Circular Economy and Digital Innovation Practices for Sustainability-A Bibliometric Analysis

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Abstract
Purpose: Circular economy (CE) and digital innovation (DI) are abstract ideas of sustainable development. After the declaration of the UN's sustainable development goals (SDGs) in 2015, research on CE, DI and sustainability has gained popularity among academia and researchers. This study seeks to present an in-depth examination and explanation of the status of existing literature in this field. Methodology: The data, 1684 documents were selected through scientific literature search from Scopus and Web of Science (WoS) for the period 2016-2023. Various bibliometric tools, biblioshiny and VOSviewer were used to analyze the gathered data for the descriptive and bibliometric analyses and to probe the research questions. Findings: From the bibliometric and content analysis, findings suggest that the development of current circularity and innovation practices leading to sustainability is steadily increasing with an extremely high annual growth rate (161.63%). About 96.67% of articles were published in the period (2020-2023), it infers that this is a trendy topic. Another finding implies that the topic has been pioneered by European countries, UK, Italy and Germany and has recently become prominence in China and India in developing economy. The data also shows that in wealthy nations, there is a significant author-country collaboration. Moreover, the result of co-occurrence analysis indicates that 'sustainability', 'circular economy', 'industry 4.0' and 'digitalization' are the emerging co-words in this field. So, the field is still new in the emerging economy. Practical Implications: The outcome of this paper will provide a helpful starting point for policymakers, academics and industrial people for making more informative decisions towards digitalization and sustainability in the circular economy environment. Research Limitations: The limitation of the study is that it cannot infer the generalized findings as it considers only two databases and English literature. Further

research can be done to explore and measure the quantitative assessment of circularity, sustainability, industry 4.0 and digitalization domain.

Keywords: Circularity, Sustainability, Content Analysis, Bibliometric and Systematic Review

Introduction
At the end 2050 the annual consumption and wastage of resources would be double and hence, the operation and production systems should be more sustainable (European Commission, 2020). The implementation of circular economy (CE) strategies and the utilization of digital innovation (DI) act as a transition to sustainability. These two terms have emerged as mostly cited keywords in the academia and industry after the declaration of the UN's sustainable development goals (SDGs) in 2015, as they can meet the most important challenges related to energy, resources, sustainability and climate-change risks. In recent years, global corporations, either in developed or in developing economies, have converted their operation and production processes to ecological and economical through design thinking and circular manufacturing strategies. The corporations also have adopted a restorative and regenerative industrial system called circular economy that is reducing waste, using renewable energy and less resources, and is placing the 'end of life' concept for creating long-term values and boosting sustainability (Rosa et al., 2020). In addition to this, CE demands environmental and economical legitimacy by changing the production and product designs (Trollman et al., 2022). According to the Ellen MacArthur Foundation (2015), the main aim of CE is to restore and regenerate resources to achieve the targets of SDGs (Acerbi et al., 2022). As a global economy model, CE gives a tremendous chance to assist address major global issues including the climate crisis, biodiversity loss, and environmental degradation in addition to providing direct economic benefits for businesses and societies. All the benefits of CE can be triggered through human-centric design and digital innovations. The digital innovations probably named as new digital technologies, that were transformed into business models after the industrial revolution 4.0. Thus, digitalization, the adoption of digital technologies can influence the business models and sustains the smart manufacturing (Ulrich & Fibitz, 2020). The innovative ideas and initiatives can be practical through the utilization of digital technologies. The implementation of digital technologies depends on the intention of impact investment. For adding social impact, they can create long-term values (Acciarini et al., 2022) and reduce the costs of operations by optimizing present model and increasing efficiency and quality of products (Ulrich & Fibitz, 2020). As the outcome of industry 4.0, the integration of circular economy strategies and digital technologies are the main driver of sustainability, and they have the reciprocal effect of overall performance (Rosa et al., 2020). Therefore, circular economy strategies are internal efforts, and digital innovations are external accomplishments towards corporations' sustainability. The study (Liu et al., 2022) advanced the synergies between CE strategies and the functions of digital technology, a means of sustainable production and consumption and a transition to circular economy. Thus, the ground of this present study is the keen interest of this triangular relationship among these new ideas and to explore the existing studies evaluating the nexus on the research domain of CE and digital practices leading to sustainability. Though the field is interesting, a few research is evidenced in this field to provide a bibliographic analysis of how this topic has emerged over time across the globe. This present study seeks to explore and evaluate the existing literature to gain a better insight on this topic and provide a direction of future research. By analyzing the metadata, the most prolific author, publication, productive sources have been identified and the contribution of top authors and countries have also been

investigated. A bibliometric review has been conducted to reveal the present, past and future direction of research on this topic by investigating documents collected from the databases. Here, co-words analysis has also been used to get the evaluation and development of this theme. A content analysis has been developed to validate the inferences from bibliometric analysis. Thus, the study has addressed the following research questions:

RQ1: What is the distribution of CE, DI and sustainability publications over the years?
RQ2: What are the topmost research elements in terms of productive journals, authors, countries, cited keywords in this field of study?
RQ3: What are the top cited papers in this field?
RQ4: What themes have been unveiled in the literature so far and how have they evolved over time?
The study is structured by following sections: the understanding the concepts is described in the section 2. The research criteria, data collection and methods are presented in section 3; The bibliographic results and network visualization are presented and discussed in section 4. The last section refers to the conclusions, limitations, and suggestions for further study.

Topic Conceptualization
The study is based on three main concepts circular economy, digital innovation and sustainability. The definition and understanding of these concepts are presented in the following sections:

Circular Economy
The first use of CE concept was revealed in 1940s through the words 'reuse' and 'exchange' of waste materials between industries (Rada, 2023), but first official use was evidenced in 2015 by the European Union for representing a more sustainable and efficient use of natural resources through an integrated model of industrial production, distribution and consumption. The CE concept can ensure a balanced economic growth with sustainability through its functions of reducing, reusing, and recycling focusing on creating closed-loop material flows (The Ellen MacArthur Foundation, 2013). Earlier, CE concept was built on the basic three principles such reuse, reduce and recycle as the opposite of take-make-dispose principles of linear economy. Over the years, this concept has evolved with many functions of CE and become a global economic model that aims at minimizing the usage of limited virgin resources. Circular economy is an economic system that accepts a new business model, which ensures the protection of resources, reduces the consumption of raw materials, and recovers the waste by repairing, refurbishing, recycling or giving it a second life as a new product for the benefits of present and prospective nations (Herrero-Luna et al., 2022).

