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Research paper

Blockchain Technology for Sustainable Development: Key Trends (2016 to 2025)

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Abstract

The United Nations introduced 17 Sustainable Development Goals in 2015, which provide a blueprint for peace and prosperity for the people and planet. Within these, 8 goals can be achieved through the utilisation of blockchain technology. Thus, current research aims to identify trends in blockchain technology to achieve sustainable development. For this purpose, literature available in the current decade (2016 to 2025) was extracted from the Scopus database after systematic filtering and analysed using software such as RStudio, VOSviewer, and Microsoft Excel. The results of this research show that blockchain technology for sustainable development is growing and attracting increasing attention from researchers. Additionally, the study identified the domination of articles and conference papers; however, review articles have a significant influence. Based on this research, the authors suggest that future researchers continue their work, especially in qualitative studies on blockchain technology, to achieve sustainable development, bridge the gap between qualitative and quantitative research, and garner researchers' attention. Furthermore, researchers can focus on integrating blockchain technology into supply chain management, particularly in the agricultural sector, given its significant impact.

Keywords: *Sustainable Development; Blockchain Technology; Sustainability; Bibliometric Analysis; Knowledge Discovery from Text (KDT).*

1. Introduction

Sustainable development has become a key focus in various discussions related to environmental issues and development. Furthermore, several international organisations like the United Nations, the World Bank, and the World Trade Organisation treated it as a principal policy goal [1]. Initially, the concept of sustainable development was introduced by the World Conservation Strategy in 1980, and subsequently popularised by the Brundtland report in 1987 [2]. Later in 2000, the United Nations provided 8 Millennium Development Goals for the world community to achieve by 2015. Where sustainable development is one of the goals, the central focus of all goals is aligned with achieving sustainable development [3]. Subsequently, it also adopted 17 Sustainable Development Goals in 2015 to be accomplished by 2030, which provide a blueprint for peace and prosperity for the people and the planet [4]. Within the 17 SDGs, goals 6 (clean water and sanitation), goal 7 (Affordable and clean energy), goal 9 (industry innovation and infrastructure), goal 11 (sustainable cities and human settlements), goal 12 (Responsible consumption and production), goal 13 (climate action), goal 14 (conserve and sustainable use of oceans, sea and marine water) and goal 15 (Forest, Desertification and biodiversity) can be achieved through blockchain technology [5].
Blockchain technology is a decentralised or peer-to-peer network that stores information in a chronological order and reacts to changes in the information automatically using algorithmic protocols [6]. It follows principles such as consensus, immutability, data provenance, and encryption, which make the technology more prominent than traditional systems, significantly attracting global attention [7].
Previous studies state that the literature between blockchain and sustainability is largely neglected [8], so current research aims to identify the trends using bibliometric analysis on the literature published in this decade (2016 to 2025)
A bibliometric analysis was introduced in the 1930s by Belgian documentalist Otlet, and later popularised by Pritchard in 1969 [9]. It gained significant understanding related to the temporal evaluation of multidisciplinary research fields and provides a comprehensive understanding of research areas, mapping research boundaries, identifying influential authors, and providing new future directions [10]. A bibliometric analysis is a quantitative technique that handles a large quantity of scientific data and produces high research impact. Its techniques are categorised into performance analysis and scientific mapping [8]. Under performance analysis, the present study conducted annual scientific production and citation analysis, as well as publication pattern analysis, to identify the most relevant sources, the most contributing authors, and the most cited documents. Meanwhile, in scientific mapping, analysis such as text mining or knowledge discovery from text (KDT) and bibliographic coupling are performed. With the help of this bibliometric analysis, researchers can gain insights into growth patterns, the impact of literature, the type of existing literature, high-contributing journals for communication or review decisions, high-contributing authors for collaborations, key themes in this field, and core documents.
The current study is divided into seven sections. The first section, which is the introduction, explains the worldwide attention towards sustainable development and the role of blockchain in achieving it, along with an explanation of the related bibliometric analysis and its

categories. The second section explores the connection between blockchain and sustainable development, followed by the third section, which provides a detailed methodology section. This section includes information related to the search term, literature selection, database selection, and software used for analysis. Fourth, the results section provides an interpretation of the analysis performed, accompanied by tables and figures. Fifth, the conclusion provides a precise explanation of the entire research, including its findings, future directions, and limitations. The sixth section is practical implications, while the last section is the references, where the researchers used the Vancouver style to cite the existing literature referred to in this research.

