Research Article

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Bibliometric Analysis of the Concept of Sustainable Digital Using the R Program *

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Abstract

Sustainability is an approach that aims to preserve environmental, economic and social balance by considering not only the present but also future generations. This approach is reflected in the digitalisation processes taking place in various fields, given rise to to the concept of sustainable digitalisation and emphasising the need for digital transformation to be designed in a way that reduces environmental impacts, optimises resource use and provides social benefits. In this study, bibliometric analysis is applied to 601 publications containing the concept of sustainable digital in the Web of Science database between 2002 and 2025. Thus, the aim is to identify academic trends in the literature on this subject, leading researchers, countries or institutions, as well as to discover collaboration and co-citation networks. As a result of analyses conducted using the Biblioshiny web interface in the R programme, China ranked first when publications on sustainable digital issues are evaluated by country. The most publications are in the article category and the institution with the most publications is Hokkaido University and the most productive author is Satoh T. Furthermore, MDPI is found to be the most effective publisher and the words most frequently used by authors are “sustainability” and “digital transformation”.

Keywords: Bibliometric Analysis, Digitalisation, Sustainable Digital, Sustainability, R Programme.

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1. INTRODUCTION

Bibliometric studies are important for assessing and understanding the importance, impact and trends of research publications in specific fields. These studies provide a comprehensive understanding of the current research structure using quantitative and qualitative techniques based on the analysis of journals, articles and associated citations over time. It can be argued that such analyses help researchers to identify study topics, clarify their focus and predict future trends (Omar & Abdullahi, 2024). Harmonizing the use of digital technology with sustainability principles is beginning to attract more attention in both academic and applied fields. In this context, it is important to quantify scientific production in this field on the basis of sustainable digital and to identify research trends, collaborations and prominent themes. Gültekin and Korkmaz (2024) examined 103 studies on digital sustainability conducted between 2007- 2024 and accessed through WoS with bibliometric analysis using VOSviewer software. In the same year, Omar and Abdullahi analyzed bibliometrics to investigate trends and patterns in the field of sustainable digital transformation. They examined the studies covering the period between 1991 and 2024 obtained from the Scopus database using Biblioshiny developed for R software. Sharma et al. (2021) applied bibliometric analysis on digital sustainability based on four different disciplines: economics, management/business, information technologies and sociology/communication. In this regard, 201 articles containing the terms “digital” and “sustain” in the SCIMago database were analyzed using VOSviewer.

In this study, 601 studies published on the WoS database between 2002- 2025 and including the subject of

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"sustainable digital" are analyzed using the Biblioshiny web interface in the R program for bibliometric analysis. In the findings obtained, first descriptive statistics are presented, then bibliometric analysis findings and network visualizations are presented.

2. SUSTAINABLE DIGITAL

Conceptually first applied to forestry in Germany in the 1840s, sustainability was later brought to the USA by Gifford Pinchot and his colleagues. While sustainability has been applied primarily to natural resources in history, it has been used in the sense of certain techniques that allow resources to be consumed and sustained at certain rates. The concept is later applied to agriculture and used to describe an emerging paradigm (Gültekin & Korkmaz, 2024:249) Sustainability generally consists of three dimensions: economic, environmental and social. This concept is social from a human perspective; economic and cultural from a social perspective; and environmental from a natural resources perspective. It is of great importance to ensure these three sub-sustainability simultaneously for a solid, holistic sustainability (Şen et al., 2018).

The growing importance of the digital world has made it necessary to move the understanding of sustainability to the digital environment. Sustainable digital is an approach that considers technical, structural, economic and institutional infrastructures as a whole to ensure the long-term accessibility, accuracy and originality of digital information. Digital sustainability involves not only storing digital objects, but also managing them in a way that preserves their value while adapting to changing technologies over time. The preservation of digital materials therefore requires the constant intervention of data specialists, the ability of archival software to manage version and change records and, most importantly, the ownership of the process by institutions (Bradley, 2007). Reducing the environmental impact of digital preservation using technology is only a temporary solution and not enough for sustainable digital preservation. Existing practices focus on the management and storage volume of digital content, targeting risk mitigation through verification and backup. However, this creates environmental problems due to high energy consumption and resource use. A paradigm change in the areas of permanence and accessibility is needed to evaluate digital content for environmental sustainability. Thus, sustainable digital preservation is possible through flexible and holistic models suitable for different circumstances (Pendergrass et al., 2019).

Digital sustainability is not only about preserving technical infrastructure, but also about eliminating social inequalities. According to Ragnedda (2018), unequal access to information and communication technologies results in algorithms and artificial intelligence systems reproducing existing social inequalities. This leads to the digital divide. In this context, digital sustainability is a multidimensional approach that involves not only the long-term preservation of digital content, but also the fair, transparent, accessible and unbiased presentation of that content. A truly sustainable digital future will be possible through the ethical use of data, the comprehensiveness of technological systems and the design of digitalization at all levels for social benefit (Kayış, 2021).

With this multidimensional nature of sustainable digital, it is understood that it is a concept that aims to ensure that digital information can serve not only the present but also the future.