A circular economy is a closed, regenerative economic model that prioritizes the environment while maximizing the use and reutilization of resources. However, a traditional linear economy is concerned with the production, consumption, and disposal of goods and materials. In contrast to the old linear economic system, where the high levels of waste are produced via the production of single-use products with little regard for other social or environmental issues, but the circular economy is free of waste.

According to the European Commission (2017), an economy refers to a circular economy, whose goal is to keep products, materials, and resources valuable for as long as possible by

reusing them in a production process while generating as little waste as feasible. A regenerative system slows, closes, and narrows material and energy loops to reduce resource input, waste, emissions, and energy leakage. Long-lasting design, maintenance and repair, reuse, remanufacturing, refurbishment, and recycling are employed to achieve this (Geissdoerfer et al., 2017).

Thus, circular economy is an "economic model that seeks to ultimately decouple global economic development from finite resource consumption," according to the Ellen MacArthur Foundation (EMF, 2015). The introduction of circular economy concept can ease the way of implementing sustainability practices with support of customers and government (Scarpellini et al., 2020) is closely related to sustainability (Korhonen et al., 2018; Larrinaga & Garcia-Torea, 2022). Presently, CE is described as waste and resource management-related activities, a tool that positively impacts many SDGs (Schroeder et al., 2019). Therefore, CE is the abstract idea of sustainable development (Kottmeyer, 2021).

Digital Innovation
Circular economy model thanks to digital innovation for the implementation of CE strategies leading to sustainable development. Without innovation, CE strategies are worthless as they cannot reduce the costs and consumption let alone the efficiency of finite resources. Innovation represents new ideas, systems, and processes that can change the people, societies, and planet for the social progress. This innovation can be impacted by technological tools, is known as digital innovation. These tools enable corporations to adopt sustainable strategies for the reduction of costs, increasing productivity and higher customer satisfaction (Dicuonzo et al., 2022). Szeto (2000), defines innovation as "a continuous improvement in the overall ability of the companies to generate innovation to develop new products to meet market needs". Digital innovation enhances overall sustainability. Sustainability related innovation is green innovation that promotes the sustainable success for an industry maintaining environmental benefits (Ghadimi et al.,2020). Thus, innovation refers to a change in process and a shifting to a new technology with the aim of achieving the targets of SDGs. Innovation integrates digital technologies in line with the vision of I4.0.

A business model should be innovative. Client's needs, new technologies, digitalization, environmental factors, market crisis, organizational learning and external stakeholders are the triggers of business innovation. According to Bashir, Naqshbandi, and Farooq (2020), organisations can innovate their business models through a combination of leadership, technology, culture, structure, and inertia. Innovation is a dynamic and multidimensional process that encompasses the creation, development, and application of new concepts, goods, services, or procedures that result in economic growth, societal progress, and technological advancements. Moreover, innovation is the key driver of product development (Varaniūtė et al., 2022). Kallmuenzer and Peters (2018), defined innovation "as a firm's will to innovate that represents the predisposition of a firm to contribute to the creation of new ideas, and to support the experiments and the creative processes that lead to the realization of new products or technological processes." The model, capacity and customers' need of the company can also change the product development process through the implementation of digital technologies or digitalization. Digitalization removes technical uncertainty; circularity removes the resource uncertainty and customers' needs remove the market uncertainty for sustainability practices. An innovative business model shall balance between the corporate

profits and the social benefits using digital technologies is called digital innovation. Furthermore, it might enhance the method in which all matters concerning the circular economy, sustainable development, energy transition, climate change, eco-innovations, and their operational business model are managed (Popescu et al., 2022). Thus, the core component of the circular economy is eco-innovation, which is defined as the introduction of novel concepts, items, procedures, or behaviours that help minimise environmental harm or meet sustainability goals that are ecologically specified (Triguero et al., 2022).

Sustainability
Everybody has empathy for sustainable development, but compassion for sustainability is more important for true sustainability practices than empathy. The lack of compassion for sustainability generates the dark side of sustainability in the form of greenwashing and window dressing sustainability (Gai, et al., 2023). In response to the compassionate responsibility, the global economy is becoming integrated (Haron et al., 2022) and the business firms are increasingly getting the global pressure for communicating sustainability-related performance. Sustainability refers to some environmental, social and economic well-being that ensures the quality of life for next generation, is not detrimental to the present nations (Dicuonzo et al., 2022).

Thus, the sustainability is the holistic approach of measuring firms' performance, which has resulted from the integrated thinking and strategic actions (innovation and circular economy practices) of corporate leaders following some important economic and ESG (environmental, social, and governance) indicators of sustainability-based activities. ESG scores are the acceptable evaluators of sustainability performance (Rajesh & Rajendran, 2019). The integration of ESG indicators into the operational and decision-making processes is essential for the evaluation of sustainability performance of corporations. Usually, corporations show sustainability-related information in their business reports for measuring the better business practices that can ensure the current and future benefits for the next generation, resilient society, and planet. Sustainability-related information can include many forms of information and approaches. Thus, sustainability is the communicative approach that identifies the sustainability-related risks and opportunities, provides information about business model, strategies, targets, and governance systems that can change the mindsets of professional accountants and corporations beyond financial reporting. (Bananuka et al., 2019) reported that sustainability information includes only non-financial information relating to ESG issues to the various stakeholders of an entity. However, the non-financial information-based sustainability reporting cannot measure the comprehensive performance of an entity to meet the information demand of global stakeholders since it excludes economic performance, which is the root of all performances. For meeting this demand, presently the corporations are highly motivated to drive for a comprehensive approach of reporting, which provides the qualitative and quantitative information to the all kinds of capital-providers that ensures the productive allocation of capitals and the values of the entity over the time through good governance. The good governance (accountability, transparency, fairness, and stewardship) for all capitals (IIRC 2021), such as financial, manufactured, human, intellectual, and social and relationship, and natural, can ensure the business performances namely, environmental, social, governance and economic performances through the circular economic practices with an innovative business model. The innovative business model can accept all capitals as input and circular economy activities as business activities and ensure financial stability and

sustainable development of the corporations by preserving and protecting nature. Thus, the true sustainability of a corporation depends on the relationships with economic resources, natural resources, environment, government, and local communities. These relationships significantly affect all economic activities that can save the resources for the next generations and can create sustainable values for the present stakeholders. In addition, sustainability is also required for the achievement of national SDGs. According to the global survey conducted by McKinsey in 2020, "sustainability endeavors often make good business sense, promising to deliver revenue gains, cost savings, and other benefits that lift business value". Thus, sustainability has changed the mindset of entrepreneurs and become a mainstream business practice.

