustainable Development Goals from 2016 to 2023. The study employed VOSviewer, MS Excel, and Biblioshiny (R Studio) to examine data collected from the Web of Science core collection database. In total, 2,814 title–based articles were analyzed and refined. Various methods were employed to identify the multidimensional contribution to the research of SDGs, including analysis of keywords, prolific authors, productive journals, active institutions and countries, and collaborations. The study identified significant clusters of SDG themes, such as environmental sustainability, education and attitude towards sustainability, and improvement in health quality and women's participation. The study also identified the top publications, prominent authors and journals, active institutions, research gaps, and nations contributing to this domain. The results show that high-income nations have a notably higher level of deliberation regarding SDG research. The results revealed significant implications, offering insightful information to stakeholders, researchers, and policymakers to prioritize future research endeavors and resource allocation to best achieve the 2030 SDGs.

1. INTRODUCTION

Under the banner of "Transforming our world: the 2030 Agenda," 193 nations accepted the notion of Sustainable Development Goals (SDGs) on September 25, 2015, and came into effect on January 1, 2016 [1]. The SDGs seek to address climate change, safeguard the environment, end extreme poverty, and promote global peace and prosperity by 2030 [2]. Agenda 2030, the global action plan, had 17 SDGs with 231 indicators and 169 specific targets [3]. The five P's—planet, peace, people, prosperity, and partnership—were included in the Agenda 2030 action plan for sustainable development [4].

Despite the precarious state of the global economy, escalating tensions such as the Russia-Ukraine and Israel-Palestine conflicts, and the urgency of the climate emergency like continuous deforestation of Amazon [5] and surging levels of greenhouse gas emissions, the fulfillment of the goals has been jeopardized. Nevertheless, it is still within our capacity to reverse this trajectory in the forthcoming six years. It is worth highlighting that there have been notable accomplishments in the SDGs since 2015, particularly in critical domains such as poverty alleviation, reduction of child mortality, enhanced electricity accessibility, and the fight against specific illnesses [6]. 17 SDG goals include "no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation,

affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace, justice and strong institutions, partnership for the goals" [7].

The advent of SDGs has prompted numerous systematic investigations aimed at comprehending, prioritizing, and assessing the advancement of goals embraced by nations. The outcomes of these researches are anticipated to encourage rigorous, fact-driven, dependable, and punctual assessment of accomplishments towards satisfying the objectives of nations in their varied socio-economic contexts [8-10]. To achieve the Sustainable Development Goals (SDGs), research, innovation, and education for sustainability are essential components. Since its acceptance in 2015, there has been a consistent increase in the study methods for examining the SDGs.

In recent years, researchers reviewed and analyzed the SDGs using quantitative tools like bibliometrics and meta-analysis to improve the present qualitative evaluation of SDG research. The study conducted by Yamaguchi et al. [11] appraised the trends and development through a systematic review of the SDGs using evocative bibliometric investigation for the period 2015 to 2022 from the WoS database. The findings confirm that several SDGs remain untouched for extensive research and review thus the research on SDGs

cannot yet be regarded as a consolidated field of research. The findings of Yamaguchi et al. [11] and Mishra et al. [2] revealed that the field of SDGs is growing rapidly, and there is a discernible development toward investigating a wider array of research vicinity. Analogous bibliometric studies focused on similar findings in the field of SDGs research [12-15]. Similarly, various bibliometric studies on the SDGs are being proliferated, mainly on the corporate sector, education, poverty, good health and well-being, renewable energy, and entrepreneurship sector [16-21]. The findings showed that eradicating poverty, embracing renewable energy, encouraging sustainable urban design, guaranteeing fair access to healthcare, and tackling climate change were among the recurring themes. However, social and economic factors including job opportunities, gender equality, peace, and social justice require greater focus [22]. The study also inferred that research is very limited in the area of localization of SDGs, as local governments are expected to take the lead in accomplishing the SDGs by evaluating the local environment, determining requirements and resources, forming alliances with stakeholders, and putting relevant policies and programs into action [23-25]. However, very few bibliometric research trends cover the broad/general outlines of the SDGs. The multidisciplinary bibliometric studies on the SDGs are necessary to give academics and researchers in this sector more comprehensive, varied, and full data. By approaching the SDGs study topic from a wider perspective and investigating the bibliometric review of trends, development, and prospects of the goals, this work seeks to support the bibliometric journey. This is meant to be used in conjunction with earlier bibliometric research.

The present study differs significantly from earlier bibliometric analyses as it delved deeper into exploring the holistic approach with multidimensional perspectives with 7 broader research questions covering all 17 SDGs. The study was analyzed for the current study period from January 2016 to December 2023. The study performed both analyses, performance analysis and science mapping analysis for complete understanding using VOSviewer, Biblioshiny (Rstudio), and MS Excel for better results. This study analyzed the different science maps, such as co-word analysis, citation and co-citation analysis, co-authorship analysis, and geographical analysis of publications through strategic maps, which were created to illustrate the intellectual makeup of the SDG domain from various perspectives. The study analyzed the clusters of themes and related research gaps using keyword analysis. An examination of the SDGs using bibliometric analysis can make a major contribution to our knowledge of the development and unification of sustainable development research. Bibliometric analysis offers a comprehensive overview of SDGs' progress by mapping scientific production, identifying trends and gaps, and revealing connections between researchers, institutions, and nations [2]. In this way, the bibliometric analysis can provide future relevance and usage to optimize efforts to achieve SDGs. Moreover, tracking publication volume and impact over time provides a gauge of progress made toward SDG targets while highlighting areas needing more attention and investment [22]. Essentially, bibliometric analysis of SDGs literature builds an evidence base to guide policymaking, research priorities, and funding allocation, thereby bolstering global sustainable development initiatives. The study is intended to seek the answers to the following research questions addressed in various sections:

RQ1: What's the trajectory of publication expansion and citation rates in SDGs research?

