International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Global Industry 4.0 and Sustainability: A Bibliometric Analysis

Nida[1], Prof. Rajanikant Verma[2], Dr. Manisha Verma[3], Dr. Srikant Prasad[4]

[1]Research Scholar, Department of Commerce, Delhi School of Economics, University of Delhi, Pin-110007.
[2]Professor, Commerce Department, Zakir Husain Delhi College (Evening), University of Delhi, Jawahar Lal Nehru Marg, New Delhi, Pin-110002
[3]Associate Professor, Commerce Department, Hansraj College University of Delhi, Mahatma Hansraj Marg, Malka Ganj, Delhi, Pin-110007.
[4]Assistant Professor, School of Engineering and Technology, Mechanical Engineering, Sandip University, Nashik, Employee Code: 110519

ABSTRACT
The global prominence of Industry 4.0 (I4.0) and Sustainability indicates a transformative shift that is poised to reshape the fundamental workings of economies and industries on a worldwide scale. These two concepts are anticipated to redefine the paradigms governing how economic sectors and industries operate. After putting key-terms into Scopus and WOS database "Industry 4.0 AND Sustainability", 2363 papers emerged, duplicates (47) were removed with the help of R-Studio and final articles left for bibliometric study were 2316. Database shows that publication started in 1991 till now 2023, with annual growth rate 10.38%, from 957 sources, 8284 authors and 7121 key-words. 20203 was the year which published the higher number of articles, Sustainability (Switzerland), Sustainability and Journal of cleaner production are the journals which have the highest number of publications, China has or working a lot in these two areas followed by India and Turkey, 14 journals consist of most of the articles as per Brandford's law, Artificial, Sustainability and Sustainable Intelligence are the most frequent words, Results from Biblioshiny shows the trending topics of 2023 are Management, China, Machine-learning and as per the Countries Collaboration world map USA is collaborating with Germany and India, China is collaborating with USA, UK and USA is collaborating with France and UK.

Keywords: Global; Industry 4.0; Sustainability; Bibliometric; Biblioshiny.

1. Introduction

Sustainability and Industry 4.0 are two well-known ideas that are projected to completely alter how economies and industries function. It is acknowledged that combining these ideas will hasten the transition to a green economy and could help align goals for balancing environmental preservation with economic growth (Bag & Pretorius, 2022; Dantas et al., 2021). The change in this sector heralds in a new techno-economic paradigm and the continuous digital transformation of value chain operations and industries. It has been acknowledged that I4.0's underlying technologies and drivers may contribute to a shift in

manufacturing methods toward those that are more in line with the triple bottom line aspects of sustainability (Elkington, 2013). Work on these two topics are imperative for navigating the complex challenges facing modern industries. (Ngjeqari, 2016; Niehoff & Xue, 2018), acknowledging the 4th Industrial Revolution as a catalyst for sustainable development, it is noteworthy that the integration of digital transformation and sustainability is still in an early stage of development. (Niehoff & Xue 2018; Kiron & Unruh, 2018). By delving into this dynamic field, researchers can uncover innovative solutions that foster economic growth while minimizing environmental impact. I4.0 technologies, such as IoT and AI, offer unprecedented opportunities for optimizing processes, reducing resource consumption, and enhancing overall efficiency. I4.0 act as a contributor to the sustainability in the economy (UN General Assembly, 2015). Investigating how these technologies can be harnessed to align with sustainability goals ensures that industries not only adhere to rules but also obtain an advantage over competitors in a market where environmental concerns are paramount. Moreover, research in this area can pave the way for the adoption of circular economy principles, enabling businesses to rethink traditional linear production models and promote resource reuse. As societies worldwide prioritize sustainable practices, researchers exploring the nexus of I4.0 and sustainability contribute in the growth of resilient, socially responsible, and future-proof industrial ecosystems that balance economic prosperity with environmental stewardship. Digitalization and sustainability are overarching themes that intersect across every segment of the production chain. (Machado et al., 2020). An attempt to contribute to solving this crucial academic issue by tackling the many synergies between these fundamental topics. This Introduction serves as a beginning point by offering an extensive and methodical analysis of the literature on these subjects. This work, which serves as the introduction to this Special Issue, is a bibliometric analysis that connects the two main subjects of the Issue—Sustainability and Industry 4.0. Its goal is to present a succinct, comprehensive literature relating the two subjects chosen for this publication's focus. Despite the fact that the literature in this area is very new—as documented latest in this paper— A growing number of incisive evaluations are supporting the organization of the literature (Kamble et al., 2018; Lopes de Sousa Jabbour et al., 2018; Machado et al., 2020) to our knowledge, none of them adopts the procedures utilized in this study, offering an in-depth analysis of an extensive body of literature. Considering the relatively nascent nature of this field of study, coupled with the escalating volume of articles, presenting an updated summary of the pertinent scientific contributions is a valuable undertaking. Following the paper's introduction is a section dedicated to the literature review and methodology that was selected, the Results, which comprise tables and diagrams and apply bibliometric techniques, and a reporting of the corresponding conclusion. Lastly, a few restrictions and directions for additional study are discussed.

Additionally, the literature synthesis that was done helps to recognize the study questions that are stated below.

RQ1: What is the recent trend in the Publication, Annual scientific production and Three-Field plot?

RQ2: What are the most relevant sources, Core sources by Bradford's Law, relevant authors with corresponding authors?