2. Blockchain and Sustainable Development

As sustainable development is mainly measured in three aspects, such as Economic, Social, and Environmental [11], many researchers try to connect blockchain with sustainable development to observe effects and benefits based on an understanding that advancement in technology can influence organisational or national sustainability [5]. In this scenario, Thanasi-Boçe and Hoxha [12] conducted a systematic literature review that integrated both institutional theory and stakeholder theory to understand how blockchain technology improves economic, social, and environmental sustainability. It stated that blockchain improves efficiency and satisfies the stakeholders' demand for real-time transparency and verifiability of ESG data. Additionally, stakeholders gain an overview of employee conditions and environmental impact through the immutability, smart contract, and open-data structure aspects of blockchain technology. Similarly, Messina et al. [13] conducted a review to understand the impact of blockchain technology on environmental and social sustainability, discovering that blockchain-based regulatory, societal, and organisational aspects can positively influence environmental and social sustainability through traceability, transparency, and immutability. Moreover, some studies have viewed blockchain technology as a tool for verifying sustainable development [15], while others have argued that it has a negative environmental impact due to its energy consumption [5]. According to these studies, current research indicates that blockchain technology has a significant impact on achieving sustainable development.

3. Materials and Methods

The current study performed a bibliometric analysis to achieve the aim. For this purpose, the authors followed a four-phase process that includes defining the aim, data collection, analysis, and visualisation [15].

3.1. Define aim

At this stage, the authors recognised the importance of blockchain technology in achieving sustainable development and, therefore, aimed to observe its trends.

3.2. Data collection

Mongeon and Paul-Hus [16] stated that both Scopus and Web of Science are prominent peer-reviewed databases that attract the attention of researchers. Initially, the authors inserted “blockchain” and “sustainable development” terms into both databases, where Scopus yielded 36,652 results, which is 48 times higher than the Web of Science results (761). Additionally, Scopus has an extraction limit of 20,000, which is also higher than the 1000 limit of Web of Science. Based on these observations, the current study preferred the Scopus database. After selecting the database, the search term for blockchain is finalised as “blockchain” or “block chain” or block-chain” [17-18]. However, according to Ruggerio [19], both sustainability and sustainable development are different from each other. So, current research only considered “sustainable development” and provided a complete search query below

- Search Query: TITLE-ABS-KEY ("blockchain" OR "block-chain" OR "block chain") AND TITLE-ABS-KEY ("Sustainable development")

With the insertion of the search string in the Scopus database, 2,344 documents were identified. Then, the authors-initiated year filter option was used, which limited the literature to those available from 2016. It suggests that blockchain for sustainable development is a new topic. Thus, literature from 2016 to 2025 was considered, while four papers published in 2026 were excluded, resulting in 2340 documents. Similarly, in the type of document filtration, literature related to articles, conference papers, books, reviews, and book chapters was included, resulting in the selection of 2254 documents. However, 86 documents were removed related to other types, such as conference reviews, short notes, and more, due to their limited contribution. Furthermore, to avoid translation errors, this research opted for documents in the English language, excluding 30 documents in other languages. Regarding the type of document selection, authors chose publication source types, including journals, conference proceedings, and books, resulting in the elimination of 248 documents and the processing of 1976 documents for further filtration. Finally, due to the uncertainty of publication time and to avoid duplication of representing document publication years, literature in the publication process (Articles in press) is excluded, resulting in the selection of 1928 documents for bibliometric analysis by excluding 48 documents in the publication process. For better clarity of the filtration process mentioned in the methodology section, a filtration criteria table was shown as Table 1 below.