RQ2: Who are the leading authors and journals making significant contributions to SDG research?

RQ3: Which institutions, organizations, and countries stand out as the foremost contributors to SDG research?

RQ4: Which publications hold the highest preference or citation rates in the realm of SDGs research?

RQ5: Which SDGs are the primary focus of research, garnering the most attention and emphasis?

RQ6: What thematic clusters emerge, and where do research gaps exist within the realm of SDGs?

RQ7: Which authors and journals wield the most influence within the domain of SDGs research?

2. RESEARCH METHODOLOGY

For a bibliometric review, the author needs to choose a citation database that indexes the literature of the concerned area of research to gather information for review. The scientific community frequently uses the databases Scopus and Web of Science for bibliometric review [26-28]. The present study used only the Web of Science (WoS) core collection database as it is among the most limiting when it comes to article acceptance [29], which ensures the quality and meticulousness of the works analyzed. WoS is considered one of the oldest and most well-liked databases in the research domain and citations [30]. The study used the following indexes: Science Citation Index Expanded (SCI-E), Social Sciences Citation Index (SSCI), and Arts & Humanities Citation Index (A&HCI). A multidisciplinary citation index SCI-E covers scientific and technological journals since 1900. It included more than 8000 scientific journals in addition to 12,000 conference and press journals [29]. More than 3000 social science journals, as well as press and conference journals, were available through SSCI [31].

Since 1975, the SSCI Arts & Humanities Citation Index has covered more than 1800 periodicals spanning 28 arts and humanities fields, more than 5 million pages, and 33.4 million cited references [32].

Figure 1 shows the PRISMA flow chart which depicts the identification of studies including identification of data, screening of data, and then final retrieval of data for the study of bibliometric analysis on Sustainable Development Goals. The following keywords were used: TI = ("SDGs" OR "Sustainable Development Goals" OR "agenda 2030") and "SDG 1" to "SDG 17" were used separately. The data was further refined based on: Document Types – Articles, Period – 2016 to 2023, and Language – English. The query retrieved 2,814 articles from 2016 to 2023 on December 30 (2023). Files in the .csv and .txt formats contained the refined 2,814 article records, citation information, bibliographic information, and other data. The time frame selected for the study is from 2016 to 2023. Since Agenda 2030 on SDGs came into effect on January 1st, 2016, that is why the year 2016 was used in the study.

The study used different software for the bibliometric analysis such as VOSviewer, Biblioshiny (R Studio), and Microsoft Excel. VOSviewer is a statistical bibliometric tool, which is widely used to construct and view bibliometric maps. It is used to construct bibliometric networks of authors, journals, and organizations by using different analysis methods like – co-authorship, co-occurrence, co-citations, and bibliometric coupling [33], which were used to analyze

scientific network mapping. Biblioshiny is the tool used in scientometrics and bibliometrics for quantitative research. It contains various methods for importing bibliographic information from the "Clarivate Analytics Web of Science" and "SCOPUS" [34], which were used to compile descriptive data and analyze the thematic structure through the word cloud. This research has examined several aspects of bibliometric analysis, including co-occurrence of keywords, co-authorship of authors and nations, and citation of publications and authors. The study has also analyzed the intellectual structure of knowledge about subject similarities based on the analysis of co-citation of authors and journals. Performance analysis and scientific mapping analysis constitute bibliometrics analysis. The foundation of performance analysis is bibliometric indicators, which quantify the influence attained through publishing and citation data and the production of particular actors (researcher, intuition, nation, and journal). An analysis of science mapping offers a historical and topological depiction of the social and cognitive framework within a specific field of study [35].
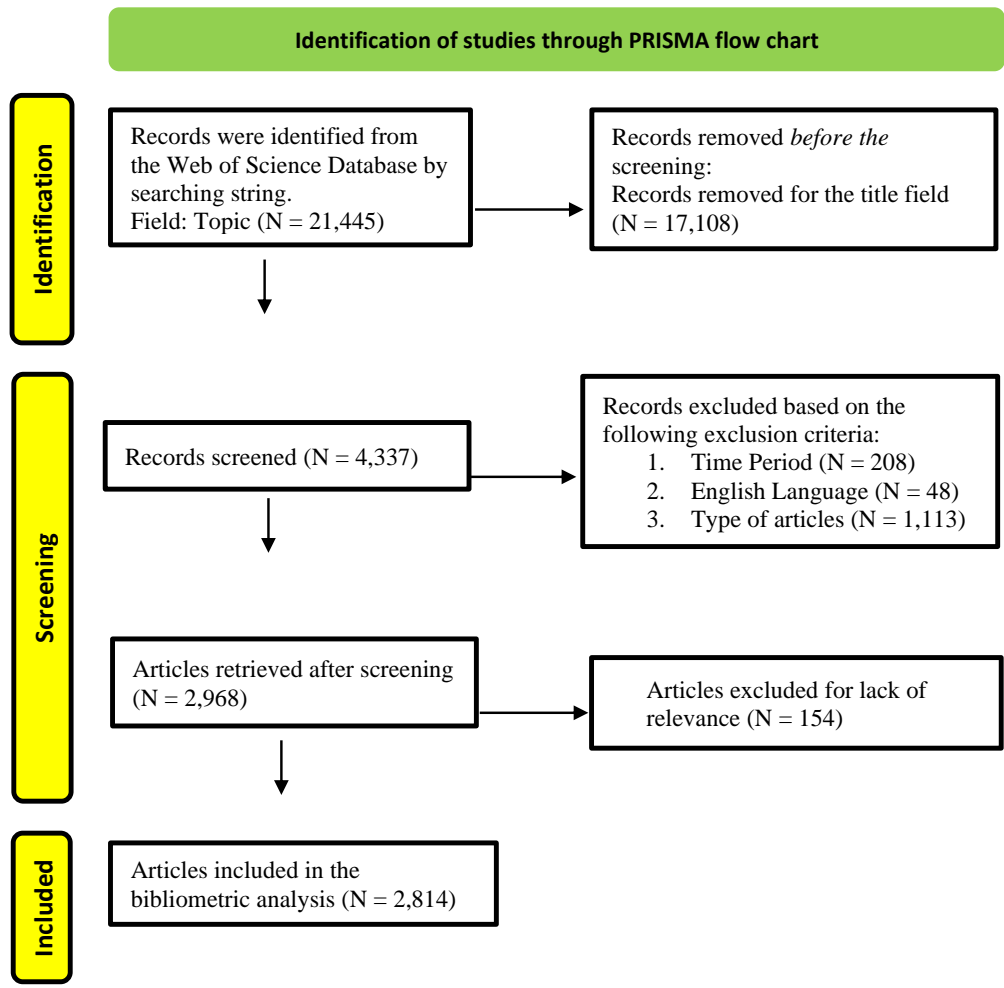
Identification of studies through PRISMA flow chart