RQ3: What are the Trending topics, Countries collaboration and keyword analysis?

A sizable number of articles—2316 journal articles—from a huge corpus of bibliometric information is studied. While Section 2 of this article covers some of the literature which is available on "Industry 4.0 and Sustainability" to assess the present condition in this area, Section 1 of this paper provides an outline of this study.

The methodology used is discussed in Section 3, which use Scientometric methods to assess the bibliometric records, Section 4 talks about the results and a conclusion based on the results is provided in Section 5. For this research papers were retrieved from Scopus and WOS database, total 2316 papers were found after searching keyword "Industry 4.0 and Sustainability".

Research Gap and Research Novelty

In the field of Industry 4.0 and sustainability, a notable research gap persists across various dimensions. Existing literature primarily lacks integrated frameworks that comprehensively assess the Environmental, Social, and Economic impacts of Industry 4.0 implementations. While studies often highlight short-term efficiency gains, there is a dearth of research examining the long-term consequences, including potential unintended effects and feedback loops. Moreover, the global diversity in Industry 4.0 adoption and sustainability practices remains insufficiently explored, leaving a gap in understanding the challenges and opportunities in different socio-economic contexts. The human-centric aspects of I4.0, such as the effect on the human force, skill requirements, & overall well-being, are often overlooked. Additionally, there is a need for research on how existing and future regulatory frameworks can support the integration of Industry 4.0 while promoting sustainable practices. The focus on large enterprises in current research neglects the crucial question of how Industry 4.0 can be framed for small & medium businesses. Specific strategies for implementing circular economy principles through smart manufacturing technologies are inadequately addressed, and there is a call for robust metrics to measure the social sustainability effect on I4.0. Bridging these gaps will contribute to a more nuanced & relationship between Industry 4.0 and sustainability. Some previous studies and reviews have been conducted, but they predominantly relied on manual approaches, lacked in-depth and comprehensive perspectives, and often adopted a singular methodological approach. Consequently, there is a substantial research gap stemming from the absence of thorough examinations of studies on carbon emissions in this sector. This study distinguishes itself from prior research efforts in the following ways.

1. This study undertakes an extensive literature on industry 4.0 and sustainability.
2. Instead of conventional literature review methods employed in previous studies, this paper utilized Countries collaboration and Keywords analysis, Trending topics, relevant authors and sources to capture the breadth of the literature.

Nevertheless, this study aims to address the deficiencies in the existing body of knowledge to rectify the identified knowledge gap. The findings will provide a detailed overview of the current situation, suggesting potential avenues for further research by identifying prevalent patterns and trends. These results are expected to contribute additional insights to the existing research landscape, offering a more nuanced understanding. Furthermore, the study will chart the network of influential institutions and scholars in the field, proposing areas for future investigation. By thoroughly examining the limitations and acknowledging the scarcity of comprehensive literature reviews, this research not only advances earlier studies but also effectively fills the identified knowledge gap. Utilizing Scientometric review tools, including Biblioshiny, the study aims to provide robust literature support in this domain, enhancing the comprehension of researchers and professionals. In light of the recognized gaps characterized by a lack of comprehensive literature, this work serves as a pivotal contribution, closing the knowledge gap and acting as a timely supplement to previous investigations.

2. Literature Review

Industrial production systems have changed as a result of increased digitalization in recent years, becoming intelligent, networked, and dispersed production systems. (Machado et al., 2020), "Industry 4.0" or "The fourth industrial revolution" is commonly employed to characterize this novel organizational level (Wahlster & Helbig, 2013; Pentek & Otto, 2016). I4.0 is a new revolution in which internet connection technologies are interfaced with various components of industrial systems to build the manufacturing companies and smart factories of the future (Thames & Schaefer, 2017). "Industry 4.0," has garnered a lot of interest recently in the literature. It shares a tight relationship with the Cyber Physical System (CPS), Enterprise Architecture (EA), ICT, IoT, and Enterprise Integration (Lu, 2017). " Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" by the Brundtland Report, which is also commonly referred to as "Our Common Future." I4.0 increases the link between Industry and sustainability and contributes to the SDGs, (UN General Assembly, 2015) by recognizing strong relationships between its constituent parts. As such, the main emphasis is on the tools and methods used to investigate these ideas in depth. Researchers have already studied sustainability and Industry 4.0 phenomena in great detail or evaluated them using cutting edge methods (Bonilla et al., 2018; Franciosi et al., 2018). An innovative concept of I4.0 Sustainability was presented by (Kamble et al., 2018), while (Ghobakhloo, 2018) Conducted a comprehensive literature review of I4.0, culminating in the growth of linkages between sustainability and Industry 4.0. Technological developments in line with the 2030 United Nations Sustainable Development Goals (UN General Assembly, 2015) are driving efforts to address the difficulty of making the shift from traditional technology to intelligent machines. The goal is to accomplish this transformation without jeopardizing the industrial economy's viability. Significantly better environmental results are obtained when production, supply chains, and distribution channels integrate robotics, artificial intelligence (AI), and other cutting-edge technologies. This integration concurrently reduces greenhouse gas emissions, minimizes pollution, conserves energy, and enhances profitability.