Table 1: Filtration Criteria

Criteria	Inclusion	Exclusion
Search date: 17 September 2025 Database: Scopus Search terms: TITLE-ABS-KEY ("blockchain" OR "block-chain" OR "block chain") AND TITLE-ABS-KEY ("Sustainable development")	2344	-
Year: 2016-2025	2340	4
Document type: Articles and reviews, conference papers, books, and book chapters	2254	86
Language: English	2224	30
Source type: Journal, conference proceedings, and book	1976	248
Publication stage: Final	1928	48

3.3. Analysis and visualisation

For analysis and visualisation, this study used software such as RStudio, VOS Viewer, and Microsoft Excel.

4. Results

4.1. Performance analysis

Performance analysis is a hallmark of bibliometric analysis that examines the contributions of existing literature in a field. This analysis is descriptive in nature and follows standard practice in every review-based study, presenting the performance of various research elements, including authors, institutions, countries, and journals [20]. In simple terms, performance analysis summarises publication trends and influencing literatures based on the number of citations at the micro level [21].

4.1.1. Annual scientific production and citation analysis

Annual scientific production provides a research area's productivity in a year, while citation analysis measures impact and influence [20]. This research conducted scientific production and citation analysis to gain insight into the research trends of blockchain technology in relation to sustainable development. Additionally, the citations and citations per document provide a significant understanding of the impact or influence of documents published in specific years. From Table 2, it is observed that the number of documents published each year has been continuously increasing, from an initial 2 documents in 2016 to 490 documents in 2024. However, the publications of 2025 (the current year) have almost reached the total of 490 from the previous year, even though the current year's publication is still ongoing. Based on these observations, the current study concludes that blockchain technology for sustainable development is gaining continuous attention from researchers, resulting in a growth pattern.

In contrast, the citations shown exhibit both increasing and decreasing patterns. Between 2016 and 2020, the number of citations experienced a rapid increase, rising from 273 to 10,378. Following 2020, the number of citations gradually decreased to 4,062 by 2024. This slow decline may be due to the publication time advantage (literature published early has an advantage in gaining more citations compared to later publications), document availability, or the relevance of the literature to future studies.

Furthermore, the citations per document analysis revealed that literature published in 2016 garnered the highest citations per document, followed by 2018 and 2017, respectively. Based on the observation, the current study concluded that the literature published from 2016 to 2018 has a significant impact due to the foundational aspect in this field. However, the number of citations for each document is gradually decreasing, indicating a decline in its impact. Thus, future researchers should focus on enhancing the quality of the documents rather than their quantity. Moreover, studies can also conduct a thematic or systematic literature review of documents published from 2016 to 2018 to identify topics that have attracted researchers' attention.

Table 2: Scientific Production and Citation Analysis from 2016 to 2025

Year	Documents	Citations	Citation per document
2016	2	273	137
2017	9	914	102
2018	27	3258	121
2019	62	4739	76
2020	111	10378	93
2021	161	9292	58
2022	232	8194	35
2023	354	8054	23
2024	490	4062	8
2025	480	912	2
Grand Total	1928	50076	

4.1.2. Type of document (publication pattern analysis)

Publication pattern analysis is the process of analysing the type and number of publications. It also provides researchers with a clear understanding of existing publications and enables them to perform future research based on established research patterns [22]. Based on the information provided in the methodology section regarding the type of document considered in this research, the current study aims to examine trends in publication. Table 3 contains detailed information related to the year of publication, the total number of publications in each year, and the number of publications of each category in each year.

Table 3: Type of Documents Analysis from 2016 to 2025

Year	Article	Book	Book Chapter	Conference papers	Review	Grade Total
2016				2		2
2017	4			5		9
2018	5		1	18	3	27
2019	11	1	4	44	2	62
2020	53		3	48	7	111
2021	74	4	9	61	13	161
2022	123	5	17	54	33	232
2023	165	13	38	108	30	354
2024	211	32	72	127	48	490
2025	182	29	133	75	61	480
Grand Total	828	84	277	542	197	1928

According to the information in Table 3, it is observed that articles and conference papers collectively dominated, accounting for 42.9% and 28.1% of the total documents (1928). Afterwards, book chapters, reviews, and books occupied subsequent positions, which combinedly accounted for 28.9% of the total documents. Based on these findings, the current study concludes that researchers are increasingly leaning toward performing quantitative or mixed-methods studies instead of qualitative research. Therefore, future researchers should conduct more qualitative studies, such as systematic literature reviews, thematic analyses, and meta-analyses, to gain further insight. Additionally, writing more book chapters, reviews, and books also reduces knowledge gaps and improves the quality of the research.