Research Methodology
The first step for conducting bibliometric analysis is to select the database(s). The relevant documents or publications on the CE and digital innovation integrating sustainability are the main data for this study. In line with the researchers (Ayan et al., 2022; Zhu & Liu, 2020 and Echchakoui, 2020), this study has considered two top citation databases such as Scopus and WoS because they are more relevant and widely used databases for bibliometric and content analysis (Zhu & Liu, 2020; Caviggioli and Ughetto, 2019). For reviewing the extent of documents, the advanced search option of both databases was selected, and "title-abstract-keywords" option and "topic" related to relevant field option were selected for Scopus and WoS database respectively. The main three keywords to search the literature were taken from the title of the study and other sub-keywords synonymous for circular economy and digital innovation were extracted from the prior studies and chosen by artificial intelligence (AI). The Boolean operator (OR, AND) is used to narrow down the search results and asterisk (*) is used after the word 'sustainability' to capture all sustainability-related literature. The final search string of this study was as ((("Circular Economy" OR "Cradle-to-Cradle" OR "Closed-Loop System" OR "Resource Circularity" OR "Biomimicry" OR "Eco-Design") AND ("Digital Innovation*" OR " Digital Transformation" OR "Human-Centred Design" OR "Disruptive Technology") AND ("Sustainability*"))). Then the search results were refined by adopting some inclusion and exclusion criteria. The exclusion was made for language and year of publication i.e., publications other than English language and beyond the period (2016-2023) were excluded. The study has excluded the unexpired year '2024' and started from 2016 as CE Action Plan of EU and SDGs of UN were introduced in 2015. All open access articles and review articles (DOCTYPE) on the areas of business, environment and social science were included in the final search string. The detailed search strategy is exhibited in Figure 01. Finally, 1679 documents with all information were imported from the Scopus database in BibTex format and 38 publications with full records were extracted from the WoS database in plain text file. The necessary codes running in RStudio (Version 4.4.1) and Bibliometrix packages functions, two separate files were converted to single excel file and removed the duplication of publications from the datasets. At last, 1684 documents have been considered for bibliometric analysis after taking cleaning procedure.
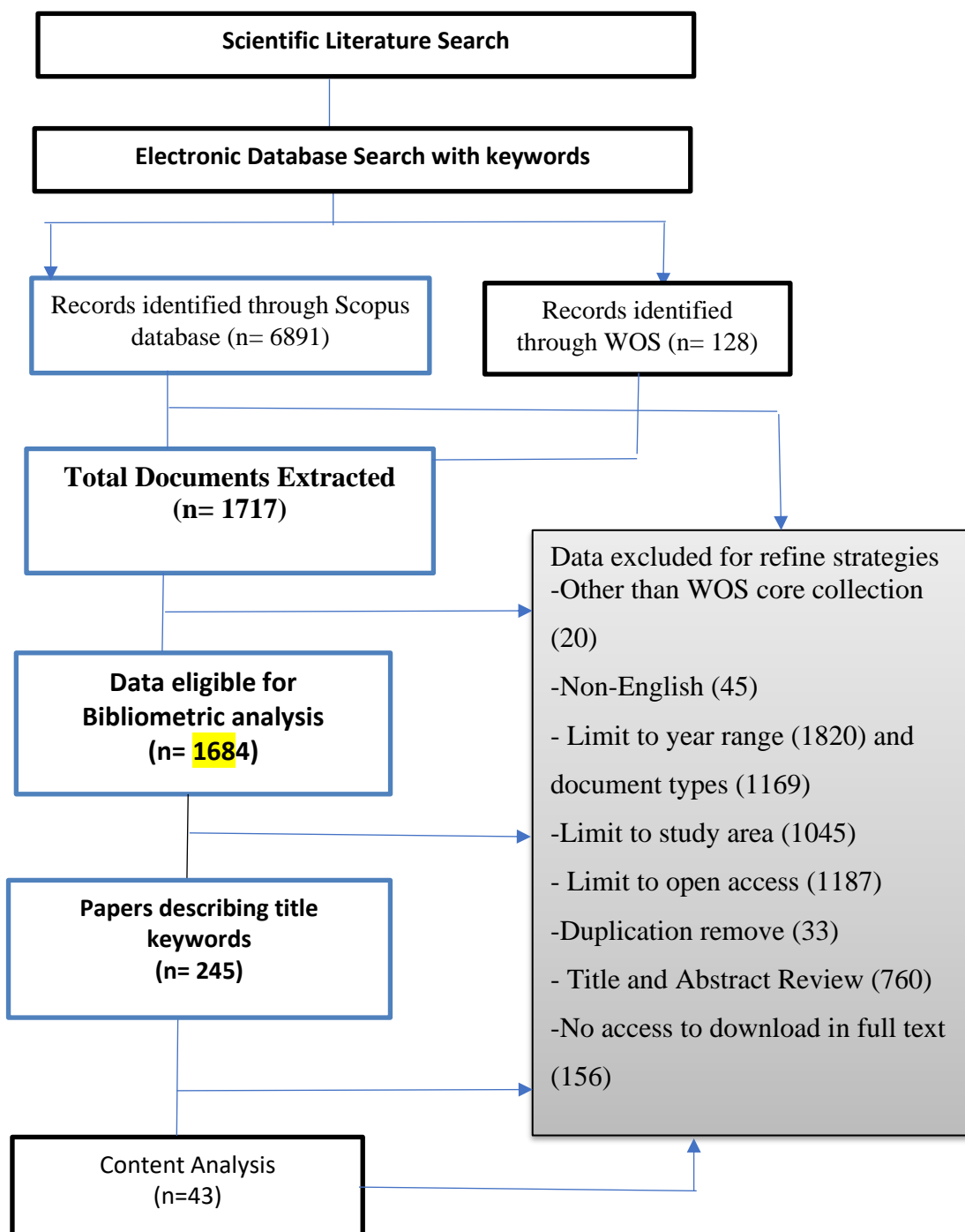
Figure 01: Search Strategy

Results and Analysis

The following results are obtained by bibliometric and content analysis through Biblioshiny R packages and VOSviewer:

Overview

The main information about the dataset is presented in table 01. During the period 2016-2023, a total of 5165 authors have produced a total of 1684 publications with 4775

keywords and the annual growth rate is 161.63%. Two types of publications (articles and review) were extracted from the different journals (423) for bibliometric analysis.

