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GREEN ECONOMY AND CIRCULAR ECONOMY NEXUS: A BIBLIOMETRIC REVIUW OF DIGITAL TRANSFORMATION AND SUSTAINABILITY RESEARCH

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Abstract:
This study examines the nexus between the green economy and the circular economy within the evolving landscape of digital transformation and sustainability research. The growing urgency of addressing environmental degradation, resource scarcity, and economic resilience has positioned both concepts as central frameworks in achieving sustainable development. However, the rapid expansion of digital technologies has generated a fragmented yet increasingly interconnected body of literature that requires systematic synthesis. This research aims to map and analyze the intellectual structure, key trends, and emerging themes in this interdisciplinary field using a bibliometric approach. Data were collected from a reputable academic database within a defined publication period and analyzed through co-authorship, keyword co-occurrence, and bibliographic coupling techniques to identify influential contributors, collaboration patterns, and thematic developments. The findings reveal a significant convergence between green and circular economy studies, largely driven by digital innovations such as artificial intelligence, big data analytics, and the Internet of Things, which enhance resource efficiency, waste reduction, and sustainable production systems. Additionally, the study identifies emerging research clusters focusing on digitally enabled circular business models, smart sustainability systems, and policy frameworks that support green transitions. Despite these advancements, gaps remain in integrating digital transformation strategies with inclusive and scalable sustainability practices. This study provides a comprehensive overview of the research landscape and offers insights for future interdisciplinary studies, contributing to the advancement of sustainable economic systems in the digital era.
Keywords: Green Economy, Circular Economy, Digital Transformation, Sustainability, Bibliometric Analysis

Abstrak :
Studi ini meneliti hubungan antara ekonomi hijau dan ekonomi sirkular dalam lanskap transformasi digital dan penelitian keberlanjutan yang berkembang. Meningkatnya urgensi untuk mengatasi degradasi lingkungan, kelangkaan sumber daya, dan ketahanan ekonomi telah memposisikan kedua konsep tersebut sebagai kerangka kerja sentral dalam mencapai pembangunan berkelanjutan. Namun, ekspansi teknologi digital yang cepat telah menghasilkan literatur yang terfragmentasi namun semakin saling berhubungan yang membutuhkan sintesis sistematis. Penelitian ini bertujuan untuk memetakan dan menganalisis struktur intelektual, tren utama, dan tema-tema yang muncul di bidang interdisipliner ini dengan menggunakan pendekatan bibliometrik. Data dikumpulkan dari database akademik terkemuka dalam periode publikasi yang ditentukan dan dianalisis melalui kepenulisan bersama, kemunculan bersama kata kunci, dan teknik kopling bibliografi untuk mengidentifikasi kontributor yang berpengaruh, pola kolaborasi, dan perkembangan tematik. Temuan ini mengungkapkan konvergensi yang signifikan antara studi ekonomi hijau dan sirkular, sebagian besar didorong oleh inovasi digital seperti kecerdasan buatan, analitik data besar, dan Internet of Things, yang meningkatkan efisiensi sumber daya, pengurangan limbah, dan sistem produksi berkelanjutan. Selain itu, studi ini mengidentifikasi klaster penelitian yang muncul yang berfokus pada model bisnis sirkular yang diaktifkan secara digital, sistem keberlanjutan cerdas, dan kerangka kebijakan yang mendukung transisi hijau. Terlepas dari kemajuan ini, kesenjangan tetap ada dalam mengintegrasikan strategi transformasi digital dengan praktik keberlanjutan yang inklusif dan terukur. Studi ini memberikan gambaran komprehensif tentang lanskap penelitian dan menawarkan wawasan untuk studi interdisipliner di masa depan, berkontribusi pada kemajuan sistem ekonomi berkelanjutan di era digital.
Kata Kunci: Ekonomi Hijau, Ekonomi Sirkular, Transformasi Digital, Keberlanjutan, Analisis Bibliometrik

1. Introduction

The paradigm of global economic development is undergoing a crucial shift from an exploitative conventional linear model to an orientation that integrates environmental sustainability through the concepts of Green Economy and Circular Economy. The conceptual nexus between these two approaches is a crucial focus in contemporary academic discourse, given the urgency of reducing ecological degradation without sacrificing macro-well-being growth. Nevertheless, in the theoretical realm there is still significant ambiguity about how the epistemological boundaries of these two concepts intersect or overlap each other. A polarization of thought is emerging among experts, with some viewing the circular economy as merely an operational instrument of the green economy, while others assert that the two have different ontological roots in viewing the limits of growth. This lack of clarity of theoretical integration fuels fragmentation in the literature, making it difficult to formulate a holistic framework to support the global sustainable development agenda(Kirchherr, Hartley, et al., 2023).

These conceptual tensions are further complicated by the acceleration of the rapidly evolving dynamics of digital transformation in the modern industrial landscape. The integration of digital technologies, such as Artificial Intelligence (AI), Internet of Things (IoT), and Big Data analytics, is theoretically projected as a key catalyst capable of optimizing resource efficiency and facilitating the transition to a circular system. However, the current literature shows that there are inconsistencies and unresolved paradoxes regarding the real impact of digitalization on sustainability. On the one hand, digitalization is recognized to increase supply chain transparency and minimize production waste, but on the other hand, the adoption of this massive technology triggers a massive surge in energy consumption and produces negative externalities in the form of new electronic waste (e-waste) that is difficult to decompose. This uncertainty of impact reflects the limitations of dominant theories that tend to assume a positive linear relationship between technological innovation and environmental sustainability (Parida et al., 2023).

Empirically, the urgency to bridge this discourse on sustainability and digital transformation is reinforced by global ecological performance data showing alarming trends. Global scientific reports confirm that extractive-based industrial activities have triggered the accumulation of global carbon dioxide (CO2) emissions that touched a new record high of 37.4 billion tons, with the manufacturing and conventional energy sectors being the main contributors. In addition, the level of global material circularity has actually decreased alarmingly, from what was previously at 9.1% and now it has declined to only 7.2% of materials that have been successfully reabsorbed into the production cycle. This data contradiction shows that in the midst of massive corporate campaigns on digitalization and green efficiency, the rate of real natural resource extraction still exceeds the regeneration capacity of planet earth (Wahyudi, 2023).