4.1.3. Relevant sources

The relevant source analysis provides a list of the journals that contribute to a specific field. To identify the top contributing journal, the current study analysed the most relevant sources and presented Table 4, listing the top 10 journals. Along with this, it also included the quantity of publications, H-index, G-index, M-index, total citations (TC), and start year of publication (PY-Start). The H-index, also known as the Hirsch index, was proposed by Jorge Hirsch as a research performance indicator designed for application at the micro level. It is measured as the number of scientific indicators (e.g., authors, journals, and more) that have h papers with at least h citations each [23]. For example, if a scientist has 12 documents that have at least 12 citations, then the h-index is 12.
Furthermore, the lack of sensitivity in the h-index led to the introduction of the g-index in 2006 by Leo Egghe as an improvement. This index is defined as the largest number such that the top g articles collectively gain at least g^2 citations. The citations of each document should be arranged in descending order, and the h-index value should also be considered when adding the citation [24]. For example, if a scientist has 5 documents with citations 12,10, 8, 7, and 3 (5^2, i.e., 25 should be less than or equal to the sum of the citations), then the g index is 2 because adding 8 citations of the 3rd document exceeds 25. On the other hand, the m-index is measured by dividing the h-index value by the duration elapsed since the year of the publication of the first document. This index focused on providing the annual effect by normalising the h-index over time [25]. For example, if a journal has an h-index of 28, the first published document in 2018, and the current research is performed in 2025, then the m-index will be 4 (28/(2025-2018)).

Table 4: Relevant Sources and Local Impact

Journal	Publication	h-index	g-index	m-index	TC	PY start
Sustainability (Switzerland)	108	28	54	4.0	3165	2018
Journal of Cleaner Production	44	29	44	5.8	3908	2020
IEEE Access	25	12	25	1.7	834	2018
Technological Forecasting and Social Change	23	19	23	4.8	1680	2021
Energies	21	11	21	2.2	572	2020
E3S Web of Conferences	21	5	8	1.0	78	2020
Procedia Computer Science	18	7	13	1.4	189	2020
International Journal of Production Research	16	13	16	2.2	4165	2019
Computers and Industrial Engineering	16	12	16	4.0	613	2022
Business Strategy and the Environment	15	11	15	3.7	1101	2022

From Table 4, it is observed that “Sustainability (Switzerland)” and “Journal of Cleaner Production” are the leading sources, with higher publication quantities, followed by higher h- and g-index values. However, in terms of the m-index, the “Sustainability (Switzerland)” journal lags behind the “Technological Forecasting and Social Change” journal, which is due to the 3-year difference in initial publication year. Future researchers can conduct a literature review based on the information provided in this review and can also utilise journal information for article communication purposes, which will provide more attention from the research community.

4.1.4. Most contributing author

Most contributing author analysis provides authors who have published a high number of papers in the development of the specific field. With reference to the information provided in the most relevant source analysis, performance measurement indices are used to evaluate the performance of experts. Table 5 presents the top 10 authors with the highest number of documents, along with their total citations, the year of initial paper publication, the number of papers, and indices such as h, g, and m.

Table 5: Top 10 List of Highly Contributing Authors

Author	Documents	h-index	g-index	m-index	TC	PY-start
Liu Y	19	7	14	1.4	203	2020
Singh R	18	10	18	3.33	600	2022
Kumar A	17	6	17	1.2	1042	2020
Li J	16	12	16	2	649	2019
Wang Y	16	7	15	0.78	237	2016
Gehlot An	15	10	15	3.33	581	2022
Zhang Y	12	7	12	1	289	2018
Skram sv	11	9	11	3	546	2022
Sarkis J	8	8	8	1.33	5289	2019
Kamble Ss	6	6	6	1.2	2522	2020