Identification

Records were identified from the Web of Science Database by searching string.
Field: Topic (N = 21,445)

Records removed *before the* screening:
Records removed for the title field (N = 17,108)

Screening

Records screened (N = 4,337)

Records excluded based on the following exclusion criteria:
1. Time Period (N = 208)
2. English Language (N = 48)
3. Type of articles (N = 1,113)

Articles retrieved after screening (N = 2,968)

Articles excluded for lack of relevance (N = 154)

Included

Articles included in the bibliometric analysis (N = 2,814)

Figure 1. PRISMA flow chart
Source: Author compilation

3. RESULTS AND DISCUSSION

The results of the bibliometric analysis of SDGs were divided into eleven sections. The first section shows the overall information about the investigation process and retrieved data. The second section investigated the trend analysis of publications and citations. The third section explored the highly preferred and productive journals for publication. The fourth section discussed highly productive organizations/Institutions. The fifth section investigated highly productive countries and their collaborations globally. The sixth section stated about the highly prolific authors. The seventh section examined the thematic cluster of SDGs. The eighth section investigated highly focused SDG goals. The ninth section investigated highly preferred published articles. The last tenth section examined the intellectual structure of knowledge for authors and journals.

3.1 Information about retrieved data

Table 1 displays the retrieved data from the Web of Science from 2016 to 2023. The data shows that 2,814 papers published in 710 journals from 146 publishers used 3,652 keywords plus, and 7,112 author keywords. A total of 12,270 authors from 153 countries have contributed to this domain. The average citation per article was 21.98, and the average number of writers per article was 4.36, indicating that four authors have written each article on average.

Collaboration among authors was also very high as out of 2,814 articles, only 354 articles were single-authored, and the rest 2,460 articles were written in collaboration. A total of 4,478 institutions/organizations have contributed to the research in this domain. The overall h-index of all retrieved 2,814 publications was 103.

Table 1. Descriptive statistics

Description	Results
Articles	2,814
Period	2016-2023
Authors	12,270
Sources (Journals, Books)	710
Countries	153
Total citations (All Database)	61,874
Average citations per article	21.98
Keywords plus (ID)	3,652
Author's keywords (DE)	7,122
Total keywords	9,832
Number of publishers	146
Single-authored articles	354
Articles per author	0.23
Authors per article	4.36
Total affiliations	4,478
H-index (Publications)	103

Source: Author compilation

3.2 Research trend analysis of publications and citations on SDGs

Figure 2 addressed RQ1, and shows the annual growth of publications and total citations on SDGs from 2016 to 2023. It has been observed that the number of publications published globally has increased more rapidly since 2016. In 2016, growth drastically increased to 238%, with a total number of articles of 54 and total citations of 65. Although, the volume of articles was very low but growth rate was very high because Agenda 2030 for SDGs came into force in January 2016. In 2017, the total growth rate was 79.36% with a total number of articles 97 and citations 495. In 2018, total growth was 83.51% with a total number of articles 178 and citations 1,391. 2019 saw a decrease in growth to 46.63% with 261 articles and 3,385 citations, whereas 2020 saw a rise in growth to 56.32% with 408 articles and 7,223 citations. Growth dropped to 23.77% in 2021, with a total of 505 papers and 12,469 citations. Growth reached 25.94% in 2022, with 636 articles overall and 17,594 citations. In 2023, growth drastically declined to 6.13%, with a total number of articles of 675 and citations of 19,252. It indicated that after COVID-19 (2020), the relative growth of publications started declining.
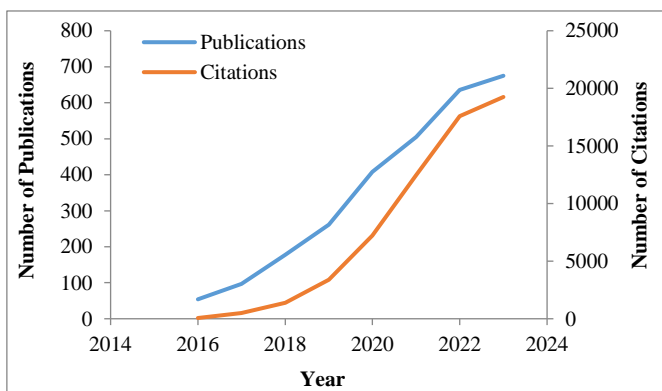
Figure 2. Trend of SDGs-related publications and citations
Source: Author complication