Table 01
Main Information about Data

Description	Results
Timespan	2016:2023
Sources	423
Documents	1684
Annual Growth Rate %	161.63
Average citations per document	24
Author's Keywords (DE)	4775
Authors	5165
Authors of single-authored document	107
Document Types:	
Article	1471
Review article	213

Publication Trends

Figure 02 represents publications from the period 2016-2023 in the research domain of circular economy, digital innovation and sustainability. An increasing trend of publications is observed over the period. About 3.33% (56/1684) of papers were published in the period 2016-2019 and 96.67% of articles were published in the period (2020-2023). The upward trend of publication indicates that the recent publication is extremely high. In 2016, the number of publications was only 01. It implies that the field is exclusively new and further research is needed in this research domain.
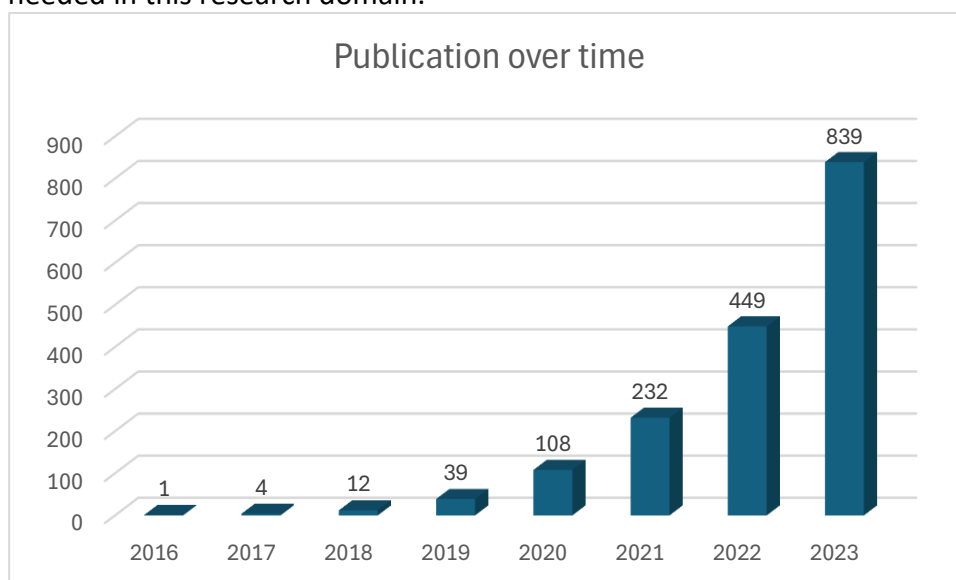

Figure 02: Publication trend on CE, DI and Sustainability research field

The Three-Field Analysis

The Biblioshiny's Three-field analysis was run to create Sankey diagram, which represents the relationship among research components i.e., keywords, authors, affiliations, journals, countries, etc. The size of the rectangles expresses the extent of relationships among

research components. Figure 03 shows relationships of top 20 countries (left), institutions (middle) and authors (right). It indicates that the strongest relationship between a country and its affiliation belongs to United Kingdom, followed by Italy. It is also evident that the London Metropolitan University is receiving the most collaborative flows from countries India, USA and Australia as well as from the authors Kumer, Agrawal and Luthra.
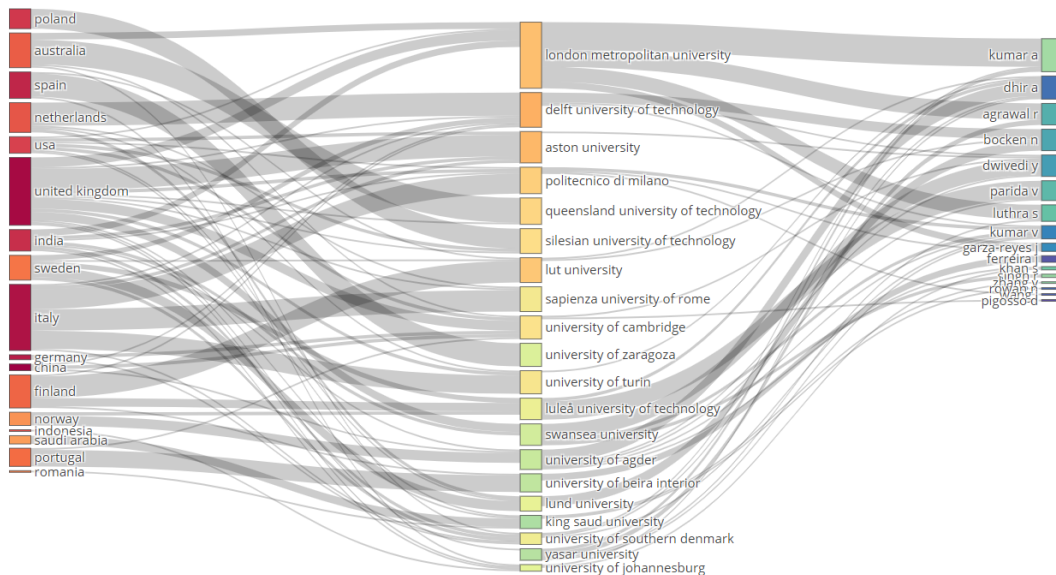

Figure 03: Three-field analysis of country, affiliation and author

Sources Analysis

A total of 1684 publications were published in the 423 journals (sources). Among the total sources, the top ten journals have 807 publications and are contributing 47.92% of total documents. Table 2 lists the most contributory journals that have been publishing articles on the field of CE, DI and sustainability over the year 2016 to 2023. The 'Sustainability (Switzerland)' is the most popular and active journal which has been contributing more to achieving sustainability practices leading to sustainability development goals (SDGs), followed by the Journal of Cleaner Production and Technological Forecasting and Social Change Journal. Therefore, Sustainability (Switzerland) Journal is the top source title among the 423 source titles that is sharing 32.01 percent contribution for CE-innovation and sustainability domain.