Another gap identified in current state of the art research is the presence of contextual and methodological biases in the literature exploring the relationship between digital transformation and sustainability research. The majority of previous studies tend to focus on micro-scale empirical analysis or sector-specific case studies, thus failing to comprehensively capture the map of macro thinking and knowledge evolution. In addition, there are conceptual inconsistencies in defining the extent to which digital technology can act as an enabler for the circular economy without obscuring the principles of social justice contained in the green economy. This methodological limitation in synthesizing fragmented literature has led to biased and difficult to map the direction of global research development, which in turn hinders academic consensus on the roadmap of technology-environment integration (Blomsma et al., 2023).

The uncertainty of this research direction is exacerbated by the limitations of dominant management and economic theories, such as Resource-Based View (RBV) or Ecological Modernization Theory, which are considered less adaptive in responding to multidimensional digital disruptions. Ecological modernization theory, for example, is often criticized for being overly optimistic about technological solutions without considering the economic rebound effect that has the potential to neutralize the positive impact of green efficiency. As a result, there is a void of conceptual frameworks that are able to integrate the dynamics of digital disruption into circular and green economy governance simultaneously. These unanswered conceptual issues trigger the urgent need for an evaluative study capable of uncovering the intellectual structures, clusters of thought, and future trends of this multidisciplinary interaction (Kanda et al., 2023).

In an effort to fill these theoretical and methodological gaps, the visual mapping-based bibliometric review approach becomes a crucial methodological instrument to reconstruct the scientific trajectory of this nexus. Through bibliometric analysis, the widespread accumulation of literature can be objectively deconstructed in order to identify intellectual structures, networks of collaboration between researchers, and conceptual evolutions that occur over time. This approach allows the detection of

research areas that have been saturated while revealing research gaps in the domains of digital transformation and sustainability research. This macro evaluation of the global bibliography is a strategic foothold to direct future academic focus and formulate a new paradigm that synergizes digitalization with systemic circular sustainability (Donthu et al., 2021).

2. Literature Review

The conceptualization of Green Economy and Circular Economy is often used overlapping in public policy, but in the theoretical realm they have different epistemological roots. The green economy focuses on a broader macro umbrella, encompassing aspects of social justice, poverty alleviation, and systemic environmental risk reduction. In contrast, the circular economy develops from the realm of industrial ecology that specifically emphasizes on closed material cycles, waste reduction, and product value retention for as long as possible in the supply chain. Theoretical tensions arise when academics attempt to bring these two concepts together; Some view the circular economy as just a technical sub-component to achieving a green economy, while others argue that the emphasis of circularity on material efficiency often ignores the dimension of social justice that is a key pillar of the green economy(Kirchherr, Reike, et al., 2023).

The integration of fourth wave digital technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Blockchain, and Big Data Analytics is theoretically positioned as the main accelerator of this circular transition. This technology enables real-time tracking of product lifecycles, predictive maintenance optimization, and the creation of new service-based business models (product-service systems). However, the contemporary literature detects the existence of a green digitalization paradox that triggers inconsistencies in empirical findings. On the one hand, digital adoption has been proven to reduce operational inefficiencies and sectoral emissions, but on the other hand, massive digital infrastructure has actually increased fossil energy consumption in aggregate and triggered a new e-waste crisis. These inconsistencies show that digital transformation is not automatically linear with the achievement of ecological sustainability(Lase et al., 2024).

A review of the environmental management and economics literature shows that there are limitations to conventional theories such as Resource-Based View (RBV) and Ecological Modernization Theory in explaining this phenomenon of digital disruption. Conventional RBV theory has been criticized for focusing too much on the company's internal capabilities to achieve a competitive advantage, stuttering when it comes to explaining a circular ecosystem that requires collaboration between organizations mediated by digital platforms. Meanwhile, Ecological Modernization Theory often gets caught up in overly optimistic technocentrism, assuming that any technological innovation will always bring environmental improvement. This theory fails to anticipate the impact of the rebound effect, where the cost efficiency generated by digital technology actually triggers an increase in production volume and overall material consumption(Kanda et al., 2023).

A critical evaluation of the state of the art research in this area ultimately reveals significant contextual biases and methodological gaps. Most previous research has been dominated by micro-scale empirical case studies, focusing on specific industrial sectors in developed countries, or speculative conceptual analysis. As a result, there has been tremendous fragmentation of the literature, where findings from one sector are difficult to generalize to form a solid macro framework. In addition, there is a methodological scarcity in terms of a comprehensive and objective synthesis of literature; The traditional literature review approach is considered vulnerable to the subjectivity bias of researchers and is less able to visually map the intellectual structure and evolution trends of global knowledge from digital-green integration (Blomsma et al., 2023).

In order to overcome these methodological limitations and conceptual fragmentation, the bibliometric analysis and visual mapping approach (science mapping) is present as a very crucial evaluative instrument. This methodology allows for the objective deconstruction of thousands of scientific articles from global databases to identify citation networks, clusters of hidden thoughts (co-citation), and the evolution of key terms (co-word analysis). Through bibliometric analysis, researchers can shift the focus from micro-narrative analysis to macro-structural mapping. This systematic approach is not only effective in detecting research areas that have experienced academic saturation, but also becomes a strategic instrument to uncover future research directions that connect digital transformation with the circular and green economy agenda holistically (Septiana et al., 2024).