Industry 4.0's rise presents a chance to combine technology with resources and talents for benefits related to sustainability (lower costs, zero effect, and social equality). Industry 4.0 has the potential to lessen the environmental impact of goods, procedures, or services by putting an emphasis on verifiable analysis and the accessibility of footprint data (Peukert et al., 2015). It facilitates enhanced functional efficiency, leading to a reduction in resource consumption. Consequently, I4.0 can lead to the establishment of digitally sustainable operations, aligning with the attainment of Sustainable Development Goal (SDG) targets. Moreover, the proliferation of smart technology is expected to have a profound impact on sustainability. Despite its recognized potential, Industry 4.0's unrealized capabilities are evident in its prospective influence on other domains like Tripple bottom line factors, (Ghobakhloo, 2018) and the creation of pathways for realizing I4.0 through intelligent systems. For this paper Bibliometric analysis, was the chosen methodology, "bibliometrics" was first used by (Pritchard,1969), who says it as "the application of mathematics and statistical methods to books and other media of communication" (Franciosi et al., 2018). Bibliometric studies, according to (Franciosi et al., 2018) "use the extant published research to examine and delve into the patterns and trends of what has been published, thus helping explore, organize and make sense of the work that has been done in a certain discipline or subject of study," is one of the many definitions that have been proposed over time (Bonilla et al., 2018). Bibliometric analysis is an increasingly popular technique across various fields of study (Kamble et al., 2018). It offers a more objective and systematic approach to selecting and evaluating scientific research within a specific topic,

providing advantages over traditional literature reviews (Bonilla et al., 2018; Peukert et al., 2015; Strozzi et al., 2017). To ascertain the current state-of-the-art in literature, often referred to as the "leading edge" by Teixeira (2014), bibliography remains the most effective method. By employing bibliometric methodologies (Franciosi et al., 2018), we could discern the present status of the field of study, identify potential knowledge gaps, and delineate its boundaries. The methodology established by Archambault & Gagné (2004) and Teixeira (2014) guides the contemporary use of bibliometric techniques. This approach facilitates an impartial evaluation of scientific output in scholarly publications, enabling the identification of articles, authors, and journals that have exerted the greatest influence on the field of study. The following actions were taken. First, the field of study was established, with an emphasis on sustainability and Industry 4.0. The choice of the bibliographic databases that supported the study came next. This stage is essential to guaranteeing a successful analysis because the quality of these databases determines the validity of the analysis. Web of Science (WoS) and Scopus, two of the most reliable and extensive content platforms, were selected in accordance with this. Users can access a vast amount of literature from prestigious publishers like Elsevier and Springer as well as other platforms like Google Scholar with these multidisciplinary databases, which also have a high citation index (Liao et al., 2017; Pereira & Romero, 2017; Strozzi et al., 2017). A number of writers, including (Ren et al., 2019), praised the benefits of these databases. The choosing of the keywords was the next phase. Using a list of directly related keywords that are shown in the table below, we searched for pertinent publications. We mandated that the phrase "Industry 4.0" be used in tandem with at least one sustainability-related keyword. SCOPUS and Web of Science, the two primary bibliographic databases, were searched methodically, the search was concluded. In addition to include highly precise keywords, we implemented other filters to guarantee the papers' pertinence. One concerned language; only English-language materials were examined. Furthermore, as indicated below, only articles and reviews were included—all other document kinds were excluded. Conversely, as the goal of this publication was to include research on the selected issue across all domains.

Objectives of the Study

1. To trace the Historical development of Industry 4.0 and Sustainability through Literature Review.
2. To analyse the Global Trend.
3. Identify the Trending topics.
4. To see Countries Co-Authorship Analysis and Key-word analysis of Journals, Relevant authors and journals.

3. Results

This paper, consists of 2316 articles, showing the major areas of research. After putting key-terms into Scopus and WOS database “Industry 4.0 AND Sustainability”, 2363 papers emerged, 500 data from WOS and 1863 from Scopus, duplicates (47) were removed with the help of R-Studio and final articles left for bibliometric study were 2316. Database shows that publication started in 1991 till now 2023, with annual growth rate 10.38%, from 957 sources, 8284 authors and 7121 key-words as seen in below (Table 1). In Figure 1, it is shown that the research on the given two topics were negligible, however, initially the number of publications were low but it started gaining attention in the year 2019, no. of documents published were 97 in year 2019 then started increasing and jumped to 793 from 97 in 2023.

Timespan 1991:2024	Sources 957	Documents 2316	Annual Growth Rate 10.38 %
Authors 8284	Authors of single-authore 187	International Co-Authorsh 10.19 %	Co-Authors per Doc 4.38
Author's Keywords (DE) 7121	References 63281	Document Average Age 2.19	Average citations per doc 19.29