From Table 5, it is observed that “Liu Y” has a high number of publications but gained a low number of citations compared to other researchers in the list. However, his H, G, and M indices showcase good performance. Afterwards, “Singh R” contributed 18 publications within the span of 3 years but gained comparatively higher citations than Liu Y, with a significant difference in the H, G, and M values. Similarly, “Sarkis J and Kamble Ss” published 8 and 6 documents respectively but got the highest citations of 5289 and 2522, which indicates each document gained at least 661 and 420 citations. So, the current study suggests that future researchers continue to produce high-quality documents in their field of interest, which will enhance their research performance and provide a good reputation. Moreover, researchers can also use the study findings to connect with experts for research collaboration, producing high-quality documents and gaining more insights in the field.

4.1.5. Most cited document

Most document analysis provides a list of documents that have gained high citations globally. For this purpose, the researchers used RStudio to extract highly cited documents along with the number of citations, citations per year, and normalised citations. Where total citation is calculated based on the number of citations divided by the age of the document, while Normalisation is all about the correction of citation practices in a scientific field, which is calculated by dividing the number of citations of a publication by the average number of all documents in the same year [26]. Using the software, this research extracted information related to the 10 highly cited documents, as well as other details such as research type, industry, and theme, by reviewing the literature. Based on the extracted information, Table 6 is presented below.

Table 6: Top 10 Cited Documents Along with Research Type, Industry, and Theme Information

References	Total Citations (TC)	TC per Year	Normalized TC	Research Type	Industry or Sector	Theme
[27]	2784	397.71	36.42	Conceptual	N/A	Supply chain
[28]	1646	205.75	13.64	Quantitative	N/A	Supply chain
[29]	988	197.60	17.12	Quantitative	Education	Supply chain
[30]	769	128.17	8.22	Review	Agriculture	Supply chain
[31]	766	127.67	8.19	Quantitative	Agriculture	Supply chain
[32]	695	115.83	7.43	Review	N/A	Supply chain
[33]	689	98.43	9.01	Review	N/A	Sustainable development
[34]	652	108.67	6.97	Review	Agriculture	Food traceability
[35]	608	101.33	6.50	Review	Agriculture	Supply chain
[36]	605	100.83	6.47	Quantitative	SME	Supply chain

According to Table 6, Saberi et al. [27] received the highest number of citations (2,784), and the total citations per year and normalised citations are also the highest. It is a concept-based study that debated on blockchain-based supply chain challenges, benefits, and applications. With reference to this information, the current study concluded that the conceptual focus on blockchain technology in supply chain management attracted the attention of researchers. This conclusion is also supported by the research type information, which indicates that 60% of the documents are reviews. Additionally, in terms of focused industries, agriculture is highly targeted, with minimal focus on Education and SMEs (Small and medium enterprises).

Moreover, the focus on the theme of the literature revealed that 8 out of 10 documents focused on supply chain, showcasing the significance of blockchain technology in supply chain management. Based on these findings, the current study suggests that future experts conduct more conceptual or review, or thematic-based studies to gain researchers' attention and also minimise the gap between the two types of documents, as specified in the type of document analysis (publication pattern). Similarly, integration of blockchain technology in the supply chain management of the agricultural sector is also gaining attention, so future research can also focus on this area. Along with the agricultural sector, focus on education and SMEs is also beneficial.

4.2. Scientific mapping

Scientific mapping analysis utilises network analysis to examine documents, keywords, and themes for interwoven relationships at both the meso and macro levels [21]. It reveals the intellectual, social, and conceptual structure and evaluation process of literature. Previous studies have noted that conducting a performance analysis in a bibliometric analysis is insufficient because it only provides information related to the performance of scientific actors (authors, journals, institutions, and keywords), but not the relationships or interactions between them. Therefore, combining scientific mapping analysis with performance analysis provides a comprehensive understanding of a research field [15]. Thus, the researchers in this study added text mining analysis and bibliographic coupling of documents.