3. Research Methods

3.1. Object, time and Place

The object of this research is the conceptual phenomenon and intellectual structure of global academic discourse that examines the nexus between Green Economy and Circular Economy in the

context of digital transformation and sustainability research. The phenomenon is deconstructed through an analysis unit in the form of metadata of internationally reputable scientific article publications that record the development of literature on related themes. The time of the research is strictly limited to the publication of documents published in the last three years, from 2023 to 2026, in order to capture the latest state of the art and accurately identify shifts in scientific focus. Given that this study applies a qualitative descriptive approach based on a secondary bibliometric review, the specific location of the research does not refer to physical geographical boundaries or specific territorial areas, but rather relies on digital space through access to indexed global scientific databases operated from the researcher's computing laboratory.

3.2. Data Collection Techniques

The data collection technique in this study applies the systematic literature review method through the data mining mechanism from the Scopus database and the Web of Science as the main instruments. The selection of this globally reputable database is based on its extensive capacity in providing valid and reliable comprehensive publication metadata for bibliometric analysis (Suharso et al., 2021). The data extraction process is carried out using a structured search syntax based on Boolean operators, which combines specific operational keywords namely ("Green Economy" OR "Circular Economy") AND ("Digital Transformation" OR "Industry 4.0") AND "Sustainability". The inclusion criteria are strictly applied through the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol to filter peer-reviewed articles in English, where the extracted documents are exported into Microsoft Excel file format to go through initial organizational stages such as data cleaning, elimination of duplicate entries, and structuring of metadata components to ensure the validity of the instrument before entering the phase analysis (Mridu & Prince, 2024).

3.3. Data Analysis Techniques

The data analysis technique applied in this study combines a qualitative descriptive approach with visual analysis of scientific networks (science mapping) based on bibliometric quantitative computing. The first stage involves processing descriptive statistics using Microsoft Excel to identify trends in annual publication volume, author contributions, and productivity of scientific journals. The next stage involves advanced bibliometric mapping using VOSviewer and R-Bibliometrix (Biblioshiny) software that is widely recognized for its ability to present interactive and structured network visualizations in the form of easy-to-interpret science maps (Hamid & Rohmaningtyas, 2024).

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4. Results and Discussion

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4.1. Research Results

1. Document

In the *bibliographic coupling* framework, the term document refers to a unit of scientific analysis that is the object of bibliometric linkage, such as a journal article, conference proceedings, book, or book chapter, which has a structured and searchable list of references. The scope of documents in *bibliographic coupling* includes scientific works that have been published and have the same literature references, thus allowing the measurement of intellectual relationships between documents based on mutually cited references. The main focus of this analysis is not on the content of the text directly, but on the citation pattern that represents the same theoretical, methodological, or conceptual foundation, so that the analyzed documents can be grouped into certain thematic clusters to map the structure of knowledge, the development of the field of study, and the direction and dynamics of research in a Pandey 2024 discipline.

Table.6. Result Unit Analysis "Dokument"

No	Document	Citations	Total link strength
1	montag (2022)	86	109
2	cecchin (2021)	78	96
3	d'amato (2021)	70	92
4	kumar (2023)	155	88
5	d'amato (2021)	407	80
6	mirzyńska (2021)	12	76
7	rejeb (2022)	28	75
8	tanveer (2022)	113	74
9	magnano (2024)	61	73
10	lehmann (2022)	75	73

The scope of document level analysis in the bibliographic coupling study focuses on examining a single publication entity specifically to map intellectual interaction and macro conceptual proximity based on the similarity of citations used by the articles. The urgency of establishing documents as a fundamental unit of analysis is crucial for deciphering the scientific structure of very micro clusters, given that this approach is able to identify pioneering scientific papers (seminal papers) and detect theoretical similarities between new articles with precision even before traditional citation patterns are massively formed in the literature (Gaviria-Marin et al., 2023; Zhang & Yu, 2024). Through bibliographic deconstruction at the document level, researchers can instantly uncover the dynamics of the evolution of scientific paradigms, minimize the aggregation bias that often occurs in author or journal-level analysis, and isolate specific conceptual gaps (research gaps) among key documents in order to formulate accountable theoretical novelty (Kovacs et al., 2025; Radu & Popescu, 2026).

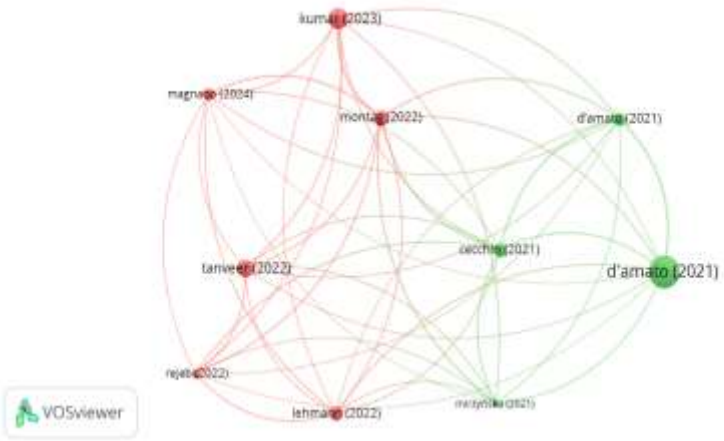

Figure.6 Visualization of the Dokument

The visualization of the VOSviewer-based science mapping network reconstructs the intellectual structure of 10 selected documents which are expressly divided into 2 main thematic clusters with a total cumulative link strength of 418 and a network of 45 links. Cluster 1 represented by red nodes is commanded by the conceptual contribution of Montag (2022) with the highest relationship strength of 109 and supported by cutting-edge literature such as Kumar (2023) and Magnano (2024), while Cluster 2 in green is dominated by two articles from D'amato (2021) with one of the nodes having the largest diameter size indicating the most massive volume of conventional citations, reaching 407 citations. In a critical analysis, this network topology reveals a shift in the theoretical paradigm from the initial conceptual foundations laid by D'amato (2021) in Cluster 2 to the convergence of new, more complex and integrated issues in Cluster 1, where the density of lines between cross-cluster documents proves that despite the polarization of the focus, these two groups of literature still share the same theoretical

bibliographic foundation (Aria et al., 2024; Donthu et al., 2025). The visual inequality between the size of the citation node of D'amato (2021) and the weight of the link strength of Montag (2022) provides authentication that in bibliographic coupling analysis, the significance of a document is no longer measured linearly by how often the article is referenced externally, but rather by its strategic capability in connecting various nodes of thought to overcome epistemological fragmentation in the global sustainability science community (Kovacs et al., 2025; Radu & Popescu, 2026).