Table 1, Source: Biblioshiny

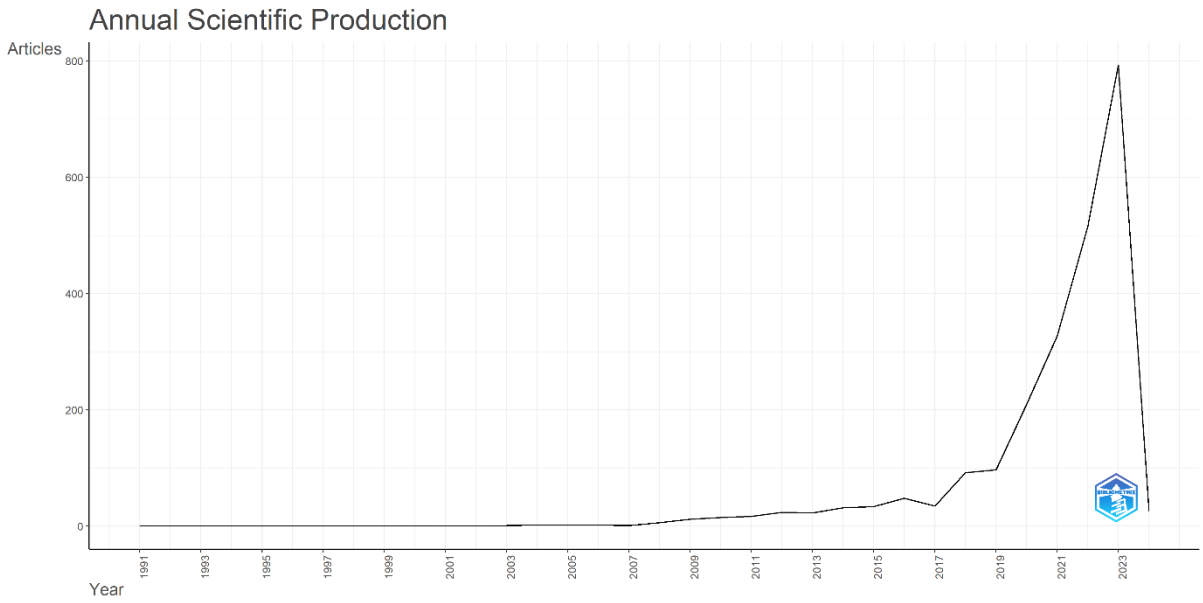

Figure 1: Annual Scientific Production, Source: Biblioshiny

3.1 Three-field Plot

Three field plot (figure 2) shows the proportion of research topic for each country with authors. Countries are on the left of the diagram with Authors at the center and Keywords lying at the right of the diagram, Diagram shows the height of the boxes and thickness of the connecting lines, which shows that China has the most thickness, with highest connecting links, followed by India and USA with major Keywords Artificial Intelligence, Sustainability, Machine Learning and Industry 4.0 and major authors belong to India and China.

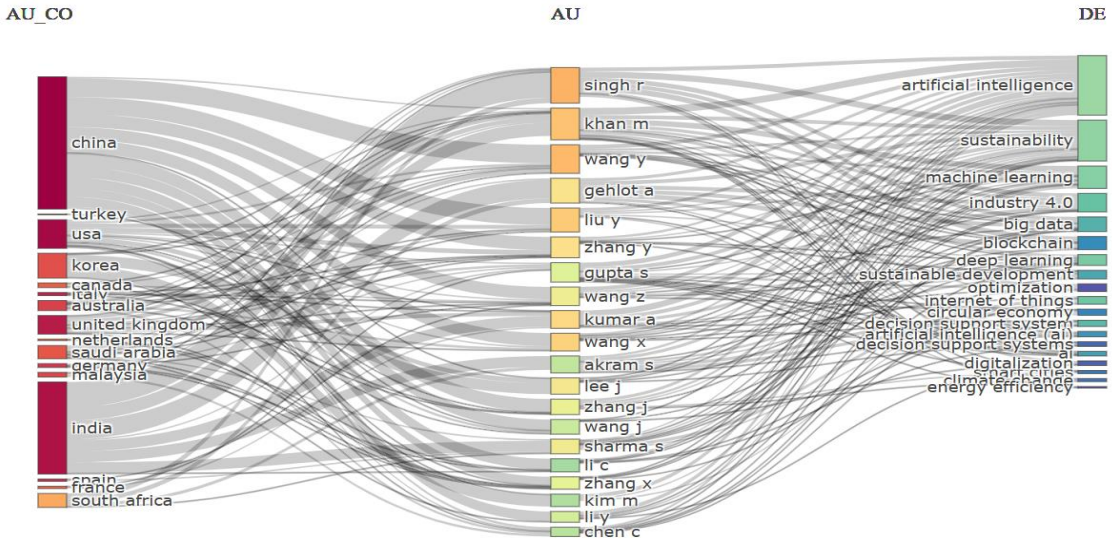

Figure 2: Three-Field Plot, Source: Biblioshiny

3.2 Most Relevant Sources

The highest paper published in the journal Sustainability (Switzerland) which is 252 Articles with Sustainability at the second top with 175 publications, followed by Journal of cleaner production (73), Energies (38), IEEE Access (34), Sustainable cities and society (30).

Sources	Articles
SUSTAINABILITY (SWITZERLAND)	252
SUSTAINABILITY	175
JOURNAL OF CLEANER PRODUCTION	73
ENERGIES	38
IEEE ACCESS	34
SUSTAINABLE CITIES AND SOCIETY	30
SENSORS	29
SCIENCE OF THE TOTAL ENVIRONMENT	27
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	22
INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	18

Table 2: Sources of the published articles, Source: Biblioshiny

3.3 Core sources by Bradford's Law

According to Bradford's Law of Bibliometrics, there will be an unequal distribution of articles per journal if scientific publications in a certain topic are classified according to how many articles they include. Specifically, it suggests that a small core of journals will contain a significant portion of the articles, followed by a larger number of journals with fewer articles each. This concept is often used to describe the uneven distribution of information in scholarly publications. The provided diagram illustrates the outcomes of the Bradford's Law analysis, revealing a concentrated segment of journals that contribute significantly by containing the highest number of published papers in "Artificial Intelligence and Sustainability." This reflects the phenomenon where a limited number of journals are responsible for

publishing a substantial volume of documents. as per Table 3 Most relevant Authors are from India and China, further table shows the corresponding countries, which means Intra and Inter country collaboration.