4.2.1. Text mining analysis

Text mining, also known as knowledge discovery from text (KDT), was first mentioned by Feldman and Dagan in 1995, which deals with text analysis using machines. It is a process that consists of four stages, including information retrieval from Knowledge discovery databases (KDD), data extraction, natural language processing (NLP), and connecting the processed information with algorithms and methods such as data mining, machine learning, and statistics [37]. In this research, the authors retrieved a data file from knowledge discovery databases like Scopus and uploaded it into the VOS viewer software using the “create” option, followed by “create map based on text data”, and then selected “read data from bibliographic database files. With the successful upload of data file, the authors selected “title and abstract fields” to extract the data as these fields consists of relevant information related the research document.

Afterwards, under the counting method, full counting is opted for instead of binary counting, as it only counts the presence or absence of a term in the document, but does not account for the occurrence. With the help of full counting, 35,512 terms were identified from 1928 literature, and then, with the option for terms with a minimum occurrence of “100”, 127 terms met the threshold out of 35,512. The threshold for minimum occurrence is selected stringently to focus on key terms and avoid unrelated terms in the visualisation [38]. Later, the application calculated a relevant score for the terms and provided 76 terms. Then, the network visualisation diagram was generated, which consists of three clusters. From these three clusters, the first cluster is crimson red in colour, with 31 items, the second cluster is forest green in colour, with 29 terms, and the third cluster is steel blue, containing 16 items.

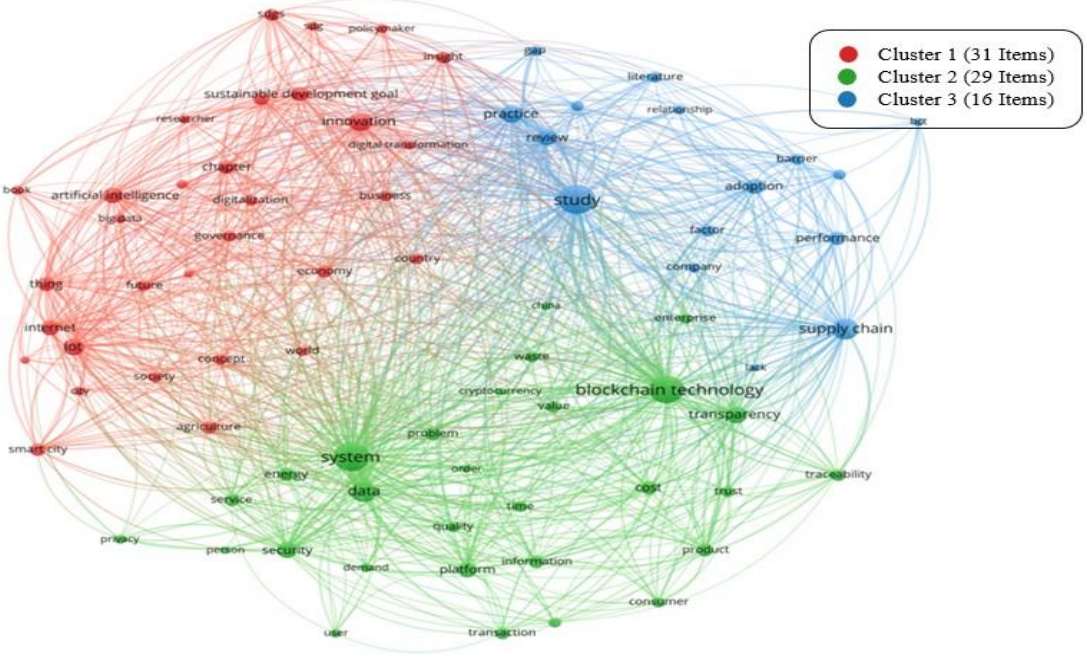

Fig. 1: Network Visualisation of Text Mining Analysis.

