

BRIDGING DIGITAL SKILL DEVELOPMENT AND THE SUSTAINABLE DEVELOPMENT GOALS (SDG 4 & SDG 8): A BIBLIOMETRIC REVIEW OF GLOBAL RESEARCH

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Abstract

This study provides a comprehensive bibliometric analysis of research on skill development and Sustainable Development Goals (SDGs), focusing on how the field has evolved over time and the dominant themes shaping its intellectual structure. Using data retrieved from the Scopus database, a total of 402 studies published between 2015 and 2025 were analyzed. Bibliometric techniques, including author citation analysis and keyword co-occurrence mapping, were applied through VOSviewer and Biblioshiny (R Studio). The analysis identified six key thematic clusters: (1) Innovation, Entrepreneurship, and Human Capital Development; (2) Economic Growth, Policy, and Energy-Environment Nexus; (3) Digital Transformation and Technological Advancement; (4) Sustainability, Green Economy, and Socioeconomic Development; (5) Digital Skills, Inclusion, and Governance; and (6) Twin Transition and Advanced Technology Integration. The results reveal a steady increase in research output and citations, indicating growing global interest in integrating digital competencies with sustainable development objectives. Unlike previous bibliometric studies that have examined either SDGs or digital skills independently, this research bridges both domains, offering an integrated perspective on their intersection. The study contributes to the literature by mapping emerging research frontiers and providing valuable insights for policymakers, educators, and practitioners aiming to align digital skill initiatives with sustainable development agendas. Future research should integrate cross-regional collaboration, longitudinal analyses, and policy-driven studies to strengthen the linkage between digital competencies, sustainability transitions, and inclusive growth within the framework of SDG 4 and SDG 8.

Keywords: Digital Skill Development; Sustainable Development Goals; SDG 4; SDG 8; Digital Transformation; Human Capital; Innovation; Green Economy; Twin Transition; Bibliometric Analysis; VOSviewer; Biblioshiny; Sustainability; Digital Inclusion.

1. Introduction

In the context of the United Nations' 2030 Agenda for Sustainable Development, the interconnected goals of ensuring inclusive and equitable quality education (Sustainable Development Goal 4, SDG 4) and promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (Sustainable Development Goal 8, SDG 8) assume critical priority (United Nations, 2015). At the same time, the rapid digitalisation of economies and societies has foregrounded the significance of digital

competencies—often phrased as “digital skills,” “digital literacy,” and “digital competence”—as foundational enablers of both educational inclusion and labour-market relevance (IFLA, 2024; Miyamoto & Bashir, 2020). The evolving nexus between digital skill development, education, employment, and sustainable growth therefore merits systematic scholarly attention.

Digital skill development is not simply a matter of technical proficiency. It encompasses the capacity to access, manage, evaluate, create and communicate information through digital technologies, and thereby participates in human capital formation, innovation capabilities and economic resilience (IFLA, 2024). From an education perspective (SDG 4), digital skills open the possibility of expanding access, enhancing pedagogical quality and supporting lifelong learning (Singh & Martolia, 2024). From a labour-market and economic development viewpoint (SDG 8), these same competences underpin employability, productivity and the transition to more inclusive and technologically resilient economies (World Bank, 2020).

Against this background, the present study undertakes a comprehensive bibliometric review of global research connecting digital skill development and the Sustainable Development Goals (specifically SDG 4 and SDG 8). Using Biblioshiny (R/Bibliometrix) and VOSviewer, the analysis traces publication trends over time, country-wise and journal-wise patterns, author influence, citation dynamics, institutional productivity, keyword networks and thematic clustering. The analytical framework identifies six key thematic clusters — (1) Innovation, Entrepreneurship, and Human Capital Development; (2) Economic Growth, Policy, and Energy-Environment Nexus; (3) Digital Transformation and Technological Advancement; (4) Sustainability, Green Economy, and Socioeconomic Development; (5) Digital Skills, Inclusion, and Governance; and (6) Twin Transition and Advanced Technology Integration.

The focus on these clusters is justified by the diverse yet interlinked contours of the field: for example, the cluster “Innovation, Entrepreneurship and Human Capital Development” acknowledges that digital skill formation contributes to entrepreneurial capabilities and human capital accumulation, thereby feeding into economic growth (SDG 8). Simultaneously, “Digital Skills, Inclusion and Governance” emphasises the role of digital inclusion, governance frameworks and skill equity—themes strongly tied to SDG 4’s emphasis on inclusive and equitable quality education. The inclusion of “Twin Transition and Advanced Technology Integration” recognises the dual shift towards digital and green economies, aligning the study with broader sustainability imperatives beyond education and employment. By mapping and synthesising these clusters, the study offers a structured overview of the field, highlights research hotspots, identifies gaps and suggests avenues for future investigation.

The significance of this work lies in its ability to provide an evidence-based foundation for scholars, educational and policy practitioners, and international organisations concerned with digital skills, education policy and sustainable development. The bibliometric approach allows us to quantify and visualise trends, reveal influential actors and institutions, and trace the evolution of research domains over time. In doing so, it richly complements a qualitative systematic literature review (SLR) of the included articles, thereby yielding both breadth and depth in understanding the digital skill–SDG nexus.

In sum, this study addresses three major research questions:

1. What are the publication trends (time, country, journal) in the digital skill–SDG 4/SDG 8 research domain?
2. Who are the most productive authors, institutions and countries and what is their influence?

3. What thematic clusters and keyword networks characterise this field, and where do conceptual or methodological gaps remain?

By employing Biblioshiny and VOSviewer as analytical tools, the study maps the field's intellectual structure, reveals emergent thematic clusters and offers a research agenda for strengthening linkages between digital skill development and sustainable development goals. The paper is structured to present a coherent progression from conceptual framing to empirical insights and future implications. Following this introduction, the Research Methodology section details the analytical design adopted for the study, including the data source selection, search strategy, and screening and filtering process implemented through Scopus, Biblioshiny, and VOSviewer. This is followed by the Results section, which presents the key findings of the bibliometric analysis, encompassing publication trends, influential authors, productive institutions, and thematic clusters derived from keyword co-occurrence mapping. The subsequent section delineates the identified research gaps, highlighting underexplored intersections between digital skill development, sustainable education, and inclusive economic growth. Building upon these insights, the paper advances suggestions for future research, offering conceptual and methodological directions to strengthen the digital skills-SDG nexus. Finally, the Conclusion encapsulates the overall findings, emphasizing the study's theoretical contribution and policy relevance in promoting digital competence as a driver of sustainable development within the frameworks of SDG 4 and SDG 8.

2. Methodology

2.1. About bibliometric analysis

In order to evaluate the impact and influence of scholarly work, bibliometrics is a quantitative technique that examines patterns and trends in academic literature, such as citation counts, authorship networks, and publication rates (Moharram et al., 2024; Mishra et al., 2025). This sheds light on how research in certain sectors or disciplines is disseminated and made visible (Gao et al., 2021). In addition, this study offers useful directions and ideas for future research (Gursoy et al., 2019).

2.2. Data source selection

This study adopts a bibliometric approach to analyze research focused on skill development and Sustainable Development Goals (SDGs). In contrast to the Web of Science (WoS), the Scopus database's broad journal coverage and effective citation analysis skills led to its selection as the main data source (Joshi et al., 2016; Senadheera et al., 2022). Scopus is the recommended option for bibliometric analysis since it provides a wider selection of business and management articles and facilitates easy data export. The Scopus database, which removes the need for manual procedures when exporting more than 500 papers, is more convenient for data export than the Web of Science (WoS). Additionally, Scopus offers a greater selection of business and management periodicals. Thus, for bibliometric analysis, Scopus is a superior choice than the WOS database (Gao et al., 2021).

2.3. Search strategy

A comprehensive search was conducted in the Scopus database using the following search

string: TITLE-ABS-KEY ("digital skill*" OR "digital literacy" OR "digital competence" OR "digital transformation" OR "ICT skill*" OR "digital education" OR "digital training" OR "digital inclusion" AND "sustainable development goals" OR "SDG" OR "SDG4" OR "SDG 4" OR "quality education" OR "SDG8" OR "SDG 8" OR "decent work" OR "economic growth"). The search was applied to titles, abstracts, and keywords of publications, yielding an initial dataset of 2,407 documents published up to October 2025.

The time period from 2015 to 2025 was selected as it aligns with the formal adoption of the United Nations Sustainable Development Goals (SDGs) in 2015, marking the beginning of global policy emphasis on sustainability, digital inclusion, and skill development. Although the time frame begins in 2015, the first document in the dataset was published in 2018, indicating that academic interest in this intersection emerged gradually. This range allows the study to capture the decadal evolution of research trends, policy implications, and academic attention on the intersection of digital skill development and sustainable development goals.

2.4. Screening and filtering process

A systematic and multi-stage screening process, as illustrated in the accompanying flowchart Flowchart 2.4 : Stepwise Screening Process for Bibliometric and SLR Study, was applied to refine the initial dataset and ensure the inclusion of only the most relevant and high-quality publications for bibliometric analysis. This initial query generated 2,407 papers.

In the first stage, publications were filtered based on the year of publication, restricting the range to the period between 2015 and 2025. This ten-year window was chosen to capture recent developments in digital transformation, sustainability education, and skill-based economic discourse, resulting in 2,385 papers.

In the second stage, the dataset was limited to specific subject areas most relevant to the study—namely *Business, Management, Economics, and Econometrics*. This ensured that the analysis focused on the economic and managerial dimensions of digital skills and sustainability, yielding 870 papers.

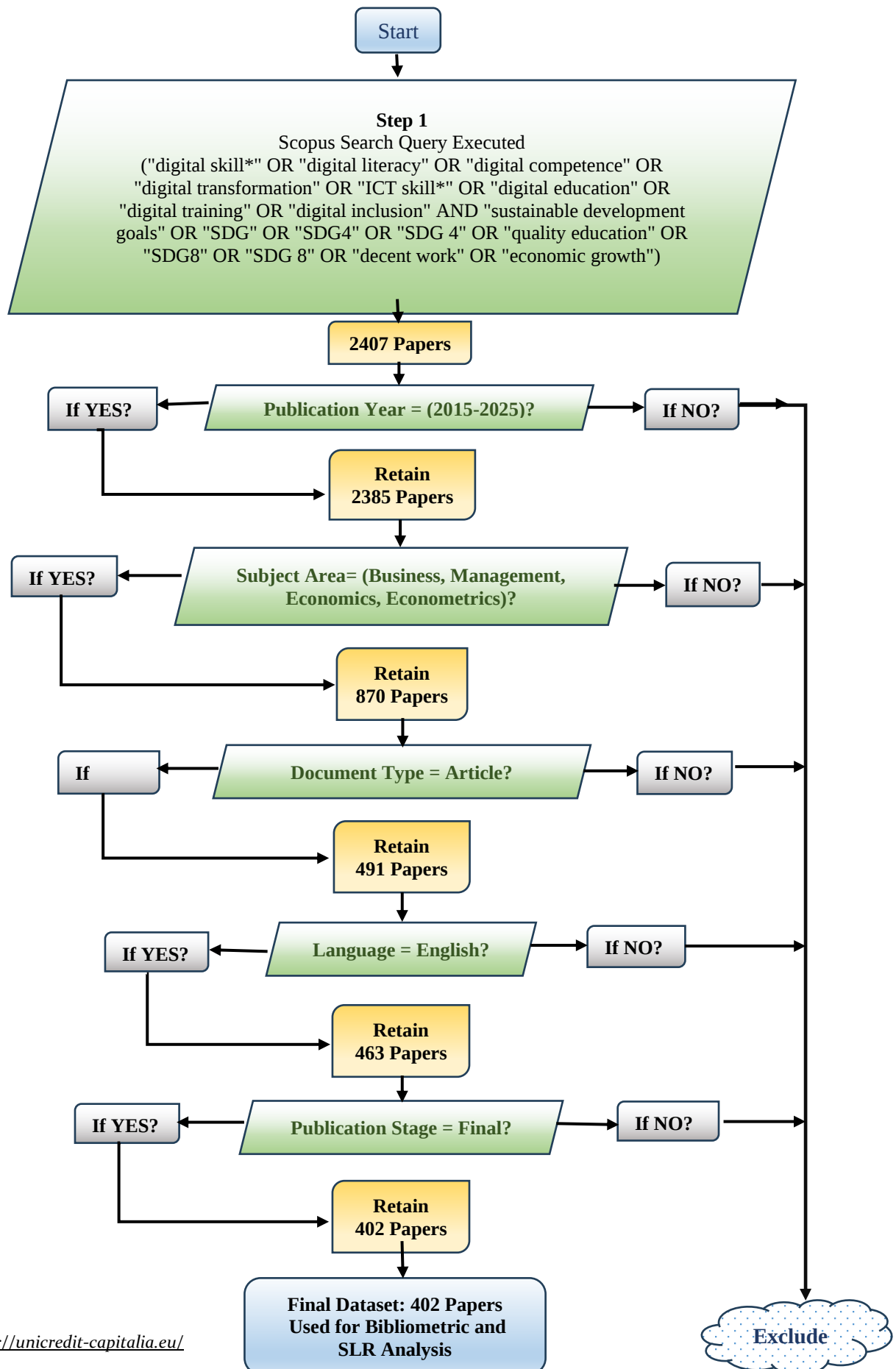
In the third stage, only records categorized as articles were retained, while conference papers, reviews, book chapters, and editorials were excluded. This step enhanced the academic rigor and comparability of the dataset, leaving 491 articles.

The fourth stage refined the dataset by including only publications written in English language to maintain analytical consistency. After this filtration, 463 papers remained.

The fifth stage filtered documents by publication stage, retaining only those with a *final publication status* and excluding articles still “in press.” This final screening yielded 402 papers, forming the definitive dataset used for bibliometric and SLR analysis.

Each stage of this process was performed manually within Scopus to ensure accuracy and eliminate duplication. The resulting dataset of 402 articles was then exported in CSV formats for analysis in VOSviewer and Biblioshiny (R/Bibliometrix). These tools enabled visualization of publication trends over time, country-wise and journal-wise contributions, author influence and citation networks, institutional productivity, and keyword co-occurrence clusters. The structured screening approach ensured methodological transparency, reproducibility, and thematic precision—core principles of bibliometric research design.

Flowchart 2.4 : Stepwise Screening Process for Bibliometric and SLR Study



2.5 Software used for analysis

Vosviewer and Biblioshiny, two popular programs for bibliometric analysis and visualisation, were employed in this study. The Vosviewer, created by Van Eck and Waltman (2010) at Leiden University, provides useful insights into the ESG research landscape by mapping connections between journals, authors, citations, and keywords (Gao et al., 2021; Wan et al., 2023). This is very helpful for keyword analysis and co-citation. Furthermore, bibliometric analysis is made easier to understand by Biblioshiny, an intuitive user interface of the Bibliometrix R package (Aria & Cuccurullo, 2017). Both approaches are well recognized for identifying patterns and trends in research (Baker et al., 2020).

3. Results

Results are derived from two types of analyses: scientific production and bibliometric mapping.

3.1. Publication Trend over Time

The temporal distribution of publications and citations presented in the Table 3.1.2 (Publication Trend over Time- Based on the no. of Documents and Yearly Citations) and Figure 3.1.1 (Publication Trend over Time- Based on the no. of Documents) illustrates the progressive evolution of research focusing on skill development and Sustainable Development Goals (SDGs) from 2018 to 2025.

The analysis indicates that scholarly attention to this domain began modestly in 2018 and 2019, with only one and seven publications, respectively, accumulating a total of 206 citations. This initial stage represents the emergence phase of research, where the conceptual connection between digital skills and sustainable development was beginning to gain recognition.

A notable escalation is observed from 2020 to 2023, marking the growth phase of the research field. During this period, the number of publications increased substantially, from 14 in 2020 to 51 in 2023, accompanied by a sharp rise in citation counts, peaking at 1,686 citations in 2023. This surge reflects a growing academic and policy interest, coinciding with the post-pandemic acceleration of digital transformation, online education, and employment transitions associated with SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth).

In 2024 and 2025, the number of publications reached its highest levels, with 118 and 156 documents, respectively, suggesting sustained research momentum and diversification of topics within this field. However, citation counts showed a relative decline, likely due to the recency of publications that have not yet had sufficient time to accrue citations. This trend indicates a shift towards the maturation phase of the research area, characterised by thematic expansion and consolidation of existing knowledge.

Overall, the increasing trajectory of publications underscores the rising academic significance and interdisciplinary nature of the nexus between skill development and the SDGs. Meanwhile, the citation patterns reveal that studies published during 2020–2023 provided a foundational intellectual base for subsequent research, reinforcing the strategic importance of digital competencies in achieving sustainable and inclusive growth.

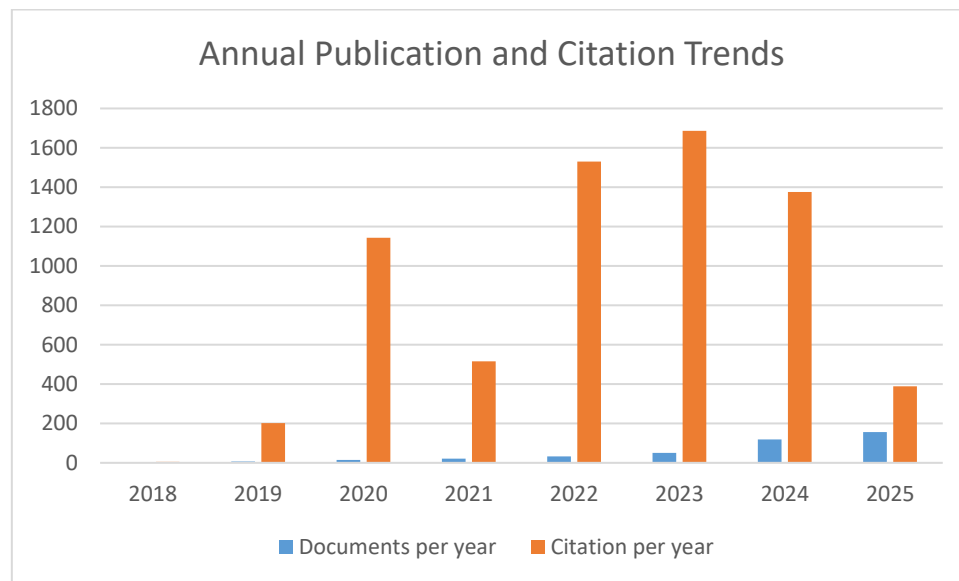


Figure 3.1.1 (Publication Trend over Time- Based on the no. of Documents)

Years	Documents Per Year	Citation Per Year
2018	1	5
2019	7	201
2020	14	1143
2021	22	515
2022	33	1531
2023	51	1686
2024	118	1375
2025	156	389
(blank)		
Grand Total	402	6845

Table 3.1.2 (Publication Trend over Time- Based on the no. of Documents and Yearly Citations)

3.2 Country-wise publication trend

The bibliometric analysis based on the keywords “*skill development*” and “*Sustainable Development Goals (SDGs)*” includes research contributions from a total of 71 countries. The results reveal a wide disparity in publication productivity across nations, highlighting both regional strengths and research gaps.

China dominates the field with 226 publications, accounting for the highest research output. This leadership underscores China’s strategic emphasis on aligning skill development initiatives with sustainable growth and technological innovation. Ukraine (97 publications) and India (80 publications) follow, reflecting growing academic and policy-oriented interest in integrating education, employability, and sustainability goals.

Among other emerging economies, Indonesia (65), Kazakhstan (49), Malaysia (46), and Bangladesh (19) display substantial engagement, emphasizing the significance of skill enhancement and workforce readiness in advancing SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth).

Developed nations such as Spain (45), USA (42), UK (36), Italy (34), Australia (27), and South Korea (27) also contribute considerably, suggesting a global recognition of the role of digital

skills, innovation, and education reform in achieving sustainability objectives.

However, a notable number of countries — including Afghanistan, Armenia, Denmark, Iran, Moldova, Morocco, and Sudan — record only one publication each, indicating limited research activity in this domain.

Overall, the findings suggest that the research on *skill development* and *SDGs* is concentrated primarily in Asia and Europe, with China, Ukraine, and India emerging as the most influential contributors. There remains considerable potential for increased collaboration and scholarly engagement from underrepresented regions such as Africa, the Middle East, and Latin America.

Country	Frequency
CHINA	226
UKRAINE	97
INDIA	80
INDONESIA	65
KAZAKHSTAN	49
MALAYSIA	46
SPAIN	45
USA	42
UK	36
ITALY	34
ROMANIA	32
AUSTRALIA	27
SOUTH KOREA	27
SAUDI ARABIA	25

Table 3.2.1 (Country-wise publication trend)

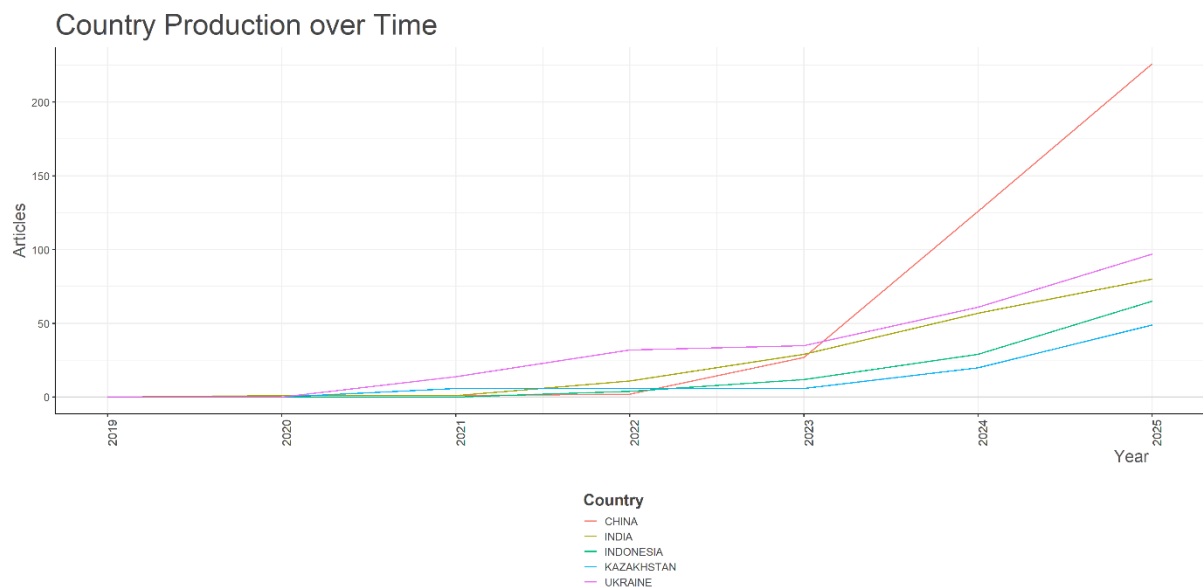


Figure 3.2.2 (Trend shown in graph)

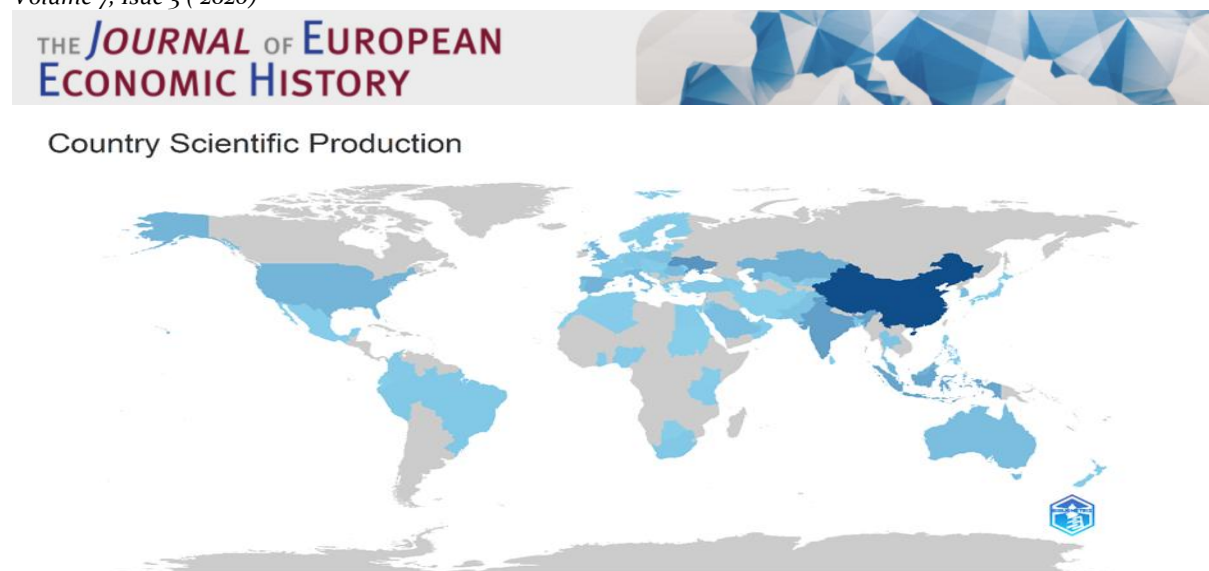


Figure 3.2.3 (Global presentation of country publication Density)

3.3 Journal-wise publication trend

The bibliometric analysis identified research contributions from a total of **204 different journals** that have published studies related to “*skill development*” and “*Sustainable Development Goals (SDGs)*”. The wide distribution of publications across journals indicates that this topic is interdisciplinary, bridging domains such as economics, management, technology, innovation, and sustainability studies.

Among all sources, the most prolific journal is Resources Policy with 16 publications, emphasizing its central role in exploring how resource allocation and sustainable policy frameworks intersect with skill enhancement and SDG achievement. This is followed by the Journal of Cleaner Production (11 articles), which frequently publishes research on sustainability, green innovation, and circular economy approaches aligned with skill-based transitions toward sustainable industries.

Other influential outlets include, International Review of Economics and Finance (9), Technological Forecasting and Social Change (9), Humanities and Social Sciences Communications (8), Journal of Open Innovation: Technology, Market, and Complexity (8), Journal of the Knowledge Economy (8).

These journals highlight the growing importance of innovation, technology, and knowledge transfer in promoting sustainable skill ecosystems.

Additionally, journals such as IEEE Transactions on Engineering Management (7), Telecommunications Policy (7), and Economies (6) reflect an expanding focus on digital transformation, economic restructuring, and governance frameworks that support SDG-driven education and employment outcomes.

A large number of journals (over 150) have published only one article each, indicating that while the topic is gaining attention globally, it remains widely dispersed across different publication outlets without a single dominant disciplinary home. This dispersion suggests that research on skill development and SDGs is still evolving, with opportunities for more cohesive and cross-journal scholarly collaboration.

Sources	Articles
RESOURCES POLICY	16
JOURNAL OF CLEANER PRODUCTION	11

INTERNATIONAL REVIEW OF ECONOMICS AND FINANCE	9
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	9
HUMANITIES AND SOCIAL SCIENCES COMMUNICATIONS	8
JOURNAL OF OPEN INNOVATION: TECHNOLOGY, MARKET, AND COMPLEXITY	8
JOURNAL OF THE KNOWLEDGE ECONOMY	8
IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT	7
TELECOMMUNICATIONS POLICY	7
ECONOMIES	6
PROBLEMS AND PERSPECTIVES IN MANAGEMENT	6

Table 3.3.1

3.4 Author influence analysis

Out of a total of 1,264 authors contributing to the research on skill development and the Sustainable Development Goals (SDGs), the top 10 most influential authors were identified based on their publication count (minimum of two documents) and citation impact. Table X presents the results.

Among these, Rakesh Dulichand Raut from the Department of Operations and Supply Chain Management, Indian Institute of Management Mumbai, India emerged as the most influential author, with 2 publications and an impressive 285 citations, highlighting his significant contribution to the intersection of sustainability, supply chain, and skill development research. Mohammad Iranmanesh from La Trobe University, Melbourne, Australia followed with 169 citations, indicating his strong research influence in digital transformation and sustainable business practices.

Adnan Safi and Muhammad Umar, both affiliated with the Adnan Kassar School of Business, Beirut, Lebanon, have each contributed 3 publications with 77 citations, reflecting consistent engagement and collaboration in the field. From Eastern Europe, K. M. Kraus of The Bohdan Khmelnytsky National University of Cherkasy, Ukraine, and Nataliya M. Kraus from Borys Grinchenko Kyiv Metropolitan University, Ukraine, also demonstrated substantial research visibility with 58 and 57 citations, respectively.

In Asia, authors such as Hongyun Tian (Jiangsu University, China), Ghulam Ghouse (University of Lahore, Pakistan), Qiang Wu (School of Accounting and Finance, Hong Kong), and Tanpat Kraiwanit (Pathumthani University, Thailand) have made notable contributions with moderate citation counts ranging between 16 and 38, signifying emerging research influence and growing participation from developing regions.

Overall, these results highlight a geographically diverse authorship pattern, with strong representation from Asia, the Middle East, and Eastern Europe. The concentration of highly cited authors in these regions suggests a global and multidisciplinary interest in linking skill development initiatives with the achievement of SDGs through digital transformation and sustainable practices.

Author	Documents	Citations	Affiliation	Country
Raut, Rakesh Dulichand	2	285	Department of Operations and Supply Chain Management, Indian Institute of Management Mumbai	India
Iranmanesh,	2	169	La Trobe University, Melbourne	Australia

Mohammad				
Safi, Adnan	3	77	Adnan Kassar School of Business, Beirut, Lebanon; School of Economics, Qingdao University, Qingdao	Lebanon / China
Umar, Muhammad	3	77	Department of Finance & Accounting, Adnan Kassar School of Business, Beirut	Lebanon
Kraus, K. M.	3	58	The Bohdan Khmelnytsky National University of Cherkasy, Cherkasy	Ukraine
Kraus, Nataliya M.	2	57	Department of Economics and Finance, Borys Grinchenko Kyiv Metropolitan University, Kyiv	Ukraine
Tian, Hongyun	2	38	Jiangsu University, Zhenjiang	China
Ghouse, Ghulam	2	31	Department of Economics, University of Lahore, Lahore	Pakistan
Wu, Qiang	2	31	Faculty of Business, School of Accounting and Finance, Hong Kong	Hong Kong (China)
Kraiwanit, Tanpat	3	16	Pathumthani University, Pathum Thani	Thailand

Table 3.4.1 (Author influence analysis- Based on Documents and Citations)

3.5 Publication citation analysis

The bibliometric analysis highlights the most impactful publications addressing *skill development* in relation to the *Sustainable Development Goals (SDGs)*, particularly emphasizing themes such as *digital transformation*, *economic growth*, and *technological innovation*. The table comprises 10 highly cited papers published between 2020 and 2024, reflecting the growing academic interest in the intersection of digitalization, sustainability, and human capital development.

Among these, the paper “The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities” (Journal of the Knowledge Economy, 2022) emerges as the most influential, with 375 global citations and 4 local citations, underscoring its foundational contribution to discussions on the role of higher education and advanced technologies (Industry 5.0, Society 5.0) in fostering skill development for a sustainable future.

The study “Digitalization and its Impact on Economic Growth” (Brazilian Journal of Political Economy, 2022) follows, with 39 global citations, highlighting the macroeconomic implications of digitalization as a key enabler for achieving SDG-driven growth.

Similarly, “The Role of Digitalization in Business and Management: A Systematic Literature Review” (Review of Managerial Science, 2024) and “Extenuating Operational Risks through Digital Transformation of Agri-Food Supply Chains” (Production Planning and Control, 2023) received 126 and 78 global citations, respectively. These works emphasize the transformative role of digital technologies in business processes and sustainable supply chain management, linking closely with SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure).

Papers such as “Pairing AI and Sustainability: Envisioning Entrepreneurial Initiatives for Virtuous Twin Paths” (Appio et al., 2024) and “Measuring the Grand Challenge of the Digital

Transformation of Society” (Diniz et al., 2023) illustrate the emerging integration of artificial intelligence and sustainability practices in entrepreneurship and governance.

Notably, the “Role of National Intellectual Capital in the Digital Transformation of EU Countries” (Dumay & Marini, 2020) with 90 global citations also contributes significantly by addressing the “digital divide” and capacity-building challenges within the European context, which are directly relevant to SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities).

Overall, the period from 2020 to 2024 has seen rapid scholarly advancements, with increasing attention toward digital competencies, sustainability-oriented innovation, and inclusive growth. The dominance of journals such as the *Journal of the Knowledge Economy* and *IEEE Transactions on Engineering Management* indicates that the convergence of digital transformation and sustainability has become a core research domain connecting economics, management, and policy disciplines.

Document	Year	Journal	Local Citations	Global Citations	References
The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities	2022	Journal of the Knowledge Economy	4	375	(Lukovics & Udvari, 2021)
Digitalization and its impact on economic growth	2022	Brazilian Journal of Political Economy	3	39	(Aleksandrova, Truntsevsky, & Polutova, 2022)
The role of digitalization in business and management: a systematic literature review	2024	Review of Managerial Science	2	126	(Marques & Santos, 2023)
The productivity and unemployment effects of the digital transformation: an empirical and modelling assessment	2020	Review of Evolutionary Political Economy	2	57	(Bertani, Raberto, & Teglio, 2020)
Pairing AI and Sustainability: Envisioning Entrepreneurial Initiatives for Virtuous Twin Paths	2024	IEEE Transactions on Engineering Management	1	16	(Appio, Platania, & Hernandez Toscano, 2024)
Measuring the Grand Challenge of the Digital	2023	IEEE Transactions on Engineering	1	4	(Diniz, Santos, & Cunha, 2022)

Transformation of Society: Practices for Operationalizing Robust Action Strategies		Management			
Extenuating operational risks through digital transformation of agri-food supply chains	2023	Production Planning and Control	1	78	(Ali & Govindan, 2021)
Digital Government and Sustainable Development	2022	Journal of the Knowledge Economy	1	147	(Castro & Lopes, 2022)
Digital transformation and economic cooperation: The case of Western Balkan countries	2020	Zbornik radova Ekonomskog fakulteta u Rijeci / Proceedings of Rijeka Faculty of Economics	1	12	(Broz, Buturac, & Parežanin, 2020)
The role of national intellectual capital in the digital transformation of EU countries. Another digital divide?	2020	Journal of Intellectual Capital	1	90	(Dumay & Marini, 2020)

Table 3.5.1 (Publication citation analysis)

3.6 Highly productive institutions/organizations

A total of 660 institutions and universities contributed to research on the theme of *skill development and Sustainable Development Goals (SDGs)* within the analyzed dataset. However, Table X highlights only the top contributing institutions, representing those with the highest number of publications in this field.

Among these, the L.N. Gumilyov Eurasian National University leads with 16 research publications, demonstrating its prominent role in advancing scholarly discourse on digital skill development and sustainability. It is followed by King Faisal University and Kyiv National Economic University Named After Vadym Hetman, each contributing 10 papers, indicating strong institutional engagement in this emerging interdisciplinary area. The University of Craiova also made a notable contribution with 9 publications, reflecting growing academic interest from Eastern Europe.

Several other universities, including the Adnan Kassar School of Business, Bucharest University of Economic Studies, Plekhanov Russian University of Economics, Pontificia Universidade

Católica do Rio de Janeiro, Silesian University of Technology, Sumy State University, and Universiti Utara Malaysia, each contributed seven papers, underscoring the geographically diverse yet collaborative nature of this research field.

The distribution of these institutions reveals a balanced mix of contributions from both developed and emerging economies, indicating that the discourse on skill development and SDGs has gained global research attention. However, the dominance of a few institutions suggests the need for broader international collaboration to enhance cross-country learning and policy exchange. Future studies may benefit from exploring co-authorship networks and institutional partnerships to understand how academic collaboration fosters innovation in digital skill enhancement aligned with the Sustainable Development Goals.

Affiliation	Articles
L.N. GUMILYOV EURASIAN NATIONAL UNIVERSITY	16
KING FAISAL UNIVERSITY	10
KYIV NATIONAL ECONOMIC UNIVERSITY NAMED AFTER VADYM HETMAN	10
UNIVERSITY OF CRAIOVA	9
ADNAN KASSAR SCHOOL OF BUSINESS	7
BUCHAREST UNIVERSITY OF ECONOMIC STUDIES	7
PLEKHANOV RUSSIAN UNIVERSITY OF ECONOMICS	7
PONTIFÍCIA UNIVERSIDADE CATÓLICA DO RIO DE JANEIRO	7
SILESIA UNIVERSITY OF TECHNOLOGY	7
SUMY STATE UNIVERSITY	7
UNIVERSITI UTARA MALAYSIA	7

Table 3.6.1 (Highly productive institutions/organizations)

3.7 Keywords Analysis

The keyword co-occurrence analysis was conducted to identify the most frequently used research themes and conceptual linkages within the literature on *skill development* and *Sustainable Development Goals (SDGs)*. The analysis revealed a rich network of terms reflecting the interdisciplinary nature of this research domain. We extracted the most frequently used keywords from our dataset of 402 research articles using the VOSviewer software. Out of a total of 1,905 keywords, 151 keywords met the minimum threshold of three occurrences. In the Table 3.7.1, the top 15 most frequent keywords have been presented to highlight the intellectual structure and thematic focus of the field.

The results show that “digital innovation” (163 occurrences, total link strength 558) is the most dominant keyword, indicating the increasing academic and practical attention toward technology-driven solutions for advancing sustainable skills and inclusive growth. This is closely followed by “sustainable development goals (SDGs)” (110 occurrences, total link strength 461) and “economic growth” (76 occurrences, total link strength 371), which emphasize the alignment of digital and economic transformations with the United Nations’ SDG agenda.

Other frequently occurring terms such as “digitalization” (71), “digital economy” (43), “sustainability practices” (36), and “technological innovation” (20) demonstrate that researchers are exploring how technological progress can drive sustainable business models and economic resilience. The appearance of “information and communication technologies

(ICTs), “artificial intelligence”, and “digital technologies” further underscores the central role of the digital revolution in enabling education, entrepreneurship, and employment, key aspects of SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth). The inclusion of “innovation performance,” “green economy,” and “developing economies” among the top clusters reflects the growing attention toward sustainability transitions and skill enhancement in emerging markets. Collectively, the keyword trends suggest a research ecosystem that integrates technological innovation, sustainable growth, and human capital development as interdependent drivers of progress toward the SDGs.

Keywords	Cluster	Occurrences	Links	Total link strength
Digital Innovation	3	163	137	558
Sustainable Development Goals (SDGs)	2	110	121	461
Economic Growths	4	76	118	371
Digitalization	3	71	110	286
Digital Economy	3	43	84	163
Sustainability Practices	4	36	76	152
Information And Communication Technologies	4	24	64	111
Innovation Performance	1	24	68	139
Artificial Intelligence	3	21	36	64
Digital Technologies	5	21	54	83
Technological Innovation	2	20	71	130
Economics	2	17	71	124
Industry 4.0	1	17	37	58
Green Economy	4	16	58	127
Developing Economies	4	15	55	87

Table 3.7.1 (Keywords Analysis)

Figure 3.7.2 illustrates the keyword co-occurrence network generated using VOSviewer. The analysis categorised the keywords into six distinct clusters, each represented by a different colour, signifying thematic domains that define the relationship between digital skill development and the Sustainable Development Goals (SDGs). These clusters offer valuable insights into the intellectual structure and conceptual development of the research field.

Cluster 1: Innovation, Entrepreneurship, and Human Capital Development

Key Keywords: innovation performance, entrepreneurship, small and medium-sized enterprises, human capital, human resource management, employment, business performance, competitive advantage, digital entrepreneurship, corporate social responsibility, circular economy, higher education, digital government, resource allocation.

This cluster centres on the human and organizational dimensions of digital transformation. The keywords grouped here highlight how innovation, skills, and entrepreneurship act as catalysts for economic and social progress. The inclusion of terms such as *human capital* and *higher education* signifies the academic and workforce training aspects of skill development that support SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth). Moreover, *corporate social responsibility* and *circular economy* indicate that innovation is being framed within the sustainability paradigm.

This cluster captures the micro-level interaction between individuals, firms, and education systems in fostering skills for sustainable innovation. Furthermore, *Digital entrepreneurship* and *digital government* appear with low occurrences, indicating a research gap in understanding how digital governance and start-ups foster sustainable skill ecosystems. Under this cluster, future studies can focus on the role of entrepreneurial education, e-governance, and leadership skills in advancing sustainability-