Table 02
List of Top Ten Journals

Serial No.	Sources	Articles	Publisher	Country
1	Sustainability (Switzerland)	539	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland
2	Journal of Cleaner Production	61	Elsevier Inc.	UK
3	Technological Forecasting and Social Change	52	Elsevier Inc.	USA
4	Business Strategy and the Environment	30	John Wiley and Sons Ltd	UK
5	Journal of Open Innovation: Technology, Market, and Complexity	26	Elsevier B.V.	Switzerland
6	International Journal of Environmental Research and Public Health	23	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland
7	Sustainable Production and Consumption	21	Elsevier B.V.	Netherlands
8	Journal of Business Research	19	Elsevier Inc.	USA
9	Operations Management Research	19	Springer New York	USA
10	Environmental Science and Pollution Research	17	Springer	Germany

Most Prolific Authors
Figure 04 represents the productivity of authors over the period. Many scholars have used productivity to measure the total number of periodic publications by an author and the authors' impact refers to the number of citations received per year (Forliano et al., 2021; Talukder &Lakner, 2023). The bigger the circle implies the more articles published by the author in a year and the darker the circle means the more citations received per year. It is evident that Ghobakhloo and Luthra have the longest timeline covering the study period but considering the circle size and the color density of circle, Kumar has the highest number of publications, while Ghobakhloo has the highest number of citations per year with a series of publications except COVID-19.
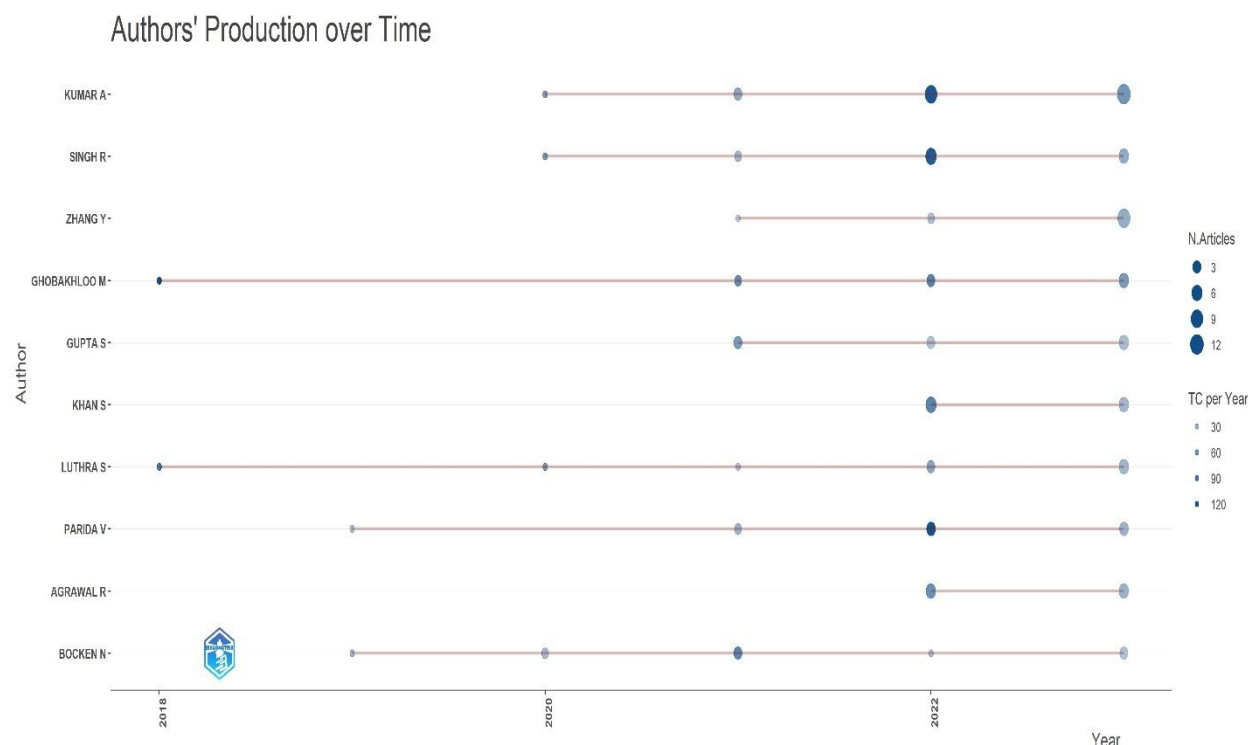
Figure 4. Top authors' production over time.

The author's productivity can also be assessed by the h-index and m-index (Forliano et al., 2021), TP, TC and PY_start (Syed, Singh & Spicer, 2023). By considering all indicators (except citation) of productivity, the author 'Kumar' leads to this table with 25 publications and 837 citations, followed by Shingh with 15 publications and 742 citations. Dwivedi has the highest citations (1765) but shares the third spot because of h-index and m-index. The h-index of Kumer is 14 which means that he has 14 publications at least 14 citations. The h-index depends on the timeline of output, while m-index depends on the activity period of a particular author. Therefore, the m-index provides an opportunity for young scholars to be the most prolific authors.

Table 03
Top Ten Productive Authors by Number of Publications (NP)

Author	h_index	g_index	m_index	TC	NP	PY_start
Kumar a	14	25	2.8	837	25	2020
Singh r	11	15	2.2	742	15	2020
Dwivedi y	10	10	2	1765	10	2020
Ghobakhloo m	10	11	1.429	1427	11	2018
Parida v	10	11	1.667	592	11	2019
Iranmanesh m	9	10	1.8	570	10	2020
Bocken n	8	10	1.333	571	10	2019
Khan s	8	11	2.667	254	11	2022
Agrawal r	7	10	2.333	224	10	2022
Dhir a	7	8	1.75	446	8	2021

TC= total number of citations and PY_start=the year of first publication

Most Influential Articles

The citation is the influencing determinant of an article (Bornmann & Daniel, 2007) whether it is impactful or not. The more citations indicate the more impact of an article on the specific field of research. Citations refers to the percentage of utilization by the other publication (Di Vaio et al., 2023). Table 4 displays the top cited 20 documents from the total 1684 documents of our data set based on the total citations. A paper published in 2018 by Ghobakhloo has the highest citations (864), followed by the publication of Dwivedi, et al. and Geissdoerfer, Vladimirova & Evans. Based on average citation, the publication of Dwivedi is considered as the most influential publication on this research domain. The findings suggest a true avenue for future research.