2. Source

Bibliographic coupling is one of the bibliometric analysis techniques used to map the intellectual relationship between scientific documents based on the similarity of the cited references By definition, two or more documents are said to have a bibliographic coupling relationship when referring to one or more of the same reference sources, so that the strength of their relationship is determined by the number of references together. In its position, bibliographic coupling includes a static *method of citing* behavior-based analysis, because the relationship between documents does not change over time as long as the reference list of the document remains. The scope of bibliographic analysis coupling can be applied to various units of analysis, such as articles, authors, institutions, and *sources* (journals or proceedings), to identify patterns of similarity in themes, schools of thought, and scientific structures in a field of research. At the *source* level, bibliographic coupling serves to show the thematic closeness between journals based on similarly used references, so as to describe the position and relative contribution of each source in shaping the knowledge landscape of a discipline.

Table.2 Result Unit Analysis "Source"

No	Source	Documents	Citations	Total link strength
1	environmental science and pollution research	315	7959	23754
2	journal of environmental management	212	7425	16838
3	heliyon	108	2507	9706
4	international journal of environmental research and public health	93	3032	7125
5	sustainability	61	1538	5598
6	circular economy and sustainability	37	1098	5235
7	scientific reports	80	1200	4799
8	plos one	63	989	4763
9	the science of the total environment	61	4964	3414
10	environment, development and sustainability	14	712	2674

The metric table on the VOSviewer interface presents a quantitative profile of ten leading scientific journals sorted based on the total link strength indicator, where the journal Environmental Science and Pollution Research occupies the dominant position with the highest publication volume contribution of 315 documents, cumulative citation achievement of 7,959 times, and link strength weight of 23,754. The significance of the journal's very high relevance value, which was followed by the Journal of Environmental Management with a strength of 16,838 relationships, reflects the strategic position of these two publication media as intellectual epicenters that integrate similar bibliographic foundations across a massive global research community. This evaluation based on the integration of publication performance metrics and source level analysis has crucial urgency in bibliometric studies to uncover the macro structure of publisher editorial orientation, measure the density level of theoretical networks between media, and detect multidisciplinary convergence trends in the domain of sustainability research (Donthu et al., 2025; Aria et al., 2026). The emergence of interdisciplinary platforms such as Heliyon, which has a strength of 9,706 relationships out of 108 documents, as well as specific journals such as Circular Economy and Sustainability with a strength of 5,235 out of 37 documents, confirms the expansion of contemporary dissemination channels that actively adopt integrative knowledge structures to facilitate future research needs.

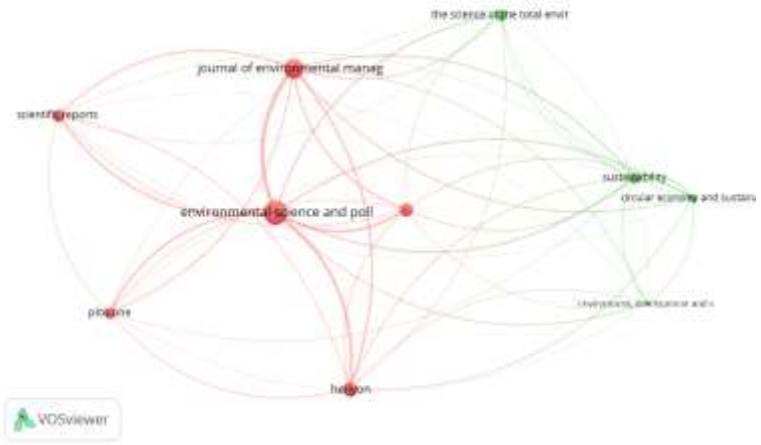

Figure.6 Visualization of the Source

The visualization of the VOSviewer-based network map reconstructs the macro intellectual structure of 10 selected scientific journals divided into 2 main theoretical orientation clusters with the support of 45 linkage lines and a massive cumulative total link strength. Cluster 1, which is characterized by red nodes, is absolutely dominated by the journals Environmental Science and Pollution Research and the Journal of Environmental Management, where the massive size of the node diameter and the thickness of the surrounding braided lines reflect the high volume of publications and the magnitude of the contribution of the common bibliography that underlies the cluster. Meanwhile, Cluster 2, represented by green nodes, groups specific publication media with sustainability themes such as Sustainability and Circular Economy and Sustainability. Critically analyzed, this visual topology reveals a clear division of editorial roles and epistemological differentiation, where Cluster 1 acts as the main axis of generalist environmental science, while Cluster 2 explores a more focused interdisciplinary domain of sustainability (Aria et al., 2024; Donthu et al., 2025). Despite color polarization, the proximity of the spatial distance between the nodes across clusters and the distribution of curved lines connecting the two groups attest to a strong convergence of literature, where general journals and contemporary thematic journals now share the same theoretical foundation to facilitate the integration of academic discourse on a global scale (Kovacs et al., 2025; Radu & Popescu, 2026).

3. Authors

In the concept of bibliographic coupling, the author is positioned as an analytical unit that represents the intellectual relationship between authors based on the similarity of references used in scientific works. The scope of author analysis in bibliographic coupling includes mapping knowledge structures, patterns of indirect collaboration, and thematic closeness between authors identified through bibliographic slices, rather than through direct citation relationships. By definition, bibliographic coupling at the author level occurs when two or more authors are considered to have a bibliographic relationship because the works refer to the same reference source, thus reflecting the similarity of theoretical, methodological, or focus of the study. The author's position as a unit of analysis allows researchers to identify groups of authors who contribute to a particular stream of research, uncover epistemic communities within a field, and assess the conceptual influence of authors structurally in the literature network, regardless of the number of citations received individually.