Figure 1: The first cluster primarily focuses on the digital transformation of various sectors to achieve sustainable development. Therefore, future studies should place further emphasis on identifying the challenges that blockchain integration faces in various sectors to achieve sustainable development. Additionally, studies can also assess the feasibility and benefits of integrating blockchain technology with other technologies, such as artificial intelligence, big data, the Internet of Things (IoT), and more. Subsequently, the second cluster focused on the benefits of blockchain technology, including trust, privacy, transparency, traceability, and security, for waste management. Thus, future studies can investigate the role of blockchain technology in achieving better resource utilisation with minimum waste. Finally, the third cluster deals with the adoption of blockchain technology in supply chain management and the circular economy. Based on this observation, future experts can study ways to mitigate the barriers to integrating blockchain technology into supply chain management, thereby enhancing the circular economy.

4.2.2. Bibliographic coupling of documents

The term "bibliographic coupling" was first coined by Dr. M. M. Kessler of the Massachusetts Institute of Technology, who stated that bibliographic coupling is a measure of the number of literatures that have a meaningful relationship with each other when they share one or more common references. It is also defined as the relationship between two documents when they share a high proportion of keywords, citations, and other indicators [39]. In simple terms, a bibliographic coupling occurs when two studies cite the same third document [40], and if two articles are coupled together, then they may be treated as the same subject. Moreover, the coupling is measured by couple strength, which means that a higher couple strength refers to two articles that have more citations from other articles they share. Additionally, it has been proven to be an effective method for identifying potential research topics [41]. Based on this significance, the current study performed bibliographic coupling on the document using the VOSviewer software.

In the application, after selecting the type of analysis as bibliographic coupling and the unit of analysis as documents, the researchers specified a minimum of 100 citations per document, primarily to focus on highly influential literature and simplify network visualisation, resulting in the selection of 102 documents out of 1928. Afterwards, the researchers proceeded to create a network visualisation diagram. However, at the final step, 48 documents were excluded due to a lack of connectivity; thus, the network visualisation was created using the 54 remaining documents, which are divided into 9 clusters. From these clusters, the first cluster is red in colour with 10 items, followed by the second and third clusters in green and blue colours with 9 and 7 items, respectively. There, the fourth, fifth, and sixth clusters are in yellow, purple, and cyan, with 6 items each. Then, the seventh, eighth, and ninth clusters consist of 4, 3, and 3 items, respectively, and are in orange, brown, and pink colours.

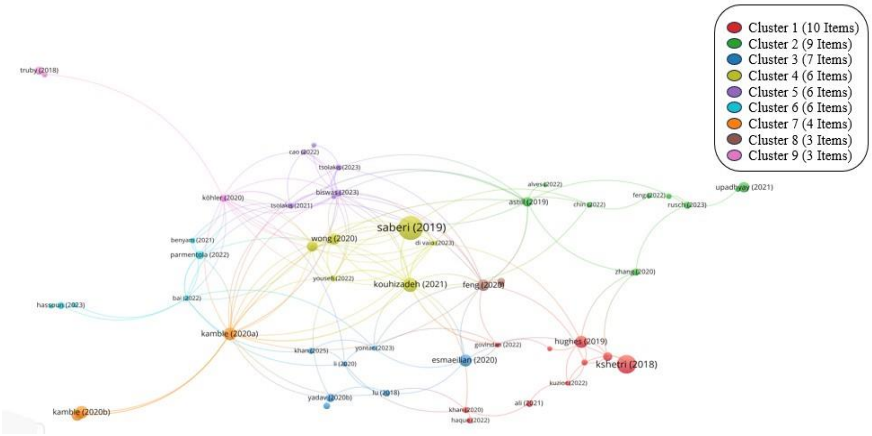

Fig. 2: Network Visualisation of Documents' Bibliographic Coupling.

The first cluster in Figure 2 focuses on the benefits, features, problems, applications, and emerging trends of blockchain technology in the process of achieving sustainable development. Future research can focus on determining the relevance of these characteristics of blockchain in various businesses and creating options for those industries to maximise blockchain benefits while minimising risk. Similarly, the second cluster concentrated on the circular economy, green innovation, and digital technologies. Based on these topics, the current study recommends that future researchers investigate the impact of various digital technologies on green innovation activities aimed at achieving a circular economy. While the third cluster's literature concentrated on Industry 4.0, sustainable practices, and supply chain management, future research should investigate the impact of Industry 4.0 on sustainable supply chain management practices.