Table 04
Top 20 most cited publications

	Title	Source	Year	TC	C/y
Ghobakhloo m	The future of manufacturing industry a strategic roadmap toward industry 4.0	Journal of manufacturing technology management	2018	864	123.429
Dwivedi y, et al.	Metaverse beyond the hype multidisciplinary perspectives on emerging challenges opportunities and agenda for research practice and policy	International journal of information management	2022	796	265.333
Geissdoerfer m;vladimirova d;evans s	Sustainable business model innovation a review	Journal of cleaner production	2018	738	105.429
Dutta p;choi t;somani s;butala r	Blockchain technology in supply chain operations applications challenges and research opportunities	Transportation research part e: logistics and transportation review	2020	682	136.4
Klerkx l;jakku e;labarthe p	A review of social science on digital agriculture smart farming and agriculture 4.0 new contributions and a future research agenda	Njas - wageningen journal of life sciences	2019	632	105.333
Luthra s;mangla s	Evaluating challenges to industry 4.0 initiatives for supply chain sustainability in emerging economies	Process safety and environmental protection	2018	585	83.571
Ceschin f;gaziulusoy i	Evolution of design for sustainability from product design to design for system innovations and transitions	Design studies	2016	500	55.556
Farooque m;zhang	Circular supply chain management a definition and structured literature review	Journal of cleaner production	2019	418	69.667

a;thürer m;qu t;huisingh d					
Kouhizadeh m;sarkis j	Blockchain practices potentials and perspectives in greening supply chains	Sustainability (switzerland)	2017	399	57
Rosa p;sassanelli c;urbinati a;chiaroni d;terzi s	Assessing relations between circular economy and industry 4.0 a systematic literature review	International journal of production research	2017	389	77.8
Piccarozzi m;aquilani b;gatti c	Industry 4.0 in management studies a systematic literature review	Sustainability (switzerland)	2018	364	52
Bonilla s;silva h;da s m;gonçalves r;sacomano j	Industry 4.0 and sustainability implications a scenario-based analysis of the impacts and challenges	Sustainability (switzerland)	2018	352	50.286
Despeisse m, et al.	Unlocking value for a circular economy through 3d printing a research agenda	Technological forecasting and social change	2017	339	42.375
Mondejar m, et al.	Digitalization to achieve sustainable development goals steps towards a smart green planet	Science of the total environment	2021	322	80.5
Dwivedi y, et al.	Climate change and cop26 are digital technologies and information management part of the problem or the solution an editorial reflection and call to action	International journal of information management	2022	272	90.667
Hartley k;van s r;kirchherr j	Policies for transitioning towards a circular economy expectation from the European union EU	Resources, conservation and recycling	2020	269	53.8
Oláh j et at.	Impact of industry 4.0 on environmental sustainability corporate social responsibility in agribusiness climate related empirical findings from Hungary	Sustainability (switzerland) environment, development and sustainability	2020	265	53
Kumar r; singh r;dwivedi y	Application of industry 4.0 technologies in SMES for ethical and sustainable operations analysis of challenges	Journal of cleaner production	2020	262	52.4

| Luthra s;kumar a;zavadskas e;mangla s;garza-reyes j | Industry 4.0 as an enabler of sustainability diffusion in supply chain an analysis of influential strength of drivers in an emerging economy | International journal of production research | 2020 | 250 | 50 |
| Kerin m;pham d | A review of emerging industry 4.0 technologies in remanufacturing | Journal of cleaner production | 2019 | 246 | 41 |

Publication by Country

Figure 5 displays the contribution of the top 20 nations in terms of publications on the field of CE-DI and sustainability. Our data set shows that a total of 79 nations have the contribution to publish 1684 documents on the field. The leading nation in terms of publishing paper in the different journals is China with 154 publications, followed by UK (153 papers) and Italy (138 papers). This information confirms that the hub of the research on this topic is China, the UK and Italy. Intriguingly, this concept is highly researched in the developed nations than the developing nations. Only 03 countries i.e., China, India and Indonesia fall in the top 20 nation's list. Therefore, China from developing nation is actively engage in the research on circular economy, digital innovation and sustainability.
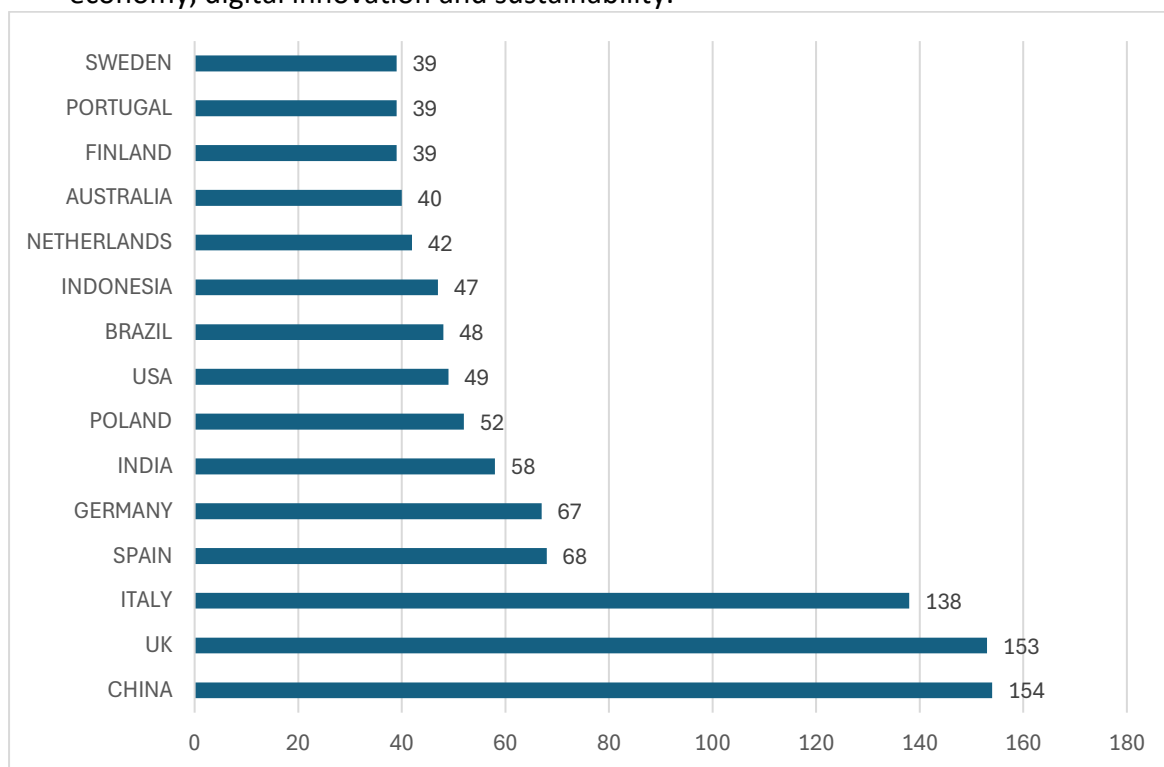