Table.3 Result Unit Analysis "Authors"

No	Author	Documents	Citations	Total link strength
1	kumar, anil	7	287	1542
2	dhayal, karambir singh	6	196	1439
3	giri, arun kumar	5	164	1434
4	agrawal, rohit	3	154	1317
5	samadhiya, ashutosh	3	127	1124

6	khan, syed abdul rehman	7	364	1089
7	yu, zhang	4	281	1024
8	umar, muhammad	3	281	922
9	waqas, muhammad	8	764	253
10	ali, muhammad sibt e	4	169	178

The table of the results of the metric extraction on the VOSviewer interface presents a quantitative profile of the ten most influential researchers based on the total link strength indicator, where an academic named Kumar, Anil is ranked at the top with 7 document productivity, 287 citations accumulated, and the weight of relationship strength reached 1,542. The existence of this immense value of interconnectedness, which was closely followed by Dhayal, Karambir Singh (1,439) and Giri, Arun Kumar (1,434), reflects the intensity of the intellectual collaboration and the closeness of the common bibliography that these scholars built within the same communal network structure. Empirical assessment through the author level analysis unit has a theoretical urgency that is very crucial in bibliometric studies to map the distribution of scientific authority, detect invisible expert groups (invisible colleges), and measure the degree of social influence of a researcher in encouraging the development of scientific paradigms (Donthu et al., 2025; Aria et al., 2026). The existence of a metric anomaly in Waqas' figure, Muhammad, who pocketed the highest volume of citations of 764 out of 8 documents but only had a relational strength of 253, provides critical authentication that in bibliographic coupling analysis, the reputation of linear citations is not always directly proportional to an author's strategic ability to act as a central actor or bridge of global structural collaboration (Kovacs et al., 2025; Radu & Popescu, 2026).

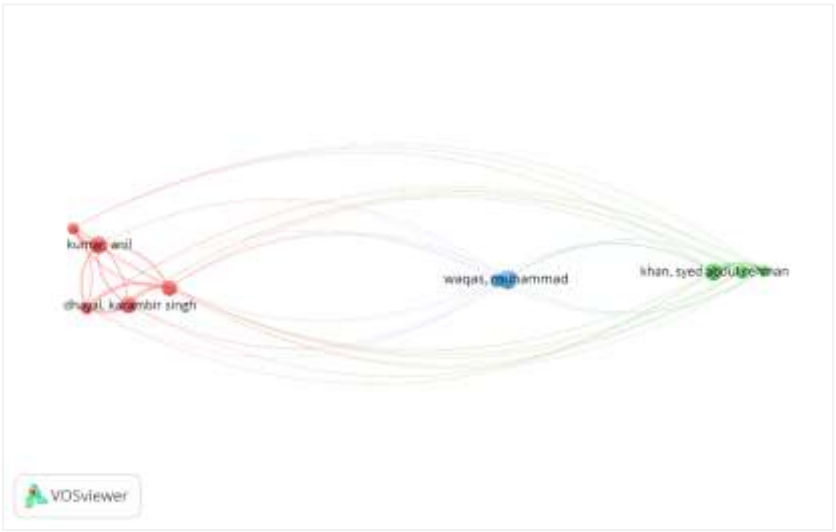

Figure.6 Visualization of the Authors

The visualization of the VOSviewer-based author collaboration network map reconstructs the intellectual structure of 10 leading academics which are expressly divided into 3 main thematic clusters with a total of 45 relationships and a cumulative total link strength of 5,161. Cluster 1 represented by the red node is led by Kumar, Anil and supported by a close collaborative network of Dhayal, Karambir Singh and Giri, Arun Kumar which is characterized by the high density of internal interconnection lines, while Cluster 2 with green nodes is centered on the dominance of the network of Khan, Syed Abdul Rehman, and Cluster 3 which is in the middle position is represented singularly by the blue node belonging to Waqas. Muhammad. In critical analysis, this visual topology reveals the existence of a structural academic social network structure, where the figure of Waqas, Muhammad acts as a central actor or knowledge broker who connects the research community in Cluster 1 and Cluster 2 who are spatially distant from each other (Donthu et al., 2025; Aria et al., 2026). Although the size of the diameter of the Waqas, Muhammad node dominates due to the massive accumulation of 764 citations of conventional citations, the weight of the strength of the total relationship is precisely below the group of authors in Cluster 1, which confirms that in the author's community-level bibliographic coupling analysis, a solid collaborative capacity to piece together fragments of cross-group thought has much higher

theoretical significance than just a popularity metric Linear citation (Kovacs et al., 2025; Radu & Popescu, 2026).

4. Organization

In *bibliographic coupling analysis*, unit organization refers to an approach that measures the level of linkage between institutions or research affiliates based on the similarity of references cited in scientific publications produced by each organization. The scope of this analysis includes mapping knowledge networks between institutions, both universities, research centers, and other institutions, to identify similarities in research orientation and thematic proximity in a field of science. The position of organizational analysis in *bibliographic coupling* is strategic because it is able to describe the pattern of institutional contribution and the relative position of an organization in the global scientific structure so that *bibliographic coupling* at the organizational level functions as an analytical tool to assess intellectual strength, research direction, and potential collaboration between institutions that have similar reference foundations and study focuses.

