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DECODING BLOCKCHAIN CONTRIBUTION IN ACHIEVING SUSTAINABLE DEVELOPMENT GOALS (SDGS) AND IDENTIFYING FUTURE RESEARCH AGENDA

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Abstract

The 17 Sustainable Development Goals (SDGs) set by the United Nations aim to solve global challenges such as poverty, hunger, inequality, climate change, etc. Blockchain technology has gained increasing attention as a potential solution for achieving these goals. This paper reviews the literature on how blockchain is helping to achieve the SDGs. Based on an analysis of 251 studies from 2016 to 2023; results indicate that USA, UK, China, and India are the most productive countries in blockchain research related to SDG goals. Furthermore, blockchain has contributed significantly to fostering SDG goals 1, 2, 8, 9, 10, 11, 12, 13, and 17, while it has not been able to expedite the achievement of goals 4, 5, 6, and 16. This study finds multiple roadblocks to blockchain technology for SDG goals, such as regulations, interoperability, the energy cost of the technology, needing to learn how to govern it, technical and scalability problems, etc. This study outlines two future research agendas, the first being to achieve goals 4, 5, 6, and 16. The second is to explore the potential of blockchain to enable more efficient data collection, storage, and sharing, as well as its potential to help more efficient fundraising and resource allocation.

Keywords: Blockchain, Sustainable Development Goals, Sustainability; digitalization, RStudio

1. INTRODUCTION

The Sustainable Development Goals (SDGs) are 17 goals established by the United Nations to ensure that all countries can achieve sustainable development by 2030(Lee *et al*., 2016). Blockchain technology has been identified as essential for achieving these goals (Di Vaio *et al*., 2020). Blockchain is an immutable, distributed ledger technology that provides an efficient way to store and share data securely and has the potential to revolutionize existing business and governmental processes. Blockchain can enable organizations to more efficiently collect, store and analyze data related to the SDGs, allowing them to better track and measure progress toward achieving these goals and identify areas of improvement (Saberi *et al*., 2019). It can reduce the time and cost associated with collecting and verifying data and improve the accuracy and traceability of information. In addition, blockchain can enable organizations to more efficiently and securely share data and resources with other organizations, allowing them to collaborate more efficiently on projects related to the SDGs. Furthermore, blockchain can enable the creation of smart contracts, which can be used to automate and streamline processes related to the SDGs. Blockchain also can revolutionize how governments, businesses, and organizations collect and manage funds (Anisha *et al*., 2022). It can enable governments and organizations to raise funds through tokenization and crowd-funding, allowing them to more efficiently and securely allocate resources towards achieving the SDGs. A growing body of literature explores the potential of blockchain to help achieve the SDGs (Parmentola *et al*., 2021). As blockchain research has proliferated, it has attracted the attention of many academics. Researchers' interest in blockchain to achieve SDG Goals has been piqued by the technology's global significance, security, and potential economic impact, which prompted us to conduct this investigation. In this setting, a clear, systematic overview can help researchers better understand the unique features of blockchain studies. To this day, there has yet to be an analysis of blockchain's potential applications in achieving SDG goals that is comprehensive. Scholars gain a much better understanding of the structure and taxonomy of various fields of study due to reading reviews that look back at emerging topics (Wang *et al*., 2021). The emergence of such a curious development is intriguing (Gartner, 2016). However, because this is a new field, more quantitative and qualitative research is needed. Becoming familiar with the most recent developments in the field is beneficial for conceptual comprehension. Together, scientists, technologists, and academicians will find long-term solutions to this problem, but their efforts will be required (Gomber *et al*., 2018). Due to the importance of blockchain technology and the paucity of research examining its potential applications in achieving SDG goals, authors will review previous efforts in this area. In order to assist us in achieving this objective, bibliometric techniques employ a vast array of quantitative tools capable of managing enormous datasets related to the study of literature (Chen *et al*., 2021). More specifically, we develop the following two research questions to which we contribute:

RQ1. What are the publication trend, top contributing authors, institutions, countries, most influential articles, and top contributing journals for blockchain in achieving SDG Goals?