Figure 05: Top 20 nation's production in the research domain

Keywords Co-Occurrence Analysis

Co-occurrence analysis is a content analysis that measures the degree of relationship between the ideas represented by those keywords. It also measures how often a given keyword appears in the same paper. A conceptual framework for future study is developed based on the co-word analysis. Figure 6 exhibits the relationship between the keywords. The distance of the keyword measures the degree of relationship among the keywords. The words 'sustainability', 'circular economy' and 'digitalization' are displayed on the core of the map.

All the nearest keywords are related to digitalization and sustainability, whereas the keywords 'innovation' is very far from the centre of the map. The size of the node measures the frequency of keywords used in the publication and the thickness of the line represents the connecting relation between two keywords. Fig. 6 shows 'sustainability', 'circular economy', 'industry 4.0' and 'digitalization' have the larger nodes and thick lines. Hence, there is a strong relation among these keywords with high frequency.
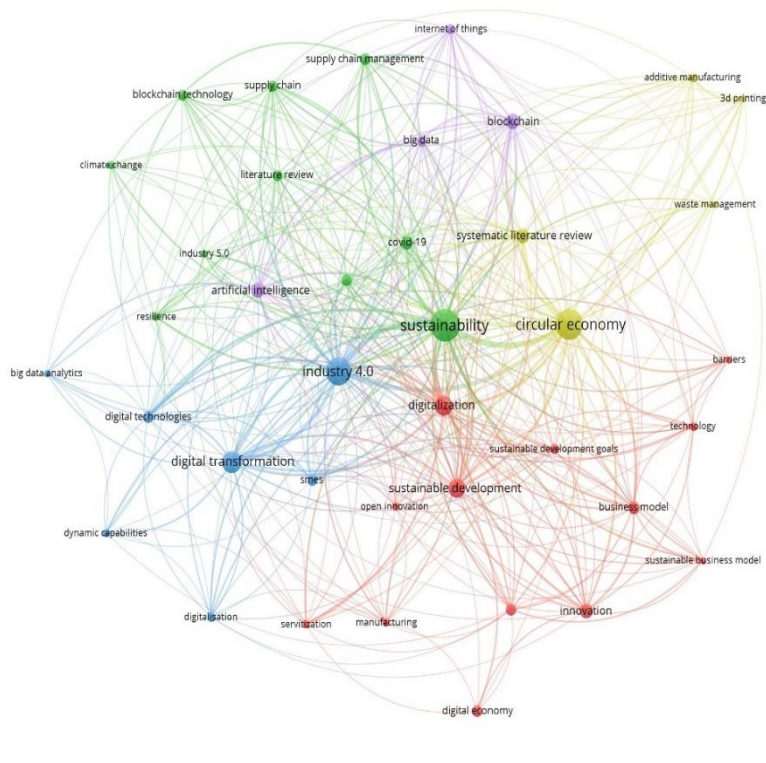

Figure 06: Network visualization of co-occurrence-author keywords

In addition, Figure 6 shows that there are five main clusters, each of which contains its own unique combination of keywords in a specified color. Table 5 indicates the total number of items, color and theme of each cluster indicating that substantial progress has been made in the study of CE, DI and sustainability. The degree to which keywords tend to group together is taken as an indication of how frequently they express similar ideas.

Table 5

Clusters of Keywords and Themes

Clusters	Number of Keywords	Keywords	Color in Visualization map and Theme
Cluster 1	13	Barriers, Business Model, Business Model Innovation, Digital Economy, Digitalization, Innovation, Manufacturing, Open Innovation, Servitization, Sustainable Business Model, Sustainable Development, Sustainable Development Goals, Technology	Red "Innovative Business Model, Digitalization and SDGs"
Cluster 2	10	Bibliometric Analysis, Blockchain Technology, Climate Change, Covid-19, Industry 5.0, Literature Review, Resilience, Supply Chain, Supply Chain Management, Sustainability	Green "Blockchain, Supply Chain, Management and Sustainability"
Cluster 3	5	Big Data Analytics, Digital Technologies, Digital Transformation, Dynamic Capabilities, SMES	Blue "Digital transformation, Industry 4.0 and SMEs' Sustainability"
Cluster 4	6	3d Printing, Additive Manufacturing, Circular Economy Industry 4.0, Systematic Literature Review, Waste Management	Yellow "Circular Economy and Sustainability"
Cluster 5	4	Artificial intelligence, Big data, Blockchain Internet of things	Purple "Artificial intelligence and sustainability"

Manual Content Analysis

From the content analysis of 43 papers, it is evident that most of papers are quantitative in nature and follows the mix methods of analysis. Only a few scholars have conducted bibliometric and content analysis at a time. The review of prior studies has been conducted by the systematic, structured, narrative and critical literature review process. The study identified that the focused of the papers was on the "Innovative Business Model, Digitalization and SDGs", "Blockchain, Supply Chain, Management and Sustainability", "Digital

transformation, Industry 4.0 and SMEs", "Circular Economy and Sustainability" and "Artificial intelligence and sustainability". the focus area of study and the key references are presented in the table 07.