From 2016 to 2023, title-based 2,814 papers on the Sustainable Development Goals were published; these articles were cited 61,874 times overall, averaging 21.98 citations per article. The maximum average citations per article were 24.69, 27.66, and 28.52 during 2021, 2022, and 2023 respectively.

The volume of total citations has consistently increased since 2016 but the growth trend of citations has been decreasing since 2017 (661.54%) to 2023 (41.10%).

3.3 Top journals in Sustainable Development Goals

Research in any scientific field is worthwhile because academic journals are regarded as the primary channel for disseminating scientific output [36]. Table 2 addressed the RQ2, which provides information about the top 15 leading and prominent journals that published publications on the SDGs-related domain from 2016 to 2023. The study has used Clarivate analytics for the impact factor data of journals, the Scimago Journal Rank Indicator for the journals' origin, and the WoS database for the h-index. A total of 1,070 articles were published on SDGs-related domains in these 15 journals.

Table 2. Top 15 journals in Sustainable Development Goals

Name of Journals	NP	H-index	TC	IF
Sustainability	491	40	7,061	3.9
Sustainable Development	106	29	2,581	12.5
Journal of Cleaner Production	95	37	4,523	11.1
Sustainability Science	57	24	2,499	6
International Journal of Sustainability in Higher Education	44	15	810	3.1
Environmental Science and Pollution Research	35	12	816	5.8
International Journal of Sustainable Development and World Ecology	34	18	1,249	5.6
Environment Development and Sustainability	32	10	275	4.9
Science of the Total Environment	31	20	1,205	9.8
Environmental Science and Policy	28	14	910	6
Remote Sensing	27	9	281	5
Business Strategy and the Environment	26	12	540	13.4
Global Policy	22	10	414	1.9
International Journal of Environmental Research and Public Health	22	9	188	4.61
World Development	20	16	1,004	6.9

Source: Author compilation

Researchers' top picks for journals are 'Sustainability' (Switzerland), with 491 publications (17.45% of total publications), 7,061 citations, and an impact factor of 3.9, followed by 'Sustainable Development' (England), with 106 publications (3.77%), 2,581 citations, and 12.5 impact factor, and 'Journal of Cleaner Production' (England), has 95 publications (3.38%), 4,523 citations, and an impact factor of 11.1. The table indicates that 'Sustainability' (40), 'Journal of Cleaner Production' (37), and 'Sustainable Development' (29) are the top three journals having high h-index values. 'World Development' is the last (15th) most productive journal based on the number of articles but the 7th most preferred based on total citations. The table also showed that England published the maximum number of articles (40%) related to the SDGs in the top 15 list than any other nation.

3.4 Top leading institutions and organizations

Addressing RQ3, the top 10 prolific institutions for SDG-

related research are listed in Table 3. Table 3 depicts that the 'University of London' is the most productive institution with a total of 90 publications from England, followed by the 'Chinese Academy of Science' with a total publication of 77 from China, and the 'World Health Organization' with a total publication of 48. Maximum of these 10 institutions are from England (30%), China (20%), Netherlands (20%), Australia (10%), and Egypt (10%).

It is important to notice that no single Indian institute was found in the list of top 10. Figure 3 shows the network visualization of the top 50 institutions' collaborations. The nodes depict different institutions or organizations [37] and the lines between nodes signify the relationship between two institutions/organizations [37, 38], The strength of the links is shown by the line's thickness in terms of how frequently the parties collaborate. The size of an institution's nodes can be used to determine its overall strength or the number of partnerships it has with other institutions worldwide [39]: the larger the node, the higher the link strength. Based on the threshold "minimum number of documents of an organization is 15", hence 54 institutions were refined out of 4,638. Figure 3 shows that the authors from University College London (UCL) have the strongest collaboration with authors from 44 other organizations in 166 publications, followed by the University of Oxford having collaboration with 40 organizations.

Table 3. The top ten most productive institutions

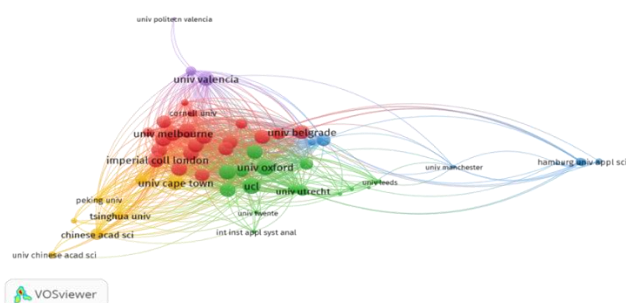| Organizations/Institutions	Articles	Country
University of London	90	England
Chinese Academy of Sciences	77	China
World Health Organization	48	WHO
Egyptian Knowledge Bank EKB	47	Egypt
University College London	41	England
Utrecht University	40	Netherlands
University of Oxford	36	England
The University of Queensland	36	Australia
Beijing Normal University	35	China
Wageningen University & Research	33	Netherlands