RQ2. To determine the viability of blockchain technology for achieving the SDG Goals, identify promising areas for future research, and suggest policymaker interventions that can help improve to achieve them faster. (Through results from our critical literature analysis)

The knowledge gained from this analysis has numerous practical applications. Researchers can use this review to get a bird's-eye view and current understanding of the publication trend of blockchain for SDG Goals research to gauge the scientific community's interest in the topic over time. This review can also help aspiring authors locate key literature (articles, journals) and potential collaborators (authors, institutions, countries) for future research. Furthermore, this study's selection of research directions can inspire aspiring writers to launch into the novel and worthwhile projects. Finally, these points of view also serve as a preview of future research that can help inform policymakers and business professionals. The remainder of the paper is laid out as follows: The second section provides an overview of our methodology. The third section provides an analysis of performance by presenting publication, citation patterns of the research, identifying the most prolific and influential contributors, blockchain adoption in achieving the SDG goals, etc. The fourth section presents the future research agenda. Finally, the conclusion and study limitations are discussed in the last section.

2. RESEARCH METHODOLOGY, SAMPLE SELECTION AND DATA ANALYSIS

This study utilized Scopus, an abstracting and citation database (~65 million records), which provides access to scholarly publications and a more extensive database than the Web of Science (~33 million records). Moreover, the Scopus database is updated daily, while the Web of Science is updated weekly. Therefore, researchers prefer to select only this database for the bibliometric analysis. Bibliometrics is vital in providing valuable insights into the progress toward Sustainable Development Goals. By analyzing bibliographic data, such as publication trends, citations, and authorship, researchers and policymakers can better understand the research and knowledge production related to each SDG, enabling them to measure the impact of research in the field and identify potential areas for further research. Bibliometric analysis can also help to identify research gaps and trends and inform policy decisions, helping to ensure that resources are directed toward the most effective strategies and interventions. VOSviewer (Van Eck & Waltman, 2010) and RStudio Bibliometric (Aria & Cuccurullo, 2017) software applications have been used as a tool for conducting the analysis that the wider research community has been utilizing to carry out bibliometric research (Jaiswal *et al*., 2022; Das *et al*., 2021).

The first step in retrieving data from this source is identifying the proper collection of blockchain-related articles published for SDG Goals, as outlined in Table 1. An initial search performed using search criterion ("blockchain") AND ("SDG" OR "Sustainab*) resulted in 2011 documents. Further, it was filtered within the fields of "Business, Management and Accounting" which produced 443 such documents. An investigation into previously published material led to this conclusion from 2016 to 2023(specifically till 26 January 2023). It was then screened for articles, excluding conference papers, books, chapter summaries, other non-articles, and English-only articles, resulting in a final corpus of 251 articles. As a result, bibliometrics is used to examine 251 pre-existing publications to analyze and provide foresight of future research directions (Ibrahim & Truby, 2021).

Table 1. Search criteria and article selection.

Filtering criteria	Exclusion	Inclusion
Selection Criteria		
Search engine: Scopus		
Search date: 26 January 2023		
Search Criteria: (Include articles "Titles, abstracts, and keywords" only)		
Search period: 2016-2023		
Search term: ("blockchain") AND ("SDG" OR "Sustainab*)		2011
Subject area: "Business, Management and Accounting"		443
Document type: "Articles"		252
Article selection		
Filter the erroneous records: Only documents with valid author(s)	0	252
Language filtration: Include only English-language documents	1	251
Tools: VOSViewer, Bibliometrix R package		

3. RESULTS AND DISCUSSION

3.1 Publication output and growth trend: Study reveals that blockchains in achieving SDG Goals are a recent development. Despite the major focus on achieving SDG Goals around the global, only six papers exist in 2017. As a result, 2023(till Jan 2023) has 14 articles, 2022 has 99 articles, 2021 has 71, 2020 has 44, 2019 has 13, and 2018 has only 4 articles. As there is a vast scope of work associated with Blockchain technology in SDG area research, the outcome indicates that researchers are becoming increasingly interested in Blockchain technology and its publication.