Table 06
Synthesis of Literature Review

Research Approach and Technique	Key References
Quantitative method	(Hettiarachchi et al., 2022); (Ogrean, 2023); (Ada et al., 2023); (Minashkina & Happonen, 2023); Chatzistamoulou, 2023); (Huy & Phuc, 2023); (Ulrich & Fibitz, 2020); (Boffa et al., 2023); (Manea et al., 2021); (De Giovanni, 2022); and (Dicuonzo et al., 2022)
Qualitative method	(Herrero-Luna et al., 2022); (Gatell & Avella, 2024); (Acciarini et al., 2022); (Ly, 2021) and (Perotti et al., 2023)
Mix method	(Acerbi et al., 2022); (Kottmeyer, 2021); (Hoang et al., 2023); (Rosa et al., 2020); (Ayan et al., 2022); (Caiado et al., 2023),;(Ivanova & Shkrobot, 2023); (Liu et al., 2022; (Jamwal et al., 2022); (Florek-Paszkowska et al., 2021); (Bui et al., 2020); (Abdelkafi et al., 2023); (Rodrigues et al., 2023); (Lopes, 2022); (Ferrigno et al., 2023); (de Bem Machado et al., 2022); (Dos Santos & Campos, 2021); (Ahmadov et al., 2023);(Pan et al., 2023); (Jin & Shin, 2021); (Sjödin et al., 2023); (Trollman et al., 2022) and (Turek et al., 2023)
Content Analysis	(Liu et al., 2022); (Lopes, 2022); (Dos Santos & Campos, 2021); (Ahmadov et al., 2023); (Ada et al., 2023); and (Caiado et al., 2023)
Bibliometric Analysis	(Ivanova & Shkrobot, 2023); (Hoang et al., 2023); (Ayan et al., 2022); (Bui et al., 2020); (Ogrean, 2023); and (Pan et al., 2023)
Content and bibliometric analysis	(Rosa et al., 2020); (Ayan et al., 2022); and (Ferrigno et al., 2023)
SLR	(Gatell & Avella, 2024); (Acerbi et al., 2022); (Liu et al., 2022); (Jamwal et al., 2022); (Rosa et al., 2020); (Ayan et al., 2022); (Herrero-Luna et al., 2022); (Rodrigues et al., 2023); (Lopes, 2022); (Hettiarachchi et al., 2022) and (Dos Santos & Campos, 2021); (Ahmadov et al., 2023); (Ada et al., 2023); and (Minashkina & Happonen, 2023)

Cluster	Key References	Focus Area
Cluster 1	(Ivanova & Shkrobot, 2023); (Ada et al., 2023); (Herrero-Luna et al., 2022); (Ulrich & Fibitz, 2020); (Acciarini et al., 2022); (Manea et al., 2021); (Kottmeyer, 2021); (Perotti et al., 2023) and (Dicuonzo et al., 2022)	"Innovative Business Model, Digitalization and SDGs"
Cluster 2	(Caiado et al., 2023); (Jamwal et al., 2022); (Ayan et al., 2022); (Abdelkafi et al., 2023); (Bui et al., 2020); (Trollman et al., 2022); (Huy & Phuc, 2023); (Boffa et al., 2023); (Ly, 2021) and (De Giovanni, 2022)	"Blockchain, Supply Chain, Management and Sustainability"
Cluster 3	(Lopes, 2022); (Hettiarachchi et al., 2022); (de Bem Machado et al., 2022); (Jin & Shin, 2021) and (Acerbi et al., 2022)	"Digital transformation, Industry 4.0 and SMEs"
Cluster 4	(Gatell & Avella, 2024); (Liu et al., 2022) and (Rosa et al., 2020)	"Circular Economy and Sustainability"
Cluster 5	(Ferrigno et al., 2023); (Ogrean, 2023); (Dos Santos & Campos, 2021); (Sjödin et al., 2023); and (Turek et al., 2023)	"Artificial intelligence and sustainability"

Conclusions, Implications, Limitations, And Future Research

For achieving the sustainable development goals, the transition to low carbon economy, the restoration of the ecosystem and the environmental balance are necessary. Present research on the circular economy, digital innovation and sustainability can play a vital role in achieving the SDGs. This study has investigated the current knowledge on the problem 'circular economy and digital innovation-based sustainability' and analyzed the role of scholars in this field in achieving SDGs of their homelands. The procedure of scientific literature review has employed to gain the understanding of the present problem and find the literature gap on this issue. The descriptive and biographical information of 1684 articles were extracted from the Scopus and Web of Science (WoS) databases, are reviewed to achieve these objectives. The tabular, graphical and bibliometric analyses are conducted by two software packages, Bibliometric R and VOSviewer to draw a conclusion about the present status of research on the current field. The evolution of publications in this field is growing up since 2020. About 96.67% of publications were published in the period (2020-2023). The upward trend of publication indicates that the recent publication is extremely high. In 2016, the number of publications was only 01. It implies that the field is exclusively new and further research is needed in this research domain. It is also evident from the Three-field analysis of country, affiliation and author collaboration indicates that the London Metropolitan University is receiving the most collaborative flows from countries India, USA and Australia as well as from the authors Kumer, Agrawal and Luthra. The results of this study include a detailed list of impactful authors, countries, journals and publications. Sustainability (Switzerland) Journal is the most productive journal, followed by the Journal of Cleaner Production, and Technological Forecasting and Social Change Journal. A paper titled "The future of manufacturing industry a strategic roadmap toward industry 4.0" published in 2018 by Ghobakhloo is the most cited (864) publication while the author, Dwivedi has the highest citations (1765). By considering

all indicators i.e., h-index and m-index (except citation) of productivity, the author 'Kumar' leads to this table with 25 publications and 837 citations, followed by Shingh with 15 publications and 742 citations. The co-occurrence of visualization map indicates that words 'sustainability', 'circular economy' and 'digitalization' are displayed on the core of the map and refers to the future publication of emerging field of research. Though the present topic is mature enough in developed countries and have a great interest in this field, the circular economy, digital innovation and sustainability research in the developing economy is still in the conceptual stage. Interestingly, the databases do not show any document on this field in context of Bangladesh. Thus, the study will contribute to both theory and practice by providing a helpful starting point for the variant of stakeholders in connecting CE and digital innovative sustainability. The present findings may be different if the more databases, the documents of non-English languages and areas are considered. Further research needs to consider the quantitative synergies among circular economy, digital innovation and sustainability.

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