Source: Author compilation

Figure 3. Network visualization of collaboration of institutions/organizations
Source: VOSviewer (January 2024)

3.5 Geographical distribution of publications in SDGs and collaboration among countries

Table 4 addressed the RQ3, depicts the top 10 hotspot countries of publications in SDGs. All publications have originated from 153 countries. With 463 publications (16.45%), the 'United States' was the most productive nation, followed by 'England' with 442 publications (15.70%), and

'China' with 393 publications (13.93%). The table also shows that the USA has more publications than England, but in terms of citations, England was more preferred country over the USA. The table additionally reveals that India is the only nation in the top 10 list with a poor SDGs index rank (112), while Germany was the only nation featured in the top 10 SDGs index rank (4) within the top ten rank 2023. According to linkages in the table, the authors from the 'United States' have collaborated the most with the authors from 138 (links) countries, followed by 'England' with 129 countries, and 'China' with 126 countries. Furthermore, it showed that India and China were the only developing nations in the top 10 most productive nations in the world. The USA has the maximum collaboration in terms of volume but the ratio of collaboration per paper or the rate of collaboration (Links / Articles) is highest in Canada (0.77), followed by the Netherlands (0.73), and India (0.72). Surprisingly, England has a minimum collaboration per paper (0.29), followed by the USA (0.30) among the top 10 productive countries.

Table 4. Top 10 hotspot countries of publications in SDGs

Country	Articles	Citations	Links	SDGs Index Rank (2023)
USA	463	19,140	138	39
England	442	19,633	129	11
China	393	11,166	126	63
Spain	299	7,108	122	16
Australia	256	9,645	128	40
Germany	224	9,219	121	4
Italy	173	6,337	125	24
India	171	4,911	123	112
Netherlands	167	8,159	122	20
Canada	154	5,648	119	26

Source: Author compilation

The map visualization in Figure 4 exhibits articles published by authors from 153 different countries based on data retrieved from the Web of Science database. The varying shades of brown on the map represent the different countries and their corresponding number of published articles. The USA has the darkest shade of brown, indicating that it has the highest number of published articles (463) followed by England (442), China (393), and Spain (299). The countries shaded in grey have not published any articles and authors from India have published a total of 171 articles, the 2nd highest in Asia after China. The analysis showed that developed countries have relatively more concentration on SDGs-related research than developing and underdeveloped countries [2]. However, the study by Indiana and Pahlevi [12] revealed that the number of studies on the Sustainable Development Goals in wealthy and developing countries is roughly equal.
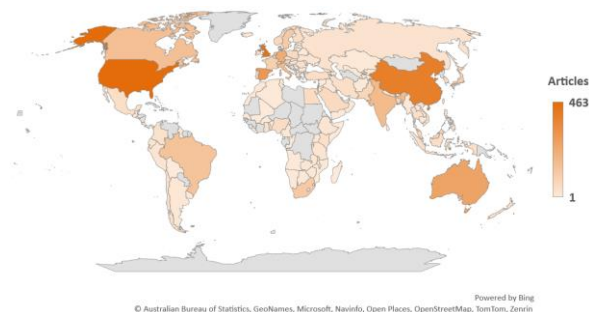

Figure 4. Geographical distribution of publications in SDGs
Source: Author compilation (January 2024)

3.6 Top prolific authors

Table 5, which deals with research question 2, enumerates the ten most prolific writers according to the number of papers on SDGs-related research that were produced between 2016 and 2023. These publications make up 4.06% of all publications, while citations account for 6.16% of all citations.

The study found that Walter Leal Filho from Germany stood out as the most productive author, the finding also supported by the study of Yumnam et al. [22] has the maximum number of articles (25) with the highest number of total citations 1,034, and an h-index of 11, followed by Amanda Lange Salvia from Brazil with total articles of 12, with total citations of 558, and h-index of 9. Gender equality, energy sustainability, education for sustainable development, business models, and the implementation of the SDGs are among Walter Leal Filho's primary research areas. "Assessing research trends related to Sustainable Development Goals: local and global issues" is one of his most cited articles.

Table 5. Top ten most prolific authors

Authors	Articles	TC	H-Index
Walter Leal Filho	25	1034	11
Amanda Lange Salvia	12	558	9
Mohammad Ali Abdelkareem	11	308	8
Abdul Ghani Olabi	11	301	8
Bojie Fu	11	238	8
Frank Biermann	10	236	5
Enas Taha Sayed	10	308	8
Kannan Govindan	9	641	8
Jianguo Liu	9	124	6
Yu Liu	9	63	5

Source: Author compilation

3.7 Investigating clusters of themes in SDGs and research gaps

Keywords used by researchers to succinctly describe the research content. Therefore, using keyword analysis, hot themes, and areas can be identified within a research domain [40]. Figure 5 addressed to RQ6, shows the investigation of clusters of themes in SDGs which provides important insights into the connections and commonalities in this field of study. The framework offered by these clusters helps to comprehend the multifaceted nature of the SDGs and their different dimensions [41].
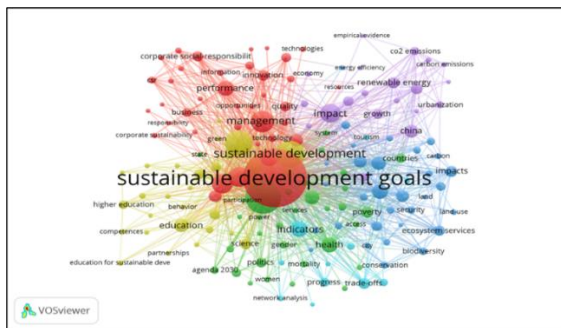

Figure 5. Clusters of themes
Source: VOSviewer (January 2024)

3.7.1 Cluster 1
Multidimensional approach to Sustainable Development Goals which encompasses various themes including Sustainable Development Goals, circular economy, 2030 agenda, corporate sustainability, management, business, innovation, technology, entrepreneurship, social responsibility, governance, and more. This cluster depicts a holistic approach to SDGs integrating various economic and technological aspects. The presence of terms like governance and social responsibility emphasizes the crucial role of government and society in achieving SDGs.