3.2 Productive Journals, Country and Author: China has published most articles (56) but when it comes to total citations, United States tops the list with 2646 total citations, followed by United Kingdom (1876), China (1325) and India (1226). Regarding journals, 10 articles published in 'International Journal of Production Research' got total citations of 1615 followed by 7 articles which published in 'International Journal of Information management' with total citations as 1083 and, 25 articles from 'Journal of Cleaner Production' with 798 citations. Regarding productive authors, 'Sarkis, J' tops the list with total citations as 1700, followed by 'Kouhizadeh, M.' with 1436 citations and 'Saberi, S.' with 1435 citations (Table 2).

Table 2. Productive Journals, Country and Author

TP	Author	TC	TP	Country	TC	TP	Sources	TC
8	Sarkis, J	1700	40	United States	2646	10	International Journal of Production Research	1615
3	Kouhizadeh, M.	1436	52	United Kingdom	1876	7	International Journal of Information management	1083
2	Saberi, S.	1435	56	China	1325	25	Journal of Cleaner Production	798
1	Shen, L.	1129	32	India	1226	2	International Journal Of Production Economies	330
3	Sharma, R.	355	19	Italy	434	1	supply chain management	293
4	Kamble, S.S.	354	11	Finland	433	19	Technological forecasting and social changes	290
2	Gunasekaran, A.	346	12	Malaysia	392	3	Production and operations management	254
1	Akella, V.	320	8	Hong Kong	333	8	Transportation Research Part e :Logistic and Transportation Review	251
1	Dwivedi Y.K.	320	18	Australia	309	13	Business Strategy and the Environment	228
1	Hughes, L.	320	11	Turkey	253	2	Strategic Change	159
Note (s): TP= total publication; TC=total citations								

Top Cited documents: Top cited documents in the field of blockchain for Sustainable Development Goals are from Taylor & Francis, Elsevier and Emerald and Wiley publisher (Table 3). Most of these studies are around supply chain management, blockchain enabled traceability, agriculture etc.