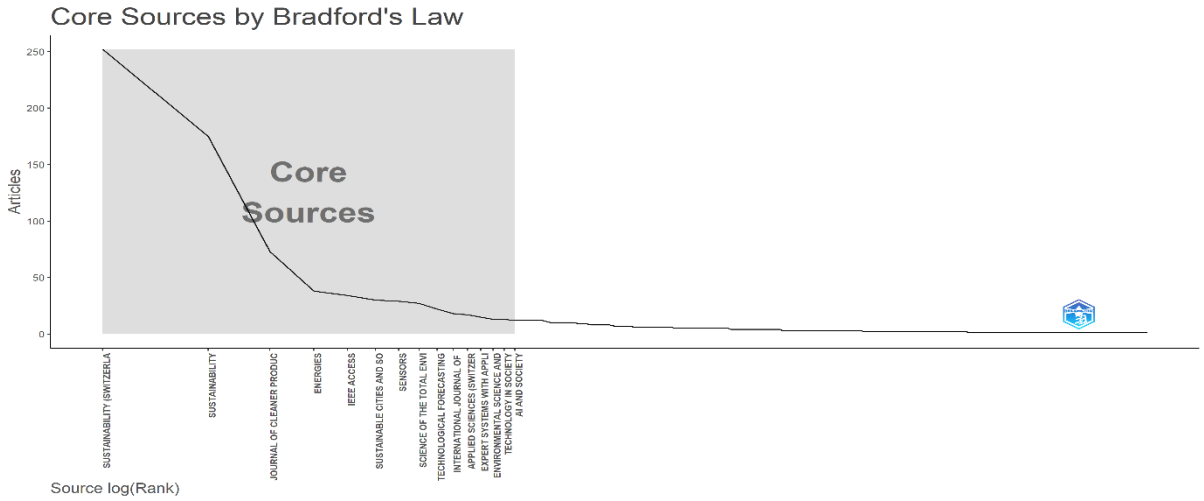

Figure 3: Core sources by Bradford's Law, Source: Biblioshiny

Most of the relevant authors belong to India (Singh R, Khan M, Kumar A) and China (Wang Y, Liu Y, Wang X) as given (Table 3) below with good number of articles.

3.4 Corresponding Author's Country

China, USA, India, Italy and UK are the highest Intra or Inter collaborating countries. Here, SCP means Intra- country collaboration and MCP means Inter-country collaboration. Table 4 shows the division of total Articles into MCP and SCP, which means how frequently one country is collaborating within its own country and with different countries. China has the highest articles as further shown in figure 4.

Authors	Articles	Articles Fractionalized
SINGH R	22	4.07
WANG Y	22	5.38
KHAN M	19	3.86
LIU Y	19	5.20
WANG X	18	3.81
KUMAR A	16	3.29
ZHANG Y	16	4.98
GEHLOT A	15	2.34
LEE J	13	3.21
SHARMA S	12	2.43

Table 3: Relevant authors, Source: Biblioshiny

Country	Articles	SCP	MCP	Freq	MCP_Ratio
CHINA	261	235	26	0.113	0.100
INDIA	155	133	22	0.067	0.142
USA	174	157	17	0.075	0.098
AUSTRALIA	83	69	14	0.036	0.169
ITALY	129	117	12	0.056	0.093
FRANCE	38	26	12	0.016	0.316
MALAYSIA	54	43	11	0.023	0.204
UNITED KINGDOM	104	95	9	0.045	0.087
GERMANY	83	75	8	0.036	0.096
KOREA	78	70	8	0.034	0.103