3.7.2 Cluster 2
Addressing health and gender equality deals with various themes including health, poverty, politics, policies, sanitation, mortality, women, gender, and more. This cluster focused on the improvement of health quality and women's participation in politics and to achieve these goals, government policies are needed.

3.7.3 Cluster 3
Highlights environmental sustainability including various themes such as climate change, biodiversity, food security, energy, carbon emissions, pollution, water, renewable energy, productivity, economic growth, urbanization, and more. This cluster focused on the environmental perspective integrating the economic aspect to ensure the significance of the green economy in promoting sustainable practices, especially in growing urbanization.

3.7.4 Cluster 4
Education and attitude towards sustainability encompass various themes including education of sustainable development, higher education, sustainability, universities, tourism, trade-offs, progress, students, and more. This cluster represents the educational and attitudinal importance of the environment. More incorporation of environmental aspects in education will have a significant impact on attitudes towards the environment. The presence of the term tourism depicts the importance of sustainable tourism promotion with the creation of jobs and the promotion of local culture and products.

The study inferred previous research focused mainly on environmental concerns, ignoring the social and economic dimensions such as racism, discrimination, employability, gender equality, and more. Thus, forthcoming research must delve into these crucial ideas, which include safeguarding the health, and safety of employees, and ensuring comprehensive quality control [42]. Figure 6 supports the analysis of clusters of themes and the focused areas by researchers using a word cloud of the 50 most frequent "author keywords". A total of 7,122 author keywords were retrieved, out of which 50 keywords were taken for the analysis using Biblioshiny (R Studio). The figure shows the keyword with a higher number of occurrences or the most focused theme results in the largest font. Keywords such as "sustainability", "Development", "Management", "Health", "policy", and "Analysis" are the most frequent keywords among the top 50, which indicates the researchers' focused areas for publications [43].

Figure 6. Word cloud of top 50 author keywords
Source: Biblioshiny

3.8 Highly focused Sustainable Development Goals

2,814 articles were retrieved for the study, focusing mostly on the top 10 Sustainable Development Goals (SDGs) based on the publication frequency. Table 6 addressed the RQ5, and shows that SDG 13th 'climate action' was the most researched goal with 529 (18.75%) total publications, and 12,337 citations among all top 10 SDGs, followed by SDG 3rd 'good health and well-being' with 399 (14.18%) total publications, 10,619 citations, and SDG 1st 'no poverty' with 292 (10.38%) total publications, 3,734 citations. The most researched goal is addressing climate change, which is vital given that greenhouse gas emissions have steadily increased leading to the world's temperature has risen by 1.1℃. Urgent action is required to reduce emissions and prepare for the effects of climate change [44]. Results showed that 'England', the 'USA', 'China', 'Australia', and 'Germany' was found the top 5 countries that contributed the most to research in the SDGs domain, SDG11 'sustainable cities and communities' and SDG12 'responsible consumption and production' were found as India's two most focused research areas among the top 10 SDGs.

Table 6. Top 10 highly focused SDGs

SDG Goals	Articles	Citations
13. Climate Action	529	12,337
3. Good Health & Well-Being	399	10,619
1. No Poverty	292	3,734
11. Sustainable Cities & Communities	229	4,614
12. Responsible Consumption & Production	142	3,830
6. Clean Water & Sanitation	130	2,702
4. Quality Education	116	901
9. Industry, Innovation & Infrastructure	114	1,030
2. Zero Hunger	96	2,968
7. Affordable & Clean Energy	77	1,420

Source: Author compilation

The result inferred that 'SDG4 (Quality Education), SDG11 (Sustainable Cities& Communities), SDG12 (Responsible Consumption & Production), and SDG13 (Climate Action) were highly focused in research and review by developed countries (USA, Canada, Europe, and Australia), whereas developing and underdeveloped countries were more inclined towards the SDG1 (No Poverty), SDG6 (Clean Water and Sanitation), SDG5 (Gender Equality), and SDG2 (Zero Hunger)' [45, 46].

3.9 Top leading publications

In the academic world, the contents of the most cited articles are highly important as they highlight the significance of research in a specific area. Understanding the present level of knowledge in a certain field and identifying knowledge gaps that require more investigation can be accomplished by examining the most cited papers. It also makes it possible to comprehend the inferences for future studies based on that content [47]. Based on the total count of citations from 2016 to 2023, the analysis of highly preferred publications offers insights into the primary areas of focus for the Sustainable Development Goals. Table 7 addressed to RQ4, lists the top 10 publications that researchers most frequently mentioned/cited. These articles were written by Liu et al. (2016), Kruk et al. (2018), Keesstra et al. (2016), Sachs et al. (2019), Hak et al. (2016), Grubler et al. (2018), Schroeder et al. (2019), Luyckx et al. (2018), and Bebbington et al. (2018).