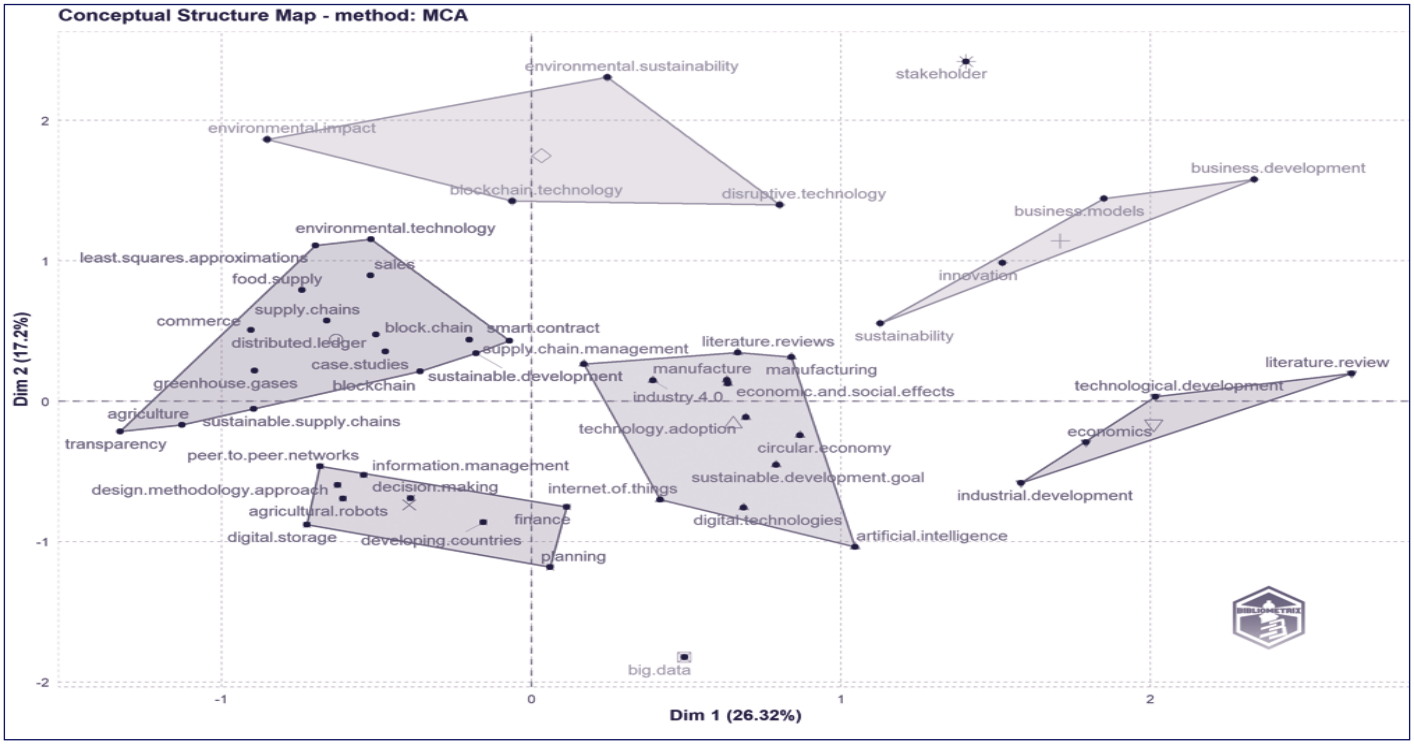
Table 3. Top Cited documents

Author	Year	Title	Journal	Publisher	TC
Saberi, S.	2019	Blockchain technology and its relationships to sustainable supply chain management	International journal of production research	Taylor & Francis	1128
Kamble, S.S.	2020	Modeling the blockchain enabled traceability in agriculture supply chain	International journal of information management	Elsevier	321
Hughes, L.	2019	Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda	International journal of information management	Elsevier	317
Kouhizadeh, M.	2021	Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers	International journal of production economics	Elsevier	306
Cole, R.	2019	Blockchain technology: implications for operations and supply chain management	Supply chain management	Emerald	292
Hastig, G.M.	2020	Blockchain for Supply Chain Traceability: Business Requirements and Critical Success Factors	Production and operations management	Wiley	238
Wong, L.W.	2020	Time to seize the digital evolution: Adoption of blockchain in operations and supply chain management among Malaysian SMEs	International journal of information management	Elsevier	225
Bai, C.	2020	A supply chain transparency and sustainability technology appraisal model for blockchain technology	International journal of production research	Taylor & Francis	213

Choi, T.M.	2019	Data quality challenges for sustainable fashion supply chain operations in emerging markets: Roles of blockchain, government sponsors and environment taxes	Transportation research part e: logistics and transportation review	Elsevier	181
Divaio, A.	2020	Blockchain technology in supply chain management for sustainable performance: Evidence from the airport industry	International journal of information management	Elsevier	143
Note(s): TC=total citations					

Conceptual structure and factorial analysis (MCA): This part of the analysis discusses the authors' prominent keywords and factorial analysis(Fig. 1) highlighting the major themes that are studied in these 251 publications under study. The red cluster keywords such as supply chain, environment, food, agriculture, commerce, sales, transparency, smart contract, distributed ledger, and greenhouse gases are related to SDG2, SDG 12, SDG 10, and SDG 17. The blue cluster keywords such as technology adoption, internet of things, artificial intelligence, industry 4.0, circular economy, economic and social effects, manufacturing, digital technologies etc are related to SDG 9, SDG 11, and SDG 8.The green cluster keywords such as innovation, business development, business models are related to SDG 9 and SDG 17.The purple cluster keywords such as decision making, information management, peer to peer networks, agricultural, robots, finance, and planning are related to SDG1, SDG 2, SDG 17, SDG 8, and SDG 12.The orange cluster keywords such as disruptive technology, environmental impact, and environmental sustainability are related to SDG 13.The brown cluster keywords such as economics, industrial development are related to SDG 9, and SDG 8.