The fourth cluster includes articles about sustainable supply chains and gender equality in relation to blockchain technology. In light of this fact, the current study recommends that future experts investigate whether gender equality exists and its impact on sustainable supply chain management, utilising blockchain technology. Furthermore, the fifth cluster is concerned with social aspects, artificial intelligence, and supply chain; hence, future research can focus on determining the impact of social variables on supply chain through the integration of artificial intelligence with blockchain technology. Furthermore, the sixth cluster emphasises ESG (Environment, Social, and Governance), agricultural technology, and sustainable development. Based on these criteria, current research directs academics to investigate the impact of environmental, social, and governance issues on agricultural sectors while integrating diverse technologies to combat food scarcity and achieve sustainable development.

The seventh cluster focuses on the agricultural supply chain and machine learning, recommending the application of machine learning techniques in agricultural supply chain management practices to decrease risk, anticipate market and yield fluctuations, and increase production. Similarly, the eighth cluster discusses the agri-food supply chain and Industry 4.0, emphasising the importance of utilising Industry 4.0 technology to address food supply chain challenges, particularly in the agricultural sector, so that future research can focus on this area. Finally, the ninth cluster includes publications on topics such as decarbonization and energy usage. Based on these themes, the authors recommend that future researchers investigate the linkage between decarbonization policies and energy efficiency measures, aiming to achieve sustainable energy efficiency.

5. Conclusion

The current study aims to examine trends in blockchain technology for sustainable development and to analyse the literature produced in this decade (2016-2025) using the Scopus database for bibliometric purposes. This study found that blockchain technology for achieving sustainable development is always garnering researchers' interest, indicating a growing pattern. Furthermore, the publication trend showed that articles and conference papers received greater attention than reviews and books. Similarly, the analysis of relevant sources found that "Sustainability (Switzerland)" and "Journal of Cleaner Production" are the top sources with the most publications. Furthermore, the most contributing author analysis revealed "Liu Y" as having high productivity, although "Sarkis J" had more citations, despite having significantly fewer publications.

Furthermore, the current study conducted a most-cited document analysis to identify the top ten highly cited documents and then evaluated them to gain insights into the research type, industry, and themes of the existing documents. The analysis revealed that Saberi et al.'s [28] work is the leading document with a considerable influence in this subject. At the same time, the research discovered that qualitative documents have a stronger influence than quantitative documents. Similarly, it was found that researchers are particularly interested in integrating blockchain technology with supply chain management in the agricultural industry. The text mining analysis highlighted the digital transformation of several industries to achieve sustainable development through the use of technologies such as blockchain, artificial intelligence, Industry 4.0, and other emerging technologies. Furthermore, the bibliometric coupling study identified important documents by ensuring that key publications are highly focused on the benefits, challenges, features, and applications of blockchain technology in achieving sustainable development.

Based on the findings, the current study suggested a few future directions. First, the study encourages future academics to continue researching blockchain technology to attain sustainable development. However, undertaking qualitative research in the agricultural industry is more useful. Second, researchers can conduct studies to identify the barriers to integrating blockchain into supply chain management, aiming to achieve sustainability. Third, this study recommends that future experts examine the results of the most contributing sources analysis while developing review-based papers or submitting literature. Fourth, research can explore the feasibility and benefits of integrating blockchain technology with other technologies, such as artificial intelligence, big data, the Internet of Things (IoT), and others. Fifth, it directs future experts to examine the impact of various digital technologies on green innovation efforts aimed at realising the circular economy.

This study also has some drawbacks. Initially, it is confined to completing a bibliometric analysis, but future researchers may combine bibliometric and systematic literature reviews to gain deeper insights. Similarly, a few scientific mapping analyses were conducted in this study, enabling future studies to incorporate keyword co-occurrence and co-citation analysis.

6. Practical Implications

The findings of this research are helpful for industries to understand the significance and limitations of blockchain technology and make necessary strategies for effective blockchain implementation. Similarly, the study provided a list of characteristics and connected blockchain with the Sustainable Development Goals (SDGs) that can help policymakers prepare strategies to achieve transparency and accountability in government systems and promote national sustainability.

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