The article by Liu et al. (2018) was the most cited article with total citations of 1,906, mainly investigated the under-5 mortality causes at the global, regional, and national levels, followed by article by Kruk et al. (2018) with total citations of 1,253 which has investigated the requirement of revolutionary high-quality health system, and article by Keesstra et al. (2016) with total citations of 846, which has investigated the challenges related to soil and its science for the realization of SDGs. The analysis's conclusions will aid scholars in their future work and assist them in accomplishing the aims of sustainable development. It was noted that none of the top 10 most cited publications was from India.

Table 7. Top leading publications

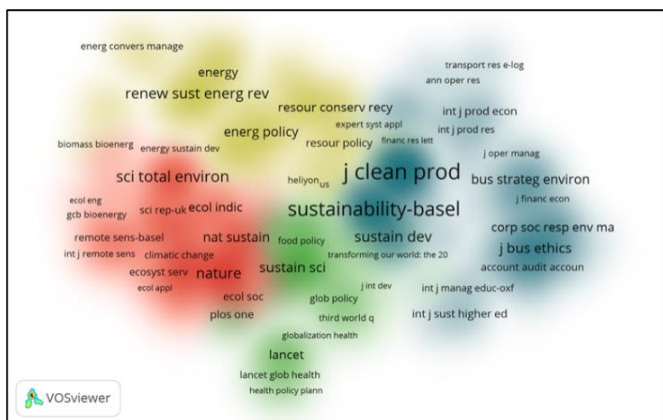| Authors	Journals	Citations	Title
Liu et al. (2016)	Lancet	1906	"Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals"
Kruk et al. (2018)	Lancet Global Health	1253	"High-quality health systems in the Sustainable Development Goals era: time for a revolution"
Keesstra et al. (2016)	Soil	846	"The significance of soils and soil science toward the realization of the United Nations Sustainable Development Goals"
Sachs et al. (2019)	Nature Sustainability	684	"Six Transformations to achieve the Sustainable Development Goals"
Hak et al. (2016)	Ecological Indicators	607	"Sustainable Development Goals: A need for relevant indicators"
Grubler et al. (2018)	Nature Energy	574	"A low energy demand scenario for meeting the 1.5℃ target and Sustainable Development Goals without negative emission technologies"
Schroeder et al. (2019)	Journal of Industrial Ecology	559	"The relevance of circular economy practices to the Sustainable Development Goals"
Luyckx et al. (2018)	Bulletin of The World Health Organisation	403	"The global burden of kidney disease and the Sustainable Development Goals"
Keesstra et al. (2018)	Land	400	"Soil-related Sustainable Development Goals: Four concepts to make land degradation neutrality and restoration work"
Bebbington et al. (2018)	Accounting Auditing & Accountability Journal	364	"Achieving the United Nations Sustainable Development Goals: An enabling role for accounting research"

Source: Author compilation

Figure 7. Density visualization of journals' co-citation
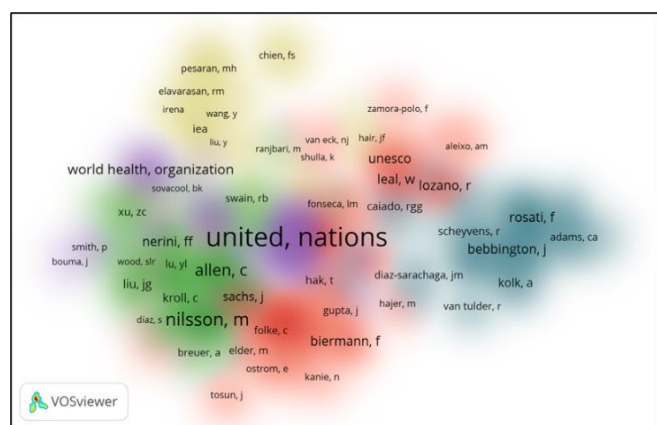Source: VOSviewer (January 2024)

Figure 8. Density visualization of authors' co-citation
Source: VOSviewer (January 2024)

3.10 Analysis of the intellectual structure of knowledge

Addressing RQ7, this section dealt with the highly influential journals and authors. Because it is a more accurate indicator, the study has chosen to analyze co-citation coupling over bibliometric coupling for analyzing the intellectual structure of knowledge about subject similarity [48]. The terminology co-citation refers to the occurrence of two items (documents, authors, or journals) being mentioned together in a third publication [49-51]. Researchers can understand the structure and evolution of a certain research topic by analyzing the co-citations [52]. The co-citation analysis for authors and journals has been analyzed in this work.

3.10.1 Top influential journals

In bibliometrics, co-citation investigation of journals is a useful tool that helps us understand the dynamics and intellectual structure of a field of study by looking at how often two journals are cited together by other publications [49, 52]. Co-citation analysis for journals was conducted using VOSviewer and the study only examined the sources with more than 60 citations. A total of 297 journals were selected for the study based on given thresholds. Figure 7 depicts the result of the density visualization of the journals' co-citation. A total of 297 selected sources were divided into four clusters. Different clusters helped identify groups of journals with shared intellectual interests and contributions by analyzing the frequency of their works being cited together by other publications of different journals. The Blue density area is the largest cluster, which shows out of 297 journals, the majority

belong to the blue cluster, which showed that they have been frequently co-cited together and share thematic similarities in their research [53], and green's density area is the smallest, which shows the frequency of co-citation of journals was minimal. The figure shows "Journal of Cleaner Production" in the largest font which depicts that it has been co-cited the most (1,84,954 link strength) with other journals (296 links), followed by "Sustainability" with a co-citation frequency of 1,35,210 and links 296, and "Sustainable Development" with 53,262 co-citation frequencies and 296 links.