Fig. 1. Factorial Analysis using Multiple Correspondence Analysis (MCA)



Further content analysis of the existing literature and organizing the data from the clusters, the author(s) found that the blockchain has the potential to facilitate the achievement of the SDG Goals. It can facilitate the tracking and verification of sustainable development initiatives, helping to ensure that resources are used most effectively and efficiently. The following sections discuss the contribution of blockchain in achieving SDG goals.

3.5 Blockchain adoption in achieving SDG goals: Goal 1 (No Poverty): Blockchain technology could eradicate poverty by providing access to financial services, such as banking and payments, to those who lack access to traditional financial institutions (Sunar & Swaminathan, 2022). Blockchain can also provide access to new, low-cost remittance services to those in developing countries, which can significantly reduce the cost of sending money to family and friends abroad(Tang, 2022). Furthermore, blockchain-based digital identity systems can

help those in poverty access services and support, including employment and education, as well as medical and social assistance (Zhang, 2022; Guo et al., 2021). Finally, blockchain can be used to create and manage aid programs, ensuring that all funds are tracked and distributed efficiently and transparently, thus reducing the potential for fraud and corruption (Quayson et al., 2020; De Sotoa, 2017). In addition, it can provide a secure platform for digital payments, remittances, and microfinance, enabling people to access banking services and potentially alleviate poverty.

Goal 2 (Zero Hunger): Blockchain technology can help eradicate hunger by tracking food's origin and movement, making it easier to identify and address food waste, spoilage, and contamination (Kör *et al*., 2021). Second, it can facilitate donations and other financial assistance to those in need, providing a secure and transparent way for funds to reach their intended recipients. Thirdly, it can streamline supply chains, reducing costs and improving efficiency, ensuring that food products are delivered to those in needs in a timely and cost-effective manner. Fourthly, blockchain can facilitate the direct distribution of food aid, reducing the need for mediators and increasing the efficiency of aid distribution (Kör *et al*., 2021; Tang, 2022). Finally, it can facilitate access to local markets for farmers and other small producers, helping to increase incomes and reduce food insecurity.

Goal 17 (Partnerships to achieve the Goal): Blockchain can provide a secure and transparent infrastructure for governments and organizations to collaborate on shared objectives (Jaiswal *et al*., 2022). It can track data and transactions related to achieving the goals, providing greater accountability and trust among partners. Additionally, blockchain can help facilitate the development of efficient and cost-effective financial systems and services, enabling partners to quickly transfer funds and resources to those in need(Khan *et al*., 2022). Finally, blockchain can help create new markets around such initiatives, providing new opportunities for collaboration and investment (Rakshit *et al*., 2022).

Goal 13 (Climate Action): Blockchain technology is being used to help reduce our environmental footprint and achieve the goals of climate action. Through blockchain-enabled applications, businesses and organizations can track their energy and resource usage and emissions, incentivize green initiatives, and establish smart contracts that enforce environmental regulations (Parmentola *et al*., 2022; Sunar & Swaminathan, 2022; Poonia *et al*., 2021). Blockchain can also develop new renewable energy sources and facilitate international climate finance (Nygaard & Silkoset, 2022). Furthermore, blockchain technology can improve transparency and data accuracy, allowing organizations to monitor climate change and its impacts better. Finally, blockchain can create new markets and trading systems for carbon offset credits and renewable energy certificates, helping to reduce emissions and create incentives for businesses to shift to renewable energy sources (Al Sadawi *et al*., 2021; Sankaran, 2019).