Table 4: Corresponding Author's Country, Source: Biblioshiny

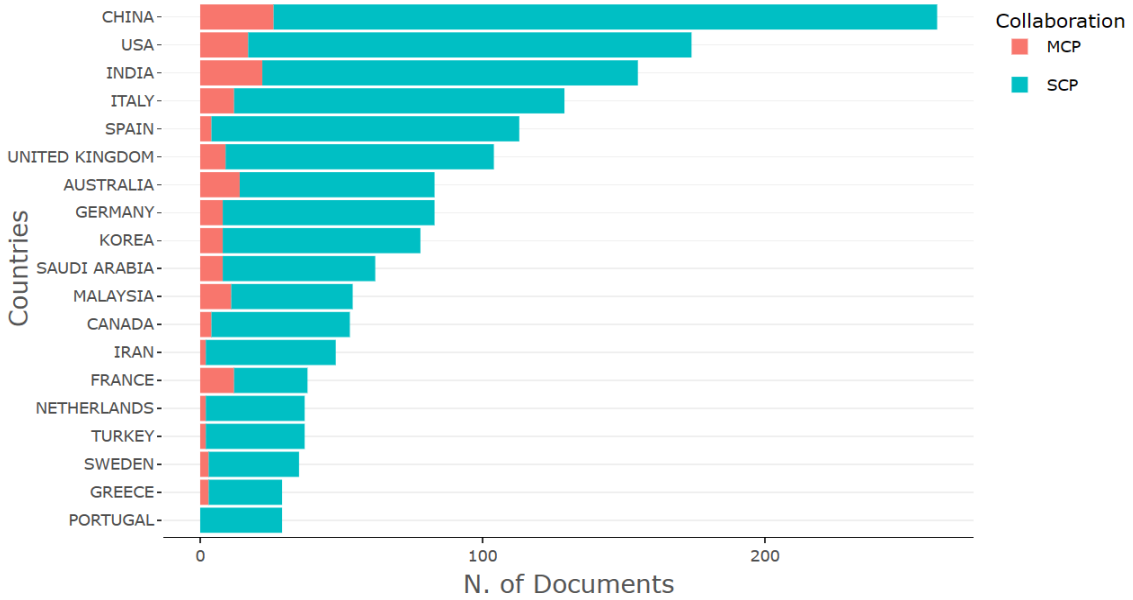

Figure 4: Corresponding Author's Country, Source: Biblioshiny

3.5 Keyword Analysis

Keyword analysis in such a context typically involves identifying and examining the keywords associated with articles, papers, or other documents to gain insights into the main themes, topics, or trends in a particular field. The keyword Analysis after merging the database f Scopus and WOS, shows that the term "Artificial" occurred 490 times, Followed by Sustainable (487), Intelligence (449) and Sustainability (369).

Figure 5: Keyword Analysis, Source: Biblioshiny

3.6 Trending Topic

As per the Biblioshiny results the trending Topics of 2023 are Management, China, Machine-learning with term frequency (73, 59, 57), followed by trending Topics of 2022 were Machine learning and climate change (TF=160, 118), Topics of 2021 were Artificial intelligence, Sustainable Development and Sustainability (TF=1157,718,509), Topics of 2020 were Decision Making, Learning System and Water Supply (TF=360, 74, 73), Topics of 2019 were Economics, Water Quality and Biodiversity (TF=55, 48, 41).

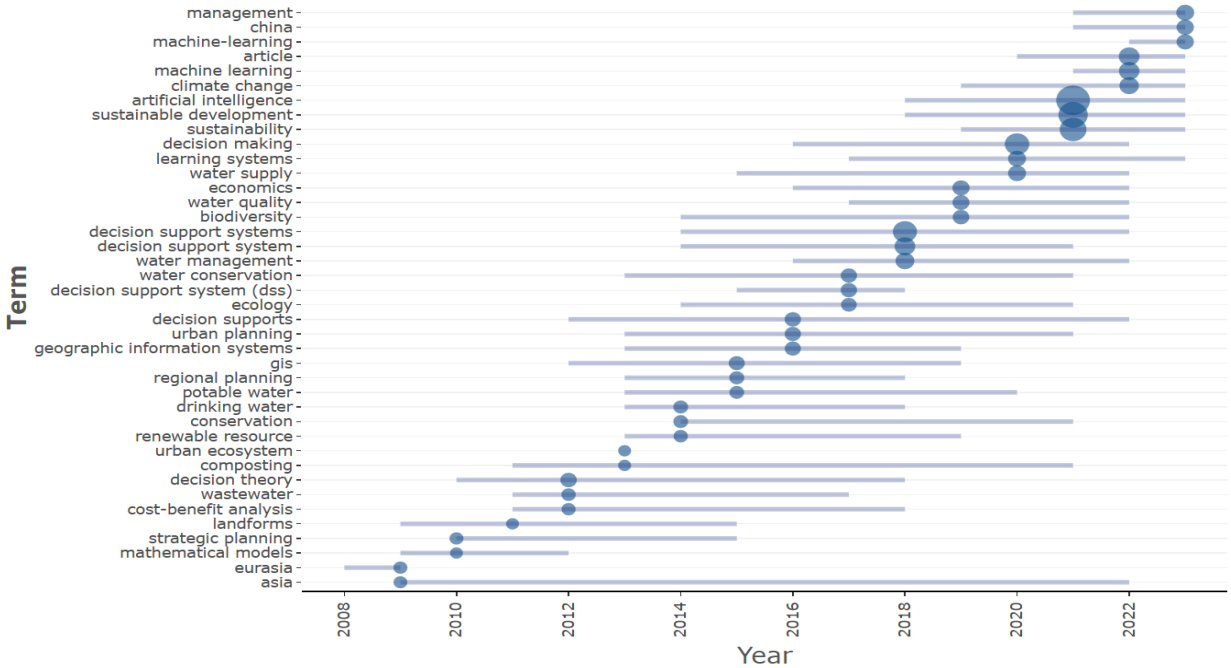

Figure 6: Trending topic analysis, Source: Biblioshiny

3.7 Countries Collaboration

Figure 7 shows the countries collaborative network derived from the retrieved bibliographic data serves as a reflection of the extent of communication between countries, showcasing influential nations in the respective field. USA is the highest collaborating country with Germany, India, France and UK (frequency- 12, 10), followed by China collaborating with USA, UK, Australia (frequency- 11, 10, 8), India is collaborating with UK and France (frequency- 9, 8), Saudi Arabia with Pakistan (frequency- 9).