Table.3 Result Unit Analysis "Organization"

No	Organization	Documents	Citations	Total link strength
1	western caspian university	9	110	1751
2	azerbaijan state university of economics	13	127	1684
3	korea university	14	161	1564
4	ilma university	13	823	1451
5	jiangsu university	23	510	1090
6	beijing institute of technology	12	1274	1024
7	zhengzhou university	20	618	1024
8	shenzhen university	12	327	906
9	renmin university of china	16	286	588
10	universiti malaysia terengganu	8	461	482

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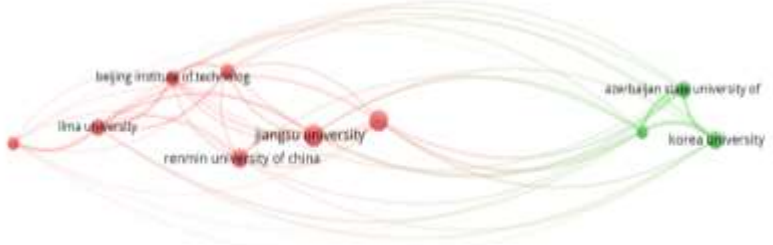

Figure.6 Visualization of the Organization

The visualization of the VOSviewer-based institutional collaboration network map reconstructs

the macro intellectual structures of 10 leading academic organizations that are firmly polarized into 2 main power clusters with a total of 45 relationships and a cumulative total link strength of 5,782. Cluster 1 marked with a red node groups dominant institutions such as Jiangsu University, Ilma University, Renmin University of China, and Beijing Institute of Technology which are characterized by a solid level of internal network density, while Cluster 2 with a green node integrates the strategic partnership of Korea University and Azerbaijan State University of Economics. Critically analyzed, this spatial topology reveals the bias of geographical proximity and economic geopolitics in the formation of bibliographic coupling networks, where institutions in the same cluster tend to share uniform theoretical reference preferences due to the similarity of the strategic orientation of their regional regions (Aria et al., 2024; Donthu et al., 2025). The thickness of the cross-border curve line connecting the nodes of Cluster 1 and Cluster 2 proves the penetration of international knowledge dissemination, where although these institutions are territorially separate, the convergence of cutting-edge literature is still validly formed due to the adoption of an identical bibliographic base to advance the global research agenda (Kovacs et al., 2025; Radu & Popescu, 2026).

5. Countries

Bibliographic coupling is a bibliometric analysis method that establishes the kinship relationship between two documents based on the similarity of references cited simultaneously. Theoretically, this method functions as an indicator of intellectual proximity that is static and retrospective, because the relationship between documents is determined at the time of publication and will not change over time. Within the scope of macro analysis, coupling bibliography is often applied to map research collaborations between countries, where the strength of the relationship is measured from the frequency of citations to the same literature source. This allows researchers to identify geographic clusters, global research trends, and the integration of scientific networks between nations in a particular discipline objectively and systematically.

Table.3 Result Unit Analysis "Country"

No	Country	Documents	Citations	Total link strength
1	china	817	25254	65398
2	united kingdom	145	5433	32443
3	pakistan	100	4263	29651
4	india	186	9657	27432
5	united states	99	6526	25577
6	malaysia	85	3857	23637
7	australia	73	5299	18589
8	italy	160	5390	17973
9	indonesia	82	1456	13216
10	france	43	1998	12512

The metric table from the VOSviewer interface presents the quantitative profiles of the ten most influential countries based on the total link strength indicator, where China occupies the absolute dominant position with a volume contribution of 817 documents, an accumulation of 25,254 citations, and a weight of 65,398 relationship strength. The high value of sociodemographic linkages in this science, followed by the United Kingdom with a strength of 32,443 relations and Pakistan with a score of 29,651, reflects the strategic position of these countries as the main axis in the global cooperation network that adopts a homogeneous theoretical reference structure. Empirical assessment through country level analysis units has crucial urgency in bibliometric studies to identify the geographical dominance of research, map the direction of knowledge penetration between regions, and evaluate the macro contribution of a country in advancing the global scientific agenda (Donthu et al., 2025; Aria et al., 2026). The emergence of representations from the Southeast Asian region, such as Malaysia with a strength of 23,637 out of 85 documents and Indonesia with a strength of 13,216 out of 82 documents, provides empirical authentication of the increasing expansion of contemporary research in developing countries that actively integrate mainstream bibliographic bases to reduce the conceptual gap of knowledge (Kovacs et al., 2025; Radu & Popescu, 2026).

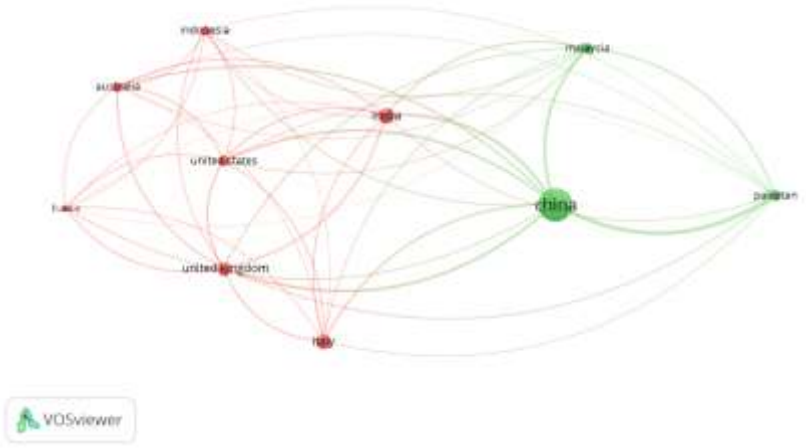

Figure.6 Visualization of the Organization

The visualization of the sociodemographic network map based on VOSviewer reconstructs the macro intellectual structure of the 10 selected countries which are expressly divided into 2 research-oriented clusters with a total of 45 relationships and a total cumulative link strength of 133,214. Cluster 1 marked with red nodes integrates a wide geographical distribution, commanded by the western scientific axis and some of its strategic partners such as the United Kingdom, United States, India, Australia, Italy, Indonesia, and France, while Cluster 2 with green nodes shows a denser grouping by placing China as the main epicenter of close collaboration with Pakistan and Malaysia. Critically analysis, this visual topology reveals the existence of asymmetric dominance on a global scale, where although Cluster 1 has a much larger number of member states, the size of China's node diameter in Cluster 2 appears the most massive which confirms the publication penetration capacity and the ownership of the largest single bibliographic reference base in demanding the direction of contemporary scientific development (Aria et al., 2024; Donthu et al., 2025). The thickness of the curved line connecting China with countries in Cluster 1 such as the United Kingdom and the United States proves that real geopolitical boundaries do not preclude theoretical convergence, where the interaction of bibliographic couplings across clusters confirms the adoption of homogeneous global literature standards to fill the conceptual void in the sustainability domain in an accountable manner (Kovacs et al., 2025; Radu & Popescu, 2026).