Goal 8(Decent Work and Economic Growth): Blockchain has helped to create a more transparent and secure system for businesses to operate within, increasing economic growth and providing more secure jobs. For example, through smart contracts, businesses can ensure that their transactions are secure, that all parties will abide by the agreement, and that payment is made on time (Rehman *et al*., 2022). This eliminates the need for third-party intermediaries and helps to reduce costs. Additionally, blockchain technology has helped reduce the cost of international payments, allowing businesses to access new markets and increase the scope of their operations (Sun *et al*., 2022; Sheikhi *et al*., 2022). This has helped to create new job opportunities and stimulate growth in different parts of the world (Dang *et al*., 2022). Finally, blockchain has also been used to create a more transparent, secure, and efficient system for international trade, allowing businesses to access more competitive prices and increases their profits (Chillakuri & Attili, 2021).

Goal 9 (Industry, Innovation and Infrastructure): Blockchain technology has significantly impacted to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation. Blockchain has enabled more efficient and secure processes in many industries, allowing for more efficient and cost-effective operations (Chin *et al*., 2022). For example, in the logistics and supply chain industry, blockchain has enabled faster and more secure tracking of goods throughout their journey, allowing companies to manage their inventory and optimize their operations more effectively. Additionally, blockchain has enabled more secure and reliable payment processing, enabling the adoption of new technologies and services, such as mobile payments and digital banking (Da Silveira *et al*., 2022). This has allowed for greater financial inclusion for those who previously lacked access to traditional banking services. In terms of fostering innovation, blockchain has also enabled the development of new technologies and services, such as smart contracts and distributed applications (Hou *et al*., 2021). These technologies have enabled the creation of new business models and opportunities for entrepreneurs, which has led to increased innovation in many industries. Overall, blockchain technology has had a positive impact on SDG 9, helping to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

Goal 10 (Reduced Inequality): Blockchain technology has been used to reduce inequalities by increasing transparency in the distribution of resources, helping to ensure that resources are being distributed equitably (Hoffmann & Dahlinger, 2019). Additionally, blockchain can create a secure and transparent platform for micro-financing, allowing people with limited access to traditional banking services to access financial resources (Van der Elst & Lafarre, 2019). Blockchain can also be used to create platforms for crowdfunding and peer-to-peer donations, allowing individuals to support causes that they believe in (Quayson *et al*., 2020). Finally, blockchain can facilitate smart contracts, enabling people to enter into contractual agreements without requiring the services of a third-party intermediary, thus reducing the likelihood of unequal power dynamics (Du *et al*., 2020).

Goal 11 (Sustainable Cities and Communities): Blockchain technology enabled the tracking of resources, such as energy, water, and materials, to understand their usage's environmental impact better. It has also enabled the development of sustainable solutions to urban problems, such as providing access to clean energy and water, tracking urban waste, and helping to reduce energy and emissions in buildings (Javed *et al*., 2022). Additionally, blockchain has facilitated the development of smart city initiatives, such as providing access to public services, monitoring traffic, and air quality, and enabling citizens to interact with their governments (Parmentola *et al*., 2022). Blockchain technology can help cities ensure data accuracy, reduce transaction costs and increase trust by providing a secure, tamper-proof, and traceable network. Finally, blockchain has been used to create digital identities for citizens, which helps to create trust and security in cities and communities (Bagloee *et al*., 2021). Blockchain technology has enabled the development of smart contracts, which can govern the sharing of resources and money, optimize energy usage and waste management, and create digital identities for citizens. This technology can also ensure that all stakeholders have a transparent view of the data and resources they share, which can help reduce corruption and create more efficient, sustainable cities (Marsal-Llacuna, 2020). Blockchain can create new markets and businesses that focus on creating more sustainable and equitable communities by leveraging new digital currencies, smart contracts, and decentralized autonomous organizations. Blockchain can also be used to securely store data related to land and property ownership, making it easier to ensure that land rights are respected(Javed *et al*., 2022).