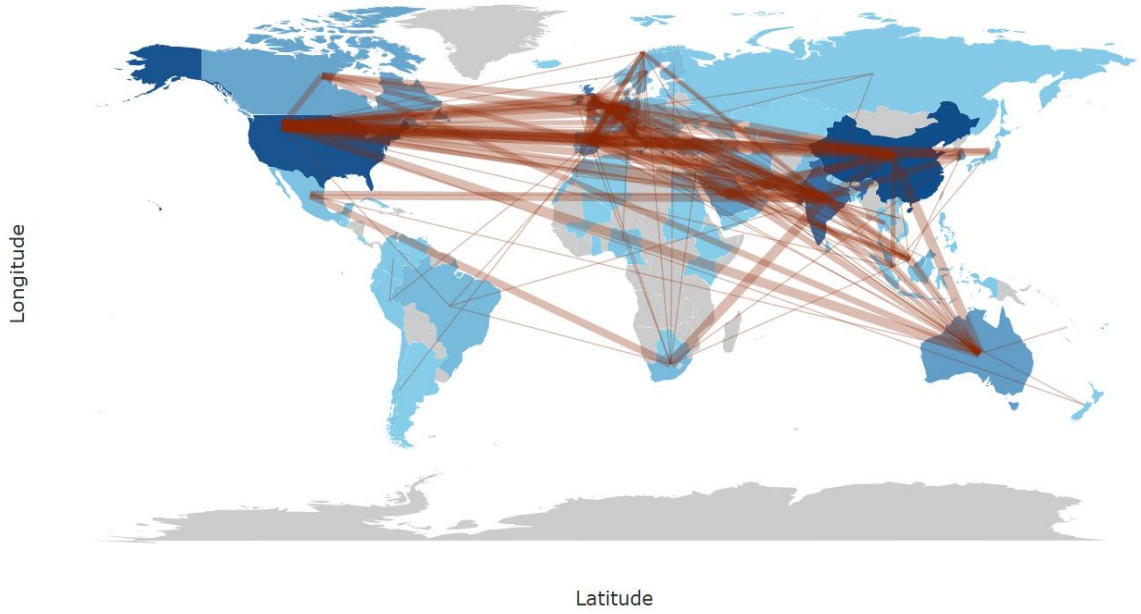

Figure 6: Countries collaboration, Source: Biblioshiny

4. Conclusion

Industry 4.0 (I4.0) and Sustainability have become widely recognized terms, gaining global popularity. These two concepts are poised to reshape the fundamental workings of economies and industries. After putting key-terms into Scopus and WOS database "Industry 4.0 AND Sustainability", 2363 papers emerged, duplicates (47) were removed with the help of R-Studio and final articles left for bibliometric study were 2316. Database shows that publication started in 1991 till now 2023, with annual growth rate 10.38%, from 957 sources, 8284 authors and 7121 key-words. Considering that it already commands a rapidly increasing quantity of publications, 20203 (793) was the year which published the higher number of articles. Sustainability (Switzerland), Sustainability and Journal of cleaner production are the journals which have the highest number of publications, As per the Three-Field plot China has the most thickness, with highest connecting links, followed by India and USA with major Keywords Artificial Intelligence, Sustainability, Machine Learning and Industry 4.0 and most of the authors belong to India and China. simultaneously, as per Core sources by Bradford's Law small section of journals, contributing and containing the most published papers. China, USA, India, Italy and UK are the highest Intra or Inter collaborating countries, China has or working a lot in these two areas followed by India and Turkey, 14 journals consist of most of the articles as per Brandford's law. The keyword Analysis after merging the database of Scopus and WOS, shows that the term "Artificial" occurred 490 times, Followed by Sustainable (487), Intelligence (449) and Sustainability (369). Results from Biblioshiny shows the Trending topics of 2023 are Management, China, Machine-learning with term frequency (73, 59, 57), followed by trending Topics of 2022 were Machine learning and climate change (TF=160, 118), Topics of

2021 were Artificial intelligence, Sustainable Development and Sustainability (TF=1157,718,509), Topics of 2020 were Decision Making, Learning System and Water Supply (TF=360, 74, 73), Topics of 2019 were Economics, Water Quality and Biodiversity (TF=55, 48, 41). Countries cooperation network of retrieved bibliographic data, which can demonstrate influential nations in the field and reflect the level of communication between nations. USA is the highest collaborating country with Germany, India, France and UK (frequency, 12, 10), followed by China collaborating with USA, UK, Australia (frequency 11, 10, 8), India is collaborating with UK and France (frequency, 9, 8), Saudi Arabia with Pakistan (frequency, 9).

4.1 Noval contribution of this paper

Examining Industry 4.0 within the framework of sustainability adds something new and revolutionary to the conversation today. Industry 4.0 provides a distinctive perspective for addressing and advancing sustainability goals because of its hallmarks, which include the integration of digital technology, automation, and data interchange in manufacturing. Reducing environmental impact, optimizing resources, and increasing efficiency are all made possible by this paradigm change in industrial operations. Industry 4.0 provides real-time production system monitoring and control by utilizing technologies like artificial intelligence, sophisticated analytics, and the Internet of Things (IoT). This not only enhances operational performance but also provides opportunities to minimize energy consumption, waste generation, and overall carbon footprint. The synergy between Industry 4.0 and sustainability opens new avenues for businesses to embrace environmentally responsible practices while simultaneously enhancing their competitiveness in the global market. This amalgamation of cutting-edge technology and sustainability principles represents a pioneering approach that has the potential to reshape industries, fostering a more ecologically conscious and economically viable future. Further, this paper particularly opens the door for new topics like which country is lacking behind in terms of research in this topic, the current topic which need to be focused more for sustainable economy, how Industry 4.0 factors can be inculcated for sustainable and inclusive growth etc.