3.10.2 Top influential authors

Co-citation analysis for authors was conducted using VOSviewer and 209 authors were selected based on the threshold "minimum number of citations of an author: 35". Figure 8 depicts the result of the density visualization of the authors' co-citation analysis. A total of 209 items were divided into five clusters. The Red density area is the largest cluster, which shows out of 209 authors, the majority belongs to red clusters that have been co-cited together a maximum number of times. "United Nations" in the largest font which means the United Nations has been co-cited the maximum number of times with other authors. In authors, M Nilsson has the largest font size after United Nations, which shows the highest number of frequencies of co-citation (6,030 link strength) with 200 (links) other authors, followed by C Allen with a co-citation frequency of (4,884 link strength) with 200 (links) other authors, and JD Sachs with co-citation frequency (4,396 link strength) with 205 (links) other authors. The result also showed that 50% of authors belong to Cluster 1st (red), followed by 40% belonging to Cluster 2 (blue), and 10% from Cluster 3 (green).

4. CONCLUSIONS

4.1 Key findings

Even after the SDGs were introduced 8 years ago, the 2030 agenda still has enormous ambitious targets and an extensive of interconnected ambitions. The Sustainable Development Goals (SDGs) are a worldwide framework that has drawn a lot of attention recently for solving urgent environmental issues. The volume of publications surged between 2015 and 2023, indicating the academic community's increasing interest and attention to the SDGs. The study examined the bibliometric analysis of the SDGs' advancement, opportunities, issues, trends, and prospects from 2016 to 2023 using the Web of Science core collection database. The study's findings revealed an increasing trend of publications from 2016 to 2023 in volume but fluctuation in growth. It was revealed that the most frequent contributors were advanced economies with well-established research infrastructure, like England, China, the US, Australia, and European countries. Although with relatively less contribution to research, a discernible rise in research output from poor nations, indicates a growing understanding of the significance of the SDGs and the necessity of addressing particular regional issues. The top five productive authors are also from developed nations, specifically from North America and Europe. Results revealed that good health, well-being, and clean water and sanitation were the most focused research areas in developing countries, whereas climate action, clean energy, quality education, and Sustainable Cities& Communities were the most focused

research areas in developed countries. Sustainability, Sustainable Development, and Journal of Cleaner Production were the most preferred and productive journals globally. Key clusters of themes were environmental sustainability, health and gender equality, and education and behavioral attitude toward sustainability. An ongoing analysis of published papers related to the SDGs is required to provide insight into the shortfall in reaching the worldwide 2030 goals. Results of clusters of themes revealed that economic and social aspects were ignored in the research of the SDGs domain. Results also showed that developing countries with high populations like India, China, and Pakistan need to focus more on research and provide more funds to facilitate the research to globally achieve the 2030 Agenda. Maximum institutions among the top 10 belong to England. Beijing Normal University was the only Asian institution from China in the top 10 productive organizations list. The USA and England have maximum collaborations with other countries. Results revealed that African regions, Gulf countries, and South Asian countries need to focus more on research related to SDGs. Studies on the SDGs are quite complicated because of the interdisciplinary nature of the goals and the breadth of the aims and targets covered by this theme. Consequently, further studies have to be done to bridge this knowledge gap by creating more precise and reliable techniques to validate the SDGs' progress. To do this, it is suggested to broaden the bibliometric review's focus by incorporating grey literature, such as reports from governmental and non-governmental organizations, and multiple indexing databases.

4.2 Limitation

The current study has certain limitations because it did not include publications from databases other than Web of Science. The study was limited to peer-reviewed literature ignoring government reports and other grey literature was excluded from the current analysis as the grey literature contained crucial data and evaluations of how well each country was doing at implementing the SDGs [54]. Another limitation was the methodology used in this analysis did not distinguish between articles that mention the phrase 'SDGs' and those that concentrate on terms related to SDGs, which means the article might discuss the problem of sanitation without mentioning the phrase 'SDGs'.

4.3 Implication and future direction

The results of this study have significant implications, offering insightful information to stakeholders, researchers, and policymakers to prioritize future research endeavors and resource allocation to best achieve the 2030 SDGs. This bibliometric analysis offers significant insights regarding trends, development, and prospects in the field of Sustainable Development Goals (SDG) research. It demonstrates how the SDGs are becoming increasingly important on a global scale and emphasizes how working together is necessary to solve urgent problems. To guarantee that all SDGs are accomplished as we get closer to achieving the 2030 Agenda, scholars, decision-makers, and stakeholders must concentrate on areas where there are large gaps, such as 'economic and social aspects including employability, gender equality, and social justice and peace'. The bibliometric analysis's examination produced the following important conclusions and suggestive directions for further study:

(1) Worldwide consensus on how urgent it is to address sustainability-related concerns.

(2) Targeted research funding on identified research gaps, especially in vital domains and research needs, particularly in crucial areas like peace, social justice, and gender equality, as well as employability.

(3) Evidence-based policymaking, guaranteeing that decisions are made in accordance with the most pressing obstacles and possibilities for sustainable development.

(4) Collaboration among researchers between low-income and high-income nations can promote capacity building, knowledge sharing, and technology transfer, which will ultimately increase the group's capacity to handle issues related to local and global sustainability [55].

(5) Capacity building by assisting developing nations with their research endeavors can result in better research infrastructure, more proficient researchers, and a rise in the engagement of developing countries in the discourse surrounding global sustainability.

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