Goal 12 (Responsible Consumption and Production): Blockchain technology provides a secure, transparent, and traceable platform for creating, tracking, and verifying responsible consumption and production practices (Centobelli *et al*., 2022). For example, blockchain can trace the origin and journey of products, ensuring that only sustainably sourced materials are used in production and that any byproducts are responsibly managed. Blockchain can also be used to create digital records of product lifecycles, allowing businesses to make informed decisions about their supply chain and the environmental impact of their production processes. In addition, it can provide a platform for creating digital tokens that incentivize sustainable practices and reward companies for their responsible production and consumption practices (Kör *et al*., 2021; Abban & Abebe, 2022). Finally, blockchain can enable more effective traceability and transparency around the production of goods, allowing consumers to make more informed decisions about the products they buy.

4. FUTURE RESEARCH AGENDA

There currently needs to be a single blockchain technology standard, making it challenging to create a unified platform for implementing and using it (Jaiswal *et al*., 2022). Blockchain technology needs to improve its ability to process high volumes of transactions quickly and efficiently. Governments and financial institutions are still trying to figure out how to regulate and use blockchain technology, creating uncertainty. The use cases for blockchain technology still need to be improved, and more research is needed to expand its potential applications. Many users need to understand how blockchain technology works, which can hinder its adoption. As blockchain technology becomes popular, the amount of energy consumed by its networks increases. Research is needed to find ways to reduce its environmental impact. As blockchain networks become complex, research is needed to assess their security and identify potential vulnerabilities. We present the future research agenda (FRA) based on the literature review and technical limitations.

FRA1: Although blockchain technology has a wide variety of potential applications in achieving multiple SDG Goals, more research is needed to explore and identify how it can contribute to achieving the Sustainable Development Goals (SDGs) least affected by blockchain technology like Goals 4 (Quality Education), 5 (Gender Equality), 6 (Clean Water and Sanitation), and 16(Peace, Justice). These goals are primarily independent of technology and require more direct interventions in areas such as policy reform, infrastructure development, and increased research investments.

FRA2: Future research should focus on exploring the potential of blockchain to enable more efficient data collection, storage, and sharing, as well as its potential to enable more efficient fundraising and resource allocation. Additionally, research should focus on exploring the potential of blockchain to enable more secure and transparent processes, as well as its potential to enable more secure and efficient collaboration between organizations. Finally, research should also focus on exploring the potential of blockchain to enable more secure and efficient payment systems, allowing organizations to more efficiently and securely allocate resources towards achieving the SDGs.

5. CONCLUSION

This paper combines science mapping and bibliometric analysis to explore the antecedents of blockchain technology research in achieving SDG 2030 Goals using the Scopus database with the help of VOSviewer and the R-Studio Bibliometrix tool. It draws the top productive journals, countries, institutions, authors, and network collaborations that all help identify the linkages in the blockchain technology field and reveal the foundational themes. The result indicated a growing trend of research publications; mainly, the United States, the UK, China, and India are the most productive and cited countries. The study also explores the growing trend of blockchain research among the journals and found that the "International Journal of Production Research" is the most productive in terms of total citations and top-cited documents that highlight the most influential titles. Moreover, Using factorial analysis (MCA), this study found that blockchain has been contributing to achieving SDG goals 1 (poverty), 2 (hunger), 8 (decent work), 9 (innovation), 10 (inequality), 11 (sustainable cities), 12 (responsible consumption and production), 13 (climate) and 17 (partnership). In contrast, it has not been able to expedite the achievement of Goals 4 (Quality Education), 5 (Gender Equality), 6 (Clean Water and Sanitation), and 16 (Peace,

Justice). Despite the potential of blockchain to contribute to the achievement of the SDGs, blockchain technology is still in its early stages of development. More research is needed to understand how it can be utilized to maximize its potential for achieving SDG Goals by 2030. However, future research can address some limitations of this study, even though it provides several valuable insights into blockchain technology for SDG. Future studies can apply the same methodology and focus on other industries harnessing a single dataset (Scopus, IEEE, and Web of Science) or a hybrid dataset (combination of Scopus, Dimension, Web of Science, etc.). This study has uncovered several avenues for future study.

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