3. MATERIALS AND METHODS

The purpose, methodology, data set, analysis and findings of the study are given under this heading.

3.1. Purpose and Significance of the Research

In this study, a total of 601 publications containing the concept of "sustainable digital" in the Web of Science database between 2002 and 2025 are analyzed by bibliometric analysis method. In this context, it is aimed to reveal academic trends in the relevant literature, to identify prominent researchers, countries and institutions, and to explore collaboration and co-citation networks.

The study is important in this respect because bibliometrics allows mapping the current state of the field by examining publication patterns through quantitative analysis and statistical methods. Bibliometric analyses not only provide a descriptive assessment based on the number of publications, but also provide a more in-depth and evaluative perspective by measuring the scientific impact of these publications through citation analysis. In addition to revealing the impact of publications, citation analyses help to identify which journals, institutions or countries are leading the way in particular research areas (McBurney & Novak, 2002). In this context, understanding how the concept of sustainable digital is gained a place in the scientific literature and the academic trends in this field contributes to strategic knowledge production for both researchers and decision makers.

3.2. Research Data Set and Method

The studies in the field of sustainable digital, which are considered within the scope of the research, were searched with exact match with the keyword "sustainable digital" on June 26, 2025 from the Web of Science database. A total of 601 publications such as articles, reviews, book chapters, etc. constituted the data set of the study. In the bibliometric analysis process performed on these data set, R Programming language, RStudio and Biblioshiny web interface were used.

R is an open source and freely available software application. The R package bibliometrix, developed for bibliometric analysis, stands out as a comprehensive, flexible and adaptable tool in this field. Biblioshiny is a web-based graphical interface to the bibliometrix package developed for non-coding users (Rashid, 2023; Ahmi, 2022; Derviş, 2019; Aria & Cuccurullo, 2017).

In other words, it can be said that the Biblioshiny interface, which allows systematic and visual analysis of the literature in the field of sustainable digital, offers both a comprehensive and user-friendly bibliometric analysis process for research.

3.3. Analyses and Findings

This section presents the findings of bibliometric analyses on the concept of sustainable digital. The findings are reported under two main headings. First, the descriptive statistics of the dataset used in the study are given, and second, the findings of the bibliometric analyses performed using the Biblioshiny interface in the R Studio environment are presented.

3.3.1. Descriptive Statistics of the Data

Descriptive statistics such as distribution by year, publication types, most productive authors, affiliations and countries for 601 publications obtained from the Web of Science database are presented under this heading.

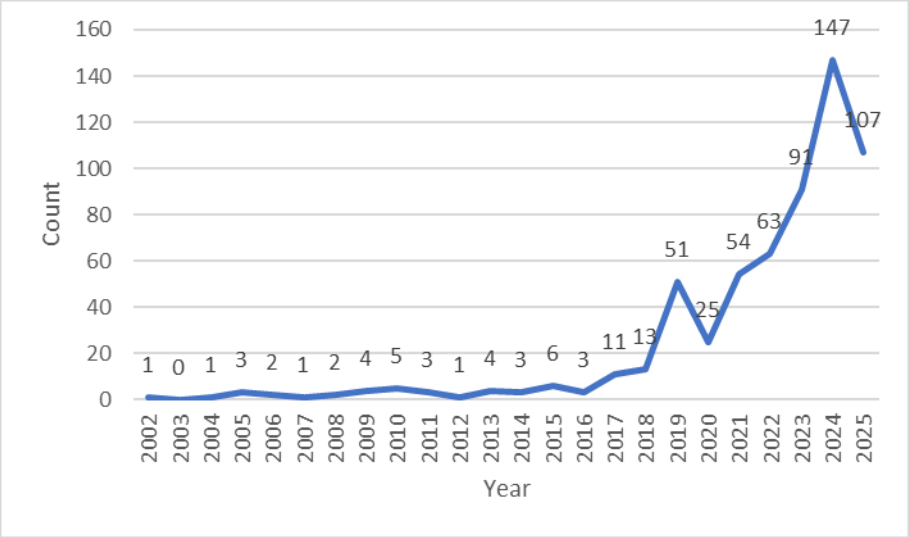

Figure 1. Number of Publications Between 2002 and 2025

When the number of publications made between 2002 and 2025 is examined through Figure 1, it is understood that the most publications were made in 2024 (147 publications). The fact that there are 107 publications in the 2nd quarter of 2025 indicates that this year will be more than 2024. This shows that the interest in sustainable digital is increasing.

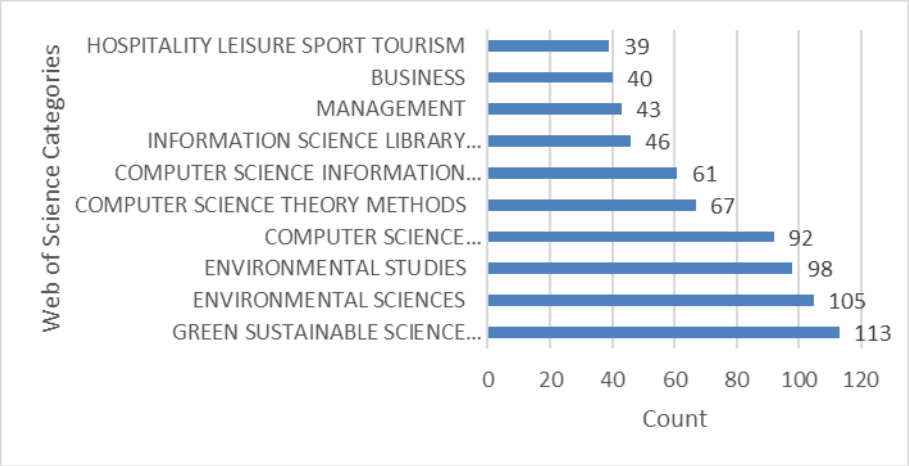

Figure 2. Number of Publications According to Categories

When examining the categories of publications on sustainable digital issues according to Figure 2, the green sustainable science technology category ranks first with 113 publications, followed by environmental sciences with 105 publications.

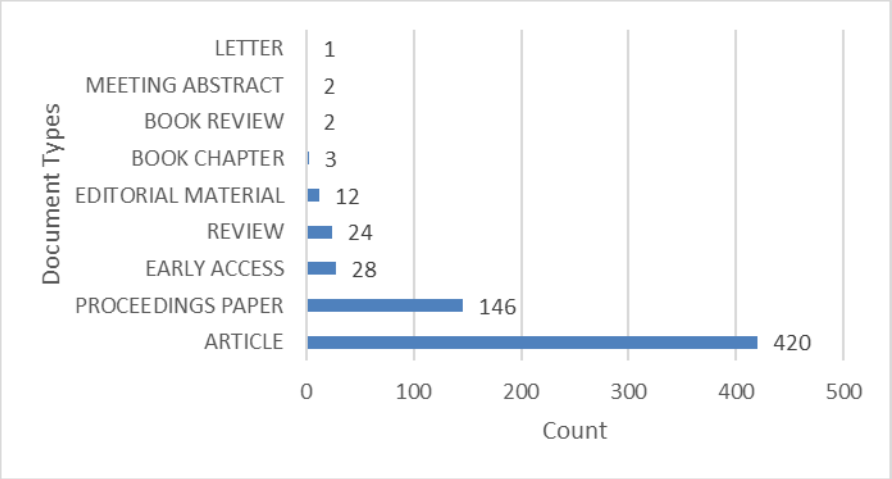

Figure 3. Number of Publications According to Type

Looking at the types of publications on sustainable digital issues in Figure 3, it is concluded that the most common type is articles (420 publications).

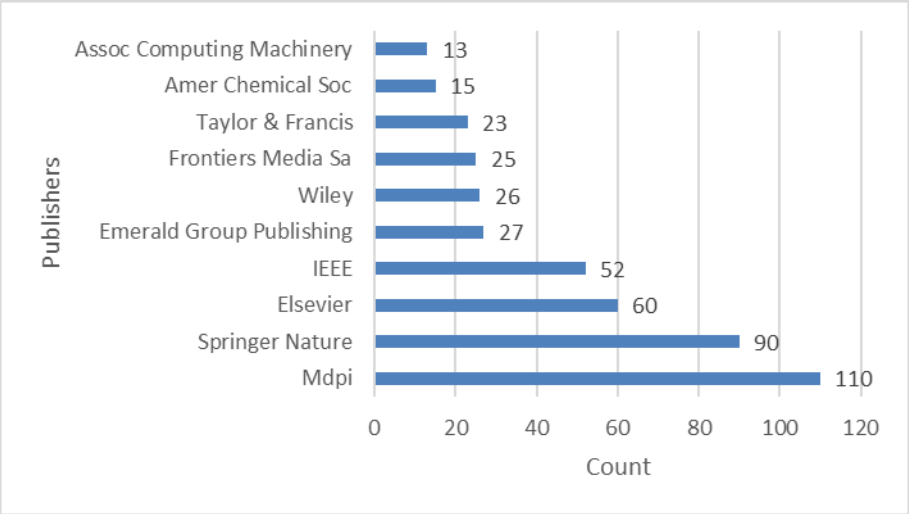

Figure 4. Number of Publications According to Publishers

When analyzing the number of publications according to the publisher presented in Figure 4, it is determined that MDPI ranks first with 110 publications and Springer Nature ranks second with 90 publications.

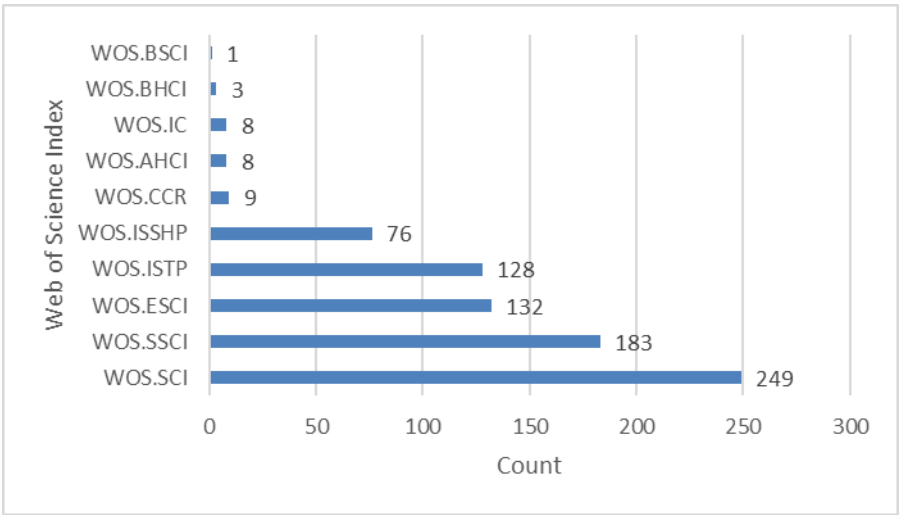

Figure 5. Number of Publications According to Indexes

The distribution of publications according to indexes in Figure 5 shows that 249 publications are indexed in SCI, the

SSCI index follows with 183 publications.

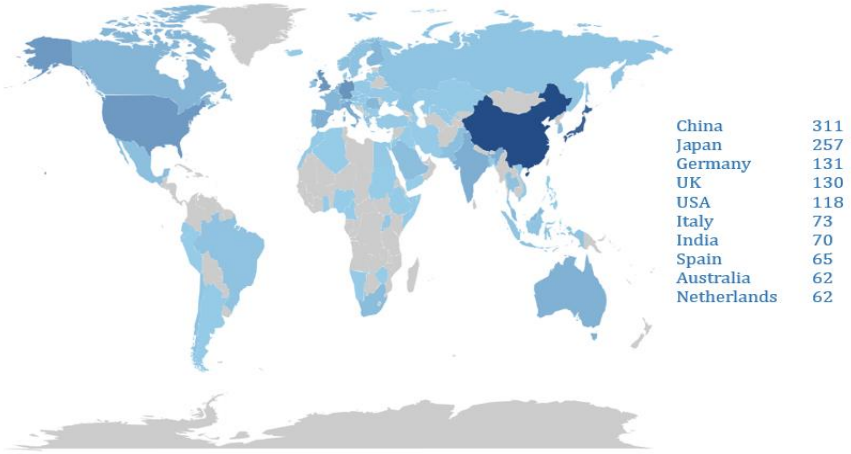

Figure 6. Distribution of Publications by Country

When review Figure 6, which shows the distribution of publications by country, it is seen that China leads with 311 publications, coming second is Japan with 257 publications.

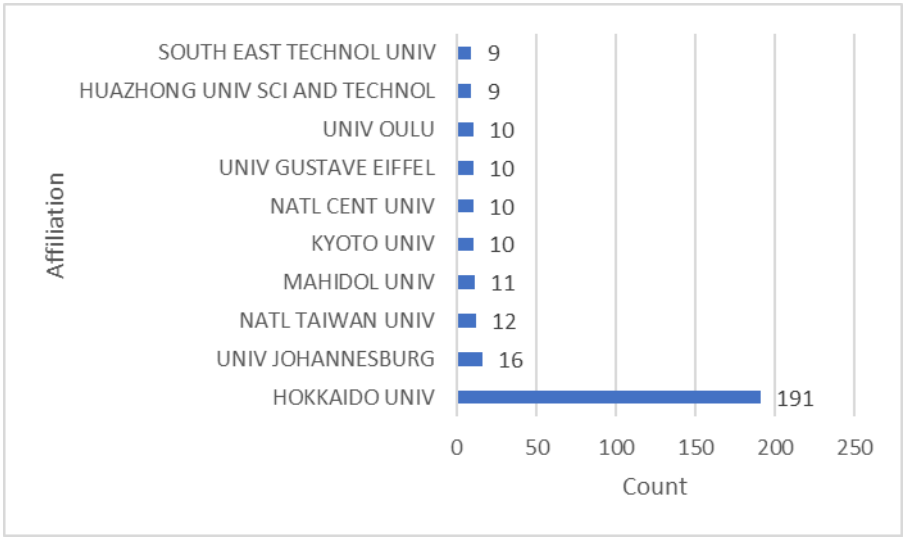

Figure 7. Number of Publications According to Affiliation

When examining Figure 7, it is seen that Hokkaido University has the most publications on sustainable digital issues, with a significant difference (191 publications).

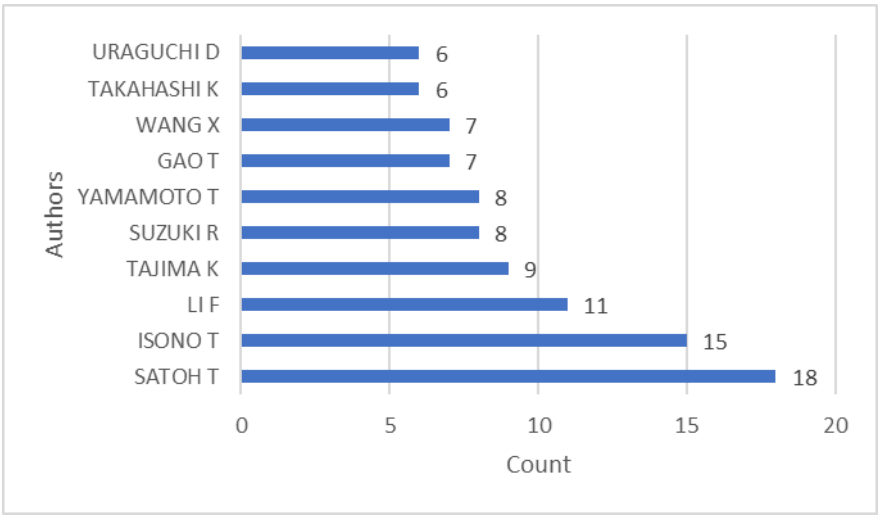

Figure 8. Number of Publications According to Authors

Figure 8 shows the number of publications by author. The most productive author is Satoh T. (18 publications), followed by Isono T. (15 publications).

Figure 9. Word Cloud of Most Frequent Words

A word cloud of the most frequently used words is provided in Figure 9. According to the numerical data obtained, sustainability ranks first with 90 words, followed by digital transformation with 46 words, management with 45 words, and technology with 44 words.

3.3.2. Bibliometric Analysis and Network Visualization of Data with R Studio

In this section, collaboration networks and co-citation analyses in the literature were performed based on bibliometric analyses conducted using the Biblioshiny interface in the R programme, and network connections were visualised.

Findings Related to Conceptual Structure

Conceptual structure analysis enables the discovery of fundamental concepts, themes, and relationships between these themes in a field of research (Bhat ve d., 2023; Aria, M., & Cuccurullo, C. (2017).

Co-occurrence Network Analysis of Authors' Keywords

In order to examine keyword frequency in articles on sustainable digital, authors' keywords were selected as the unit of analysis. At the same time, a network visualization was created by analyzing the number of nodes as 50, the minimum number of edges as 2, the number of labels as 1000, and the label size as 2, as suggested by the programme (Aria and Cuccurullo, 2017). A map of the most frequently used keyword links is shown in Figure 10.

Figure 10. Connections to the Most Frequently Used Keywords Together

As a result of the analysis, a total of 8 different clusters were obtained, each represented by a different colour and

presented in Figure 10. The nodes in the clusters represent keywords, and nodes of the same colour belong to the same cluster. The connections between nodes indicate that these words are used together. The thickness of the connections and the size of the nodes are directly proportional to the frequency of use.

Table 1. Metrics for Co-occurring Keywords

Node	*Cluster*	*Betweenness*	*Closeness*	*PageRank*
Sustainability	2	412,91	0,016	0,147
Digital	2	195,16	0,014	0,107
Digital Transformation	2	127,59	0,013	0,076
Artificial İntelligence	1	186,10	0,011	0,062
Digital Economy	8	100,13	0,013	0,055
Sustainable Development	6	90,73	0,012	0,049
Transformation	2	6,47	0,011	0,031
Sustainable	7	40,39	0,01	0,027
Blockchain	8	15,31	0,012	0,027
Entrepreneurship	2	1,32	0,011	0,026

When the metrics for the words in Figure 10 are examined in Table 1, it is seen that the most frequently used word according to the betweenness is sustainability, which belongs to the blue cluster, followed by the word digital. The term artificial intelligence is the most frequently used word in the red cluster.

Findings Related to Intellectual Structure

Analyses of intellectual structures generally provide information about intellectual trends in the field under consideration and are examined in bibliometric analyses using co-citation maps. The direct citation analysis offered by the R programme is an analysis method that provides perspectives on intellectual structure through articles and sources (Yay et al., 2022).

Co- citation Network Analysis of Papers

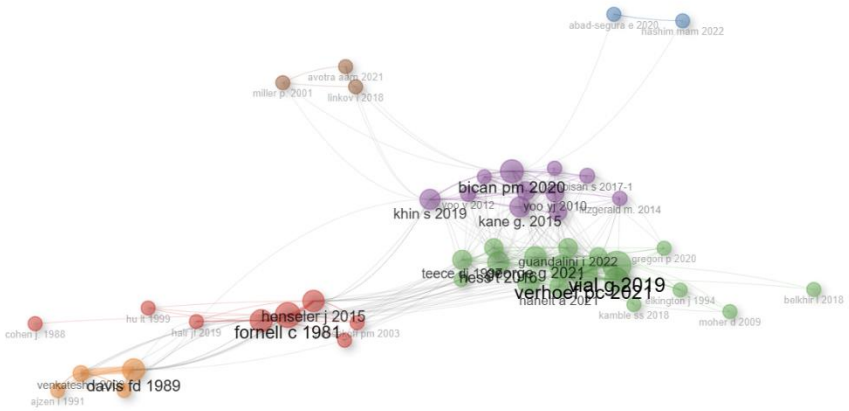

Figure 11. Connections Between Co-citation Papers

For co-citation analysis of articles, a network visualization was created by analyzing the number of nodes as 50, the minimum number of edges as 2, the number of labels as 1000, and the label size as 2, as suggested by the programme (Aria & Cuccurullo, 2017). The network map formed by the six clusters is given in Figure 11. Other numerical values related to co-citation papers are indicated in Table 2.

Table 2. Co-citation Analysis Metrics for Papers

Node	*Cluster*	*Betweenness*	*Closeness*	*PageRank*
Vial G 2019	3	71,135	0,008	0,045
Verhoef Pc 2021	3	95,142	0,009	0,043
Matt C 2015	3	20,083	0,008	0,034
Bican Pm 2020	4	234,266	0,009	0,033
Hair J. 2019	1	58,557	0,009	0,032
Warner Ksr 2019	3	11,94	0,008	0,032
Hanelt A 2021	3	9,338	0,007	0,032
Fornell C 1981	1	199,671	0,009	0,031
Feroz Ak 2021	3	31,49	0,008	0,031
Nylén D 2015	4	7,251	0,008	0,031

According to Table 2, in the co-citation analysis for papers, Vial G 2019 and Verhoef Pc 2021 were identified as the most influential papers in the prominent green cluster.

Co- citation Network Analysis of Sources

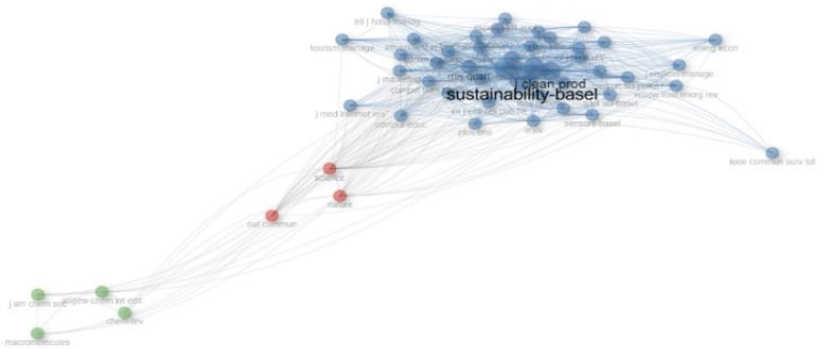

Figure 12. Connections Between Co-citation Sources

In publications on the topic of sustainable digital, sources were selected as the unit of analysis in order to perform a co-citation analysis. A network visualization was created by analyzing the number of nodes as 50, the minimum number of edges as 2, the number of labels as 1000, and the label size as 2, as suggested by the programme (Aria & Cuccurullo, 2017). In this way, as illustrated in Figure 12, a total of three clusters were identified.

Table 3. Co-citation Analysis Metrics for Sources

Node	*Cluster*	*Betweenness*	*Closeness*	*PageRank*
Sustainability-Basel	2	43,517	0,009	0,068
J Clean Prod	2	16,555	0,009	0,05
Technol Forecast Soc	2	16,612	0,009	0,047
J Bus Res	2	8,733	0,009	0,046
Int J Inform Manage	2	4,763	0,009	0,037
Mis Quart	2	2,853	0,009	0,034
Ieee Access	2	6,147	0,009	0,025
Bus Strateg Environ	2	0,458	0,006	0,024
Technol Soc	2	1,6	0,008	0,024
Int J Prod Res	2	0,387	0,008	0,023

When examining Table 3, which also presents other numerical metrics, in the co-citation analysis for sources, the most cited sources, respectively Sustainability-Basel and J Clean Prod, belong to the blue cluster.

Findings Related to Social Stcture

Analyses of collaboration networks are grouped under the concept of social structure (Aria & Cuccurullo, 2017; Büyükkıdık, 2022).

Collaboration Network of Authors

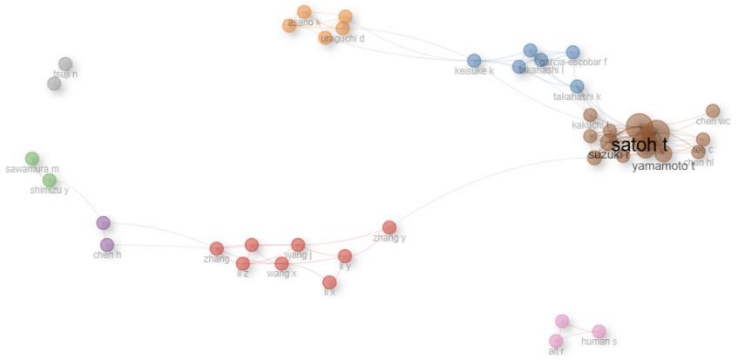

Figure 13. Collaboration Connections Between Authors

In the analyses carried out through the collaboration network, the authors were first selected, and then, as suggested by the programme, the number of nodes was chosen to be 50, the minimum number of edges to 5, the number of labels to 1000, and the label size to 2 (Aria and Cuccurullo, 2017). As a result, 8 clusters consisting of 42 authors were identified and presented in Figure 13.

Table 4. Collaboration Analysis Metrics for Authors

Node	*Cluster*	*Betweenness*	*Closeness*	*PageRank*
Satoh T	6	200,288	0,012	0,056
İsono T	6	40,462	0,011	0,054
Li F	6	23,245	0,011	0,046
Tajima K	6	12,732	0,011	0,037
Suzuki R	6	9,958	0,011	0,034
Yamamoto T	6	10,323	0,01	0,033
Zhang	1	128	0,007	0,031
Wang X	1	11	0,007	0,03
Wang J	1	198,5	0,008	0,029
Uraguchi D	5	32	0,008	0,028

Other numerical values related to the analysis of publications containing the concept of sustainable digital through collaboration between authors are presented in Table 4. In the collaboration network shown in Figure 13, the publication frequency of authors is directly proportional to the size of the nodes. It is determined that the author who collaborated the most is Satoh T., who is in the brown cluster.

Collaboration Network of Institutions

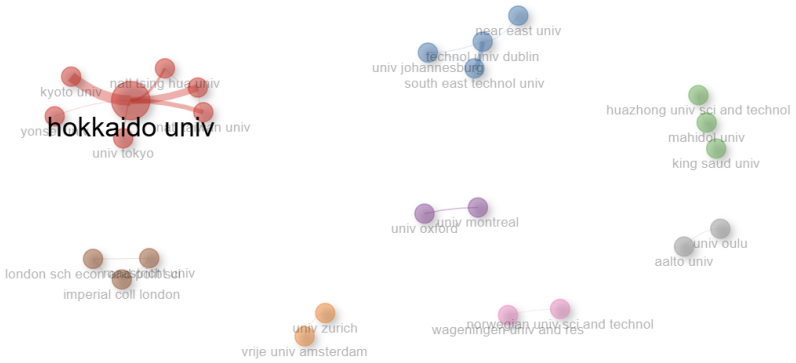

Figure 14. Collaboration Connections Between Institutions

In the analyses performed through the collaboration network, institutions were selected this time, and then the number of nodes was set to 50, the minimum number of edges to 5, the number of labels to 1000, and the label size to 2, as suggested by the programme (Aria and Cuccurullo, 2017). As a result of the analysis, 8 clusters comprising 25 institutions were formed and are presented in Figure 14. Other numerical metrics are provided in Table 5.

Table 5. Collaboration Analysis Metrics for Institutions

Node	*Cluster*	*Betweenness*	*Closeness*	*PageRank*
Hokkaido Univ	1	12,92	0,17	0,12
Technol Univ Dublin	2	2	0,33	0,07
Mahidol Univ	3	1	0,5	0,06
South East Technol Univ	2	0	0,25	0,05
Natl Cent Univ	1	0,08	0,11	0,04
İmperial Coll London	6	0	0,5	0,04
London Sch Econ and Polit Sci	6	0	0,5	0,04
Maastricht Univ	6	0	0,5	0,04
Univ Montreal	4	0	1	0,04
Univ Oxford	4	0	1	0,04

When examining Figure 14, Hokkaido Universityis highlighted in red in large, bold letters, demonstrating that it is a central player in the academic network, collaborating with numerous other universities.

Collaboration Network of Countries

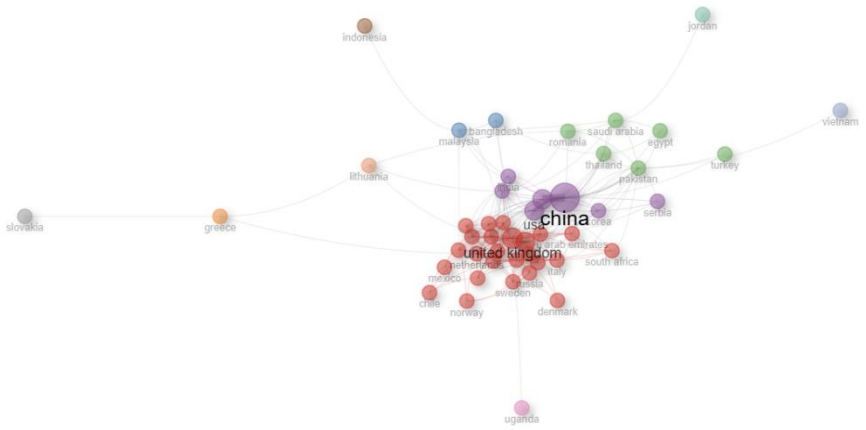

Figure 15. Collaboration Connections Between Countries

When the collaboration network was selected for countries, the number of nodes was again set to 50, the minimum number of edges to 5, the number of labels to 1000, and the label size to 2 (Aria and Cuccurullo, 2017). As a result of the analysis, 11 clusters consisting of 47 countries were found and are given in Figure 15. Other numerical metrics are shown in Table 6.

Table 6. Collaboration Analysis Metrics for Countries

Node	*Cluster*	*Betweenness*	*Closeness*	*PageRank*
China	4	228,61	0,015	0,09
United Kingdom	1	107,72	0,015	0,06
Germany	1	72,64	0,014	0,05
Netherlands	1	136,56	0,014	0,05
Usa	4	29,84	0,013	0,05
Japan	4	4,55	0,012	0,04
Spain	1	43,84	0,013	0,04
Pakistan	3	84,83	0,012	0,04
Australia	1	15,62	0,013	0,03
France	4	32,67	0,013	0,03

When examining Table 6, China has been the most collaborative country, followed by the United Kingdom. China, shown in Figure 15 in purple, is at the centre of the network and has become the most active country in the network by collaborating with many countries.

Countries' Collaboration World Map

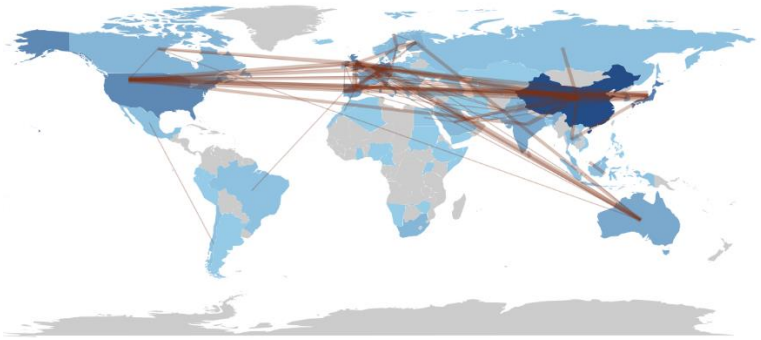

Figure 16. Countries' Collaboration World Map

The representation of countries' collaboration networks on a world map is shown in Figure 16. Table 7 shows which countries are involved in the collaboration and the frequency of collaboration.

Table 7. Collaboration Between Countries

From	*To*	*Frequency*
China	Japan	17
China	Usa	10
China	Pakistan	9
China	United Kingdom	6
United Kingdom	Netherlands	6
Germany	Australia	5
Germany	Austria	5
United Kingdom	Spain	5
United Kingdom	Usa	5
China	Germany	4

According to Table 7, China and Japan collaborate most frequently with 17 frequencies, followed by China and the

USA with 10 frequencies.

CONCLUSION AND DISCUSSION

Yazı Sustainability and digitalization have become two important concepts that have attracted a great interest both in the academic world and in applied fields on a global scale in recent years (Lozano, 2008; Bocken vd., 2014). The "sustainable digital" approach, which is located at the junction of these two fields, is increasingly appearing in the literature and becoming the focus of interdisciplinary studies (George vd., 2021). In this respect, a total of 601 publications containing the term "sustainable digital" in the Web of Science database between 2002 and 2025 were analyzed by bibliometric analysis method. The analyses conducted using the Biblioshiny web interface in the R program aimed to reveal the development trends of the subject in the literature, prominent authors, countries and institutions, collaboration structures and citation relationships.

In the results of the research, it was determined that academic publications on the subject of sustainable digital have shown an increasing trend between 2002-2025. Especially, 147 publications in 2024 and 107 publications in just the second quarter of 2025 show that the topic remains highly topical and of strong academic interest. This is an indication that sustainable digital transformation is gaining importance at both the theoretical and practical level.

In terms of publication types, the most common format is articles (420 publications); this finding coincides with Gültekin and Korkma's (2024) study in which articles are the most common type. A similar parallelism is evident in the fact that the green sustainable science and technology category is the most preferred subject area in both studies.

When the distribution of publications by country is analyzed, it is observed that China stands out as the leading country. On the other hand, in Gültekin and Korkma's study, the UK came to the forefront, in addition, in Sharma et al.'s (2021) study, the US is found to be the active country and the study differed in this respect.

While Satoh T. become the most prolific author in this study, Lago P. and Pan S.L. (4 publications each) are reported as the most prolific authors in the study of Gültekin and Korkmaz (2024), and Saad M. is identified in the study of Omar and Abdullahi (2024). Moreover, while Kim Kh is identified as the bridge author in Sharma et al. (2021), Satoh T. is the most active author in the collaboration network in this study. It is identified that the results obtained differed.

From the point of citation analysis, while the most cited article in this study is Vial G. (2019); in Sharma et al. (2021) the high number of citations to older studies such as Oliver (1997) and Watson (2010) is noteworthy.

In the context of keyword analysis, similar to the results of Sharma et al. (2021), the word "sustainability" was the most frequently used keyword. However, Omar and Abdullahi (2024) concluded that "developing countries" and "sustainable development" were the prominent words in their study.

When the results are evaluated in general, the findings of this study match the trends in the existing literature in some points, but also show differences in some points. From a bibliometric perspective, the increase in the number of publications, the density of author collaboration networks and the diversity of prominent keywords show that the sustainable digital field has a dynamic and developing structure. The formation of distinct clusters at the country, institutional and author level indicates that the field is shaped around certain foci. This diversity emphasizes the importance of interdisciplinary approaches and underlines the need for more in-depth bibliometric analyses in the

future. Furthermore, this study contributes to the theoretical understanding of sustainable digitalization by revealing academic trends, key contributors, and collaboration networks. Practically, the findings can inform institutions and industry stakeholders in integrating sustainability principles into digital transformation, particularly in areas such as environmental policy, higher education, and corporate sustainability practices.

DESTEK VE TEŞEKKÜR BEYANI

Çalışma herhangi bir destek almamıştır. Teşekkür edilecek bir kurum veya kişi bulunmamaktadır.

ÇIKAR ÇATIŞMASI BEYANI

Çalışma kapsamında herhangi bir kurum veya kişi ile çıkar çatışması bulunmamaktadır.

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