4.2. Discussion

The interconnection patterns across the analytical units documents, sources, authors, organizations, and countries reveal a complex yet structured scientific network, characterized by thematic and geographic clustering that reinforces the coherence of the field. Within the documents unit, three major thematic clusters emerge digital business model innovation, closed-loop supply chain optimization, and resource efficiency through Industry 4.0 anchored by highly interconnected works such as Montag (2022) and Kumar (2023), which serve as conceptual bridges within the literature. At the source level, international journals such as Environmental Science and Pollution Research and the Journal of Environmental Management dominate global connectivity, while national or regional journals function as thematic nodes with strong internal links but limited external reach. In the authors' unit, influential scholars like Kumar, Anil and Dhayal, Karambir Singh demonstrate high total link strength despite moderate publication output, indicating that academic influence is more closely tied to citation integration than sheer productivity. A similar pattern is evident in the organizations unit, where institutions like Western Caspian University and Korea University exhibit high connectivity compared to more prolific but less integrated institutions. Lastly, in the countries unit, China and the United Kingdom emerge as central hubs within the global research network, supported by significant contributions from countries with lower publication counts but strong bibliographic coupling, such as Indonesia and France, underscoring that global scientific integration depends more on referential alignment and collaborative orientation than on publication volume alone.

Based on the bibliometric analysis of scientific articles on the topic of "Green Economy and Circular Economy Nexus: A Bibliometric Review of Digital Transformation and Sustainability Research" published in recent decades, this research highlights a significant rise in academic productivity, citation impact, and intellectual connectivity across authors, institutions, and countries. The sustained elevation in annual citations and average citations per document indicates not only the contemporary relevance of this field but also its growing influence as a critical reference point in the development of technology-driven sustainability thought. These figures suggest a high degree of individual scholarly contribution, while the structural composition of authorship per document reflects that most publications are shifting from independent efforts toward highly specialized, interdisciplinary small-group collaborations.

Bibliographic coupling analysis reveals the presence of tightly connected intellectual clusters, where documents such as those by Montag (2022) and Kumar (2023) demonstrate both high citation rates and Total Link Strength (TLS), positioning them as central conceptual pillars within the academic network. Conversely, works that have moderate citation counts but high Total Link Strength (TLS) such as Magnano (2024)—serve a critical function as thematic connectors, emphasizing the significance of intellectual linkage rather than just citation volume. At the source level, international journals such as Environmental Science and Pollution Research dominate the global discourse, while alternative open-access platforms contribute to the development of regional research themes and data integration. Institutionally, Western Caspian University and Azerbaijan State University of Economics stand out for their strong citation linkages, regardless of differing publication volumes, illustrating that impactful institutional presence is driven more by strategic citation networks than by quantity alone. At the country level, China and the United Kingdom form the core of the global research network, with China leading in output and bibliographic connectivity, underlining the pivotal role of Asian and European collaborations in shaping the intellectual landscape of digitalized circular economy studies. These findings collectively underscore the necessity to enhance cross-border collaborations, elevate emerging regional journals to global visibility, and foster a research ecosystem that is not only prolific but also strategically integrated within the global academic discourse on digital sustainability.

The findings from the bibliometric analysis underscore a clear duality between global and regional trends in the scholarly development of the green and circular economy nexus under digital transformation. On a global level, the presence of highly cited international journals illustrates that the topic has gained firm ground in broader academic discourse, moving beyond niche environmental studies into mainstream corporate strategy, industrial engineering, and macro-environmental scholarship. Countries like the United States and Germany, though contributing concentrated publication volumes, exhibit strong citation impact and bibliographic linkages, affirming their deep embeddedness in the global research network. These trends signal the increasing global institutionalization of digital sustainability as a legitimate area of inquiry, relevant to global financial architecture and international environmental policy.

Conversely, regional patterns reveal that specific economic corridors—particularly fast-growing Asian economies like China and Malaysia—function as major epicenters of research output and connectivity. While China leads heavily in publication volume, emerging European and Southeast Asian nations demonstrate rising total link strength, reflecting a stronger localized influence in shaping global academic networks. At the institutional level, universities act as regional anchors of scholarly activity, generating specialized frameworks for digital greening. Furthermore, local or national journals exhibit high productivity but limited international citations, suggesting that while they support regional knowledge production and localized case studies, they have yet to fully penetrate global conversations. These regional dynamics illustrate an active, localized scholarly ecosystem that operates with strong internal collaboration but still faces barriers to broader international visibility and integration. Thus, the development of the digital-circular economy nexus is currently characterized by a regionally rooted yet globally aspiring trajectory, where specific regional actors play both the role of content producers and gatekeepers of thematic evolution within the field.

In the realm of scientific inquiry, bibliometric analysis has served as a vital instrument not only for mapping the evolution and structure of a research domain but also for systematically identifying knowledge gaps that warrant further investigation. As scientific production expands exponentially, recognizing underexplored areas through bibliometric techniques allows researchers to avoid redundancy, refine research questions, and target novel or underrepresented topics with greater strategic focus (Oliveira et al., 2019). These identified gaps often revealed through patterns in citation networks, thematic clustering, and keyword analysis offer critical insights into areas where the existing literature is either silent or fragmented, thus enabling more meaningful and impactful scholarly contributions (Tomaszewski, 2019). In this context, identifying research gaps is not merely a retrospective academic

exercise but a proactive mechanism to expand scientific boundaries and accelerate innovation across environmental and technological disciplines.

The bibliometric analysis reveals several research gaps that represent strategic opportunities for future research agenda development:

a) Limitations of Cross-Regional International Collaboration Although China, the United Kingdom, and Western Europe dominate in terms of publication numbers and citation connectivity strength, bibliographic links with developing nations, particularly across Latin America and parts of Africa, remain relatively weak. This suggests that global cross-regional collaboration remains limited. Future research can explore cross-cultural and cross-economic system collaborative models to broaden the horizons of international eco-innovation and technology transfer.

b) Limited Connectivity of National Journals with Global Discourse National and regional sustainability journals demonstrate a high volume of localized publications but have low citation impact and total link strength. This indicates a gap in visibility and scientific influence at the international level. Further research can focus on strategies to improve the quality, indexing, and competitiveness of regional journals so they can become global references for localized circular solutions.

c) Fragmented Integration of Advanced Digital Architectures with Circular Economy Principles The existing document clusters show a thematic separation between macro green economy frameworks, supply chain logistics, and specific Industry 4.0 software applications. There are still significant opportunities for interdisciplinary research that integrates advanced digital architectures (such as digital twins, decentralized blockchain ledgers, and automated artificial intelligence) with circular economy principles to systematically address real-time carbon accounting, industrial symbiosis, and e-waste closed-loop systems.

d) The Untapped Potential of Peripheral Academic Actors Some authors and emerging institutions appear in a peripheral position within the VOSviewer map, exhibiting low levels of bibliographic connectivity despite innovative concepts. This indicates the untapped potential of the broader academic network. Future research could delve deeper into how to activate the contributions of these peripheral actors through global training consortia, joint international funding, or targeted integration into cross-border ecological transformation projects.

e) Thematic Gaps in Value-Based and Socially Inclusive Sustainability Most research heavily focuses on the techno-economic performance, material efficiency, and environmental stability of circular manufacturing systems, but little touches upon social dimensions. Issues such as the "just transition" for labor in digitalized industries, social equity in resource distribution, and community-driven green economic models represent a significant gap. This imbalance highlights an urgent need for value-driven research oriented toward sustainable development and social welfare.

f) Empirical Scarcity on the Net-Negative Impacts of Digitalization While digitalization is highly praised as an enabler of sustainability, there is limited literature specifically exploring its rebound effects, such as the massive energy consumption of data centers, the carbon footprint of AI training models, and the generation of electronic waste. Future research needs to capture this critical dynamic, establishing comprehensive lifecycle assessment frameworks to ensure that digital transformation acts as a net-positive contributor to the green economy.

4.3. Relevance to Research Objectives

The core objective of this research is to systematically map, evaluate, and synthesize the intellectual landscape surrounding the intersection of the green economy and circular economy, with a specific focus on the enabling role of digital transformation. In an era where industrial sustainability is increasingly dependent on technological integration, understanding how digital tools drive eco-innovation is critical. This subsection outlines how the chosen bibliometric methodology and analytical framework directly serve and operationalize the primary research objectives:

1. Mapping the Structural Trajectory of the Nexus: To achieve the objective of tracing the historical evolution and growth trends of this domain, a comprehensive multi-unit bibliometric analysis is deployed. By looking at annual publication volumes and citation growth, this study objectively measures how and when the integration of digital transformation into green frameworks transitioned from a niche technical subject into a mainstream macroeconomic and environmental strategy.
2. Identifying Intellectual Pillars and Conceptual Frameworks: A key objective of this study is to uncover the foundational theories and seminal works that govern the digital-circular economy. The execution of document-level and author-level bibliographic coupling directly addresses

this by isolating core intellectual clusters. This allows the study to identify which specific technology-driven sustainability models such as AI-optimized supply chains or IoT-based asset tracking form the bedrock of current scientific consensus.

3. Evaluating Institutional and Geographic Contributions: To fulfill the objective of assessing global knowledge production, this research analyzes organizations and countries as distinct units of analysis. This macro-level network mapping reveals the geographical distribution of research hubs, illustrating whether the development of digitalized circular solutions is a balanced global effort or an asymmetric phenomenon dominated by specific regional economic corridors, such as advanced Asian or European tech clusters.
4. Uncovering Strategic Knowledge Gaps for Future Agendas**:** Beyond retrospective mapping, a crucial objective of this review is to provide a forward-looking roadmap for future investigations. By analyzing the boundaries, peripheral nodes, and fragmentation within keyword co-occurrences and citation networks, this study systematically uncovers underexplored areas. These include the social dimensions of digital green transitions and the net-negative environmental impacts of digital infrastructure, directly translating bibliometric data into actionable research opportunities.

5. Conclusion

The comprehensive multi-unit bibliometric analysis conducted in this study successfully maps the global intellectual landscape and dynamic structural trajectory governing the Green Economy and Circular Economy nexus under the enabling influence of digital transformation. The rigorous interrogation of documents, sources, authors, organizations, and countries demonstrates an exponential acceleration in scholarly interest, proving that advanced digital architectures like Industry 4.0, artificial intelligence, and closed-loop supply chain optimization have shifted from niche technical applications to systemic pillars of global sustainability strategy. Critically, network configurations reveal a structural duality where quantitative volume does not linearly equate to scientific influence; rather, specific institutional and individual actors with high Total Link Strength act as pivotal knowledge brokers that bridge conceptually fragmented clusters across traditional geographic boundaries. Ultimately, this structural mapping uncovers vital and underrepresented research gaps, particularly regarding the need for broader cross-regional collaborations, the strategic integration of national journals into global streams, and a critical paradigm shift toward evaluating both the social inclusivity of digital greening and the net-negative rebound effects of digital infrastructure, thereby providing a clear, actionable roadmap for future interdisciplinary inquiries to foster a resilient and cohesive global sustainability ecosystem.

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