5. Limitations

It is imperative to acknowledge the limitations of this paper:

1. Firstly, the study exclusively depended on data sourced from the WoS and Scopus, which is the secondary source of data.
2. Despite the widespread use of the WoS and Scopus database among scholars, its comprehensiveness cannot be assured.
3. Furthermore, the data collection was confined to academic journals, possibly excluding pertinent research on Industry 4.0 and Sustainability.
4. from sources beyond academic publications. Moreover, since the data from the WoS and Scopus were filtered based on titles, studies that did not explicitly incorporate Industry 4.0 and Sustainability in their titles were excluded from consideration.
5. The same research can be done by using primary data with the help of questionnaire.
6. Another software can be used like PLS-SEM, CB-SEM etc.

References

1. Bag, S., & Pretorius, J. H. C. (2022). Relationships between industry 4.0, sustainable manufacturing

and circular economy: proposal of a research framework. *International Journal of Organizational Analysis*, *30*(4), 864–898. https://doi.org/10.1108/IJOA-04-2020-2120

2. Bonilla, S. H., Silva, H. R. O., da Silva, M. T., Gonçalves, R. F., & Sacomano, J. B. (2018). Industry 4.0 and sustainability implications: A scenario-based analysis of the impacts and challenges. *Sustainability (Switzerland)*, *10*(10). https://doi.org/10.3390/su10103740
3. Dantas, T. E. T., de-Souza, E. D., Destro, I. R., Hammes, G., Rodriguez, C. M. T., & Soares, S. R. (2021). How the combination of Circular Economy and Industry 4.0 can contribute towards achieving the Sustainable Development Goals. *Sustainable Production and Consumption*, *26*, 213–227. https://doi.org/10.1016/j.spc.2020.10.005
4. Elkington, J. (2013). Enter the triple bottom line. *The Triple Bottom Line: Does It All Add Up*, *1*(1986), 1–16. https://doi.org/10.4324/9781849773348
5. Franciosi, C., Iung, B., Miranda, S., & Riemma, S. (2018). Maintenance for Sustainability in the Industry 4.0 context: a Scoping Literature Review. *IFAC-PapersOnLine*, *51*(11), 903–908. https://doi.org/10.1016/j.ifacol.2018.08.459
6. Ghobakhloo, M. (2018). The future of manufacturing industry: a strategic roadmap toward Industry 4.0. *Journal of Manufacturing Technology Management*, *29*(6), 910–936. https://doi.org/10.1108/JMTM-02-2018-0057
7. Kamble, S. S., Gunasekaran, A., & Gawankar, S. A. (2018). Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection*, *117*, 408–425. https://doi.org/10.1016/j.psep.2018.05.009
8. Liao, Y., Deschamps, F., Loures, E. de F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. *International Journal of Production Research*, *55*(12), 3609–3629. https://doi.org/10.1080/00207543.2017.1308576
9. Lopes de Sousa Jabbour, A. B., Jabbour, C. J. C., Godinho Filho, M., & Roubaud, D. (2018). Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations. *Annals of Operations Research*, *270*(1–2), 273–286. https://doi.org/10.1007/s10479-018-2772-8
10. Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. *Journal of Industrial Information Integration*, *6*, 1–10. https://doi.org/10.1016/j.jii.2017.04.005
11. Machado, C. G., Winroth, M. P., & Ribeiro da Silva, E. H. D. (2020). Sustainable manufacturing in Industry 4.0: an emerging research agenda. *International Journal of Production Research*, *58*(5), 1462–1484. https://doi.org/10.1080/00207543.2019.1652777
12. Pereira, A. C., & Romero, F. (2017). A review of the meanings and the implications of the Industry 4.0 concept. *Procedia Manufacturing*, *13*, 1206–1214. https://doi.org/10.1016/j.promfg.2017.09.032
13. Peukert, B., Benecke, S., Clavell, J., Neugebauer, S., Nissen, N. F., Uhlmann, E., Lang, K. D., & Finkbeiner, M. (2015). Addressing sustainability and flexibility in manufacturing via smart modular machine tool frames to support sustainable value creation. *Procedia CIRP*, *29*, 514–519. https://doi.org/10.1016/j.procir.2015.02.181
14. Ren, S., Zhang, Y., Liu, Y., Sakao, T., Huisingh, D., & Almeida, C. M. V. B. (2019). A comprehensive review of big data analytics throughout product lifecycle to support sustainable smart manufacturing: A framework, challenges and future research directions. *Journal of Cleaner Production*, *210*, 1343–1365. https://doi.org/10.1016/j.jclepro.2018.11.025
15. Strozzi, F., Colicchia, C., Creazza, A., & Noè, C. (2017). Literature review on the 'smart factory'

concept using bibliometric tools. *International Journal of Production Research*, *55*(22), 1–20. https://doi.org/10.1080/00207543.2017.1326643

16. Thames, L., & Schaefer, D. (2017). Industry 4.0: An Overview of Key Benefits, Technologies, and Challenges. In *Springer Series in Advanced Manufacturing* (Issue May 2017). https://doi.org/10.1007/978-3-319-50660-9_1
17. UN General Assembly. (2015). Resolution adopted by the General Assembly: transforming our world: the 2030 agenda for sustainable development. *Transforming Our World: The 2030 Agenda for Sustainable Development*, *16301*(October), 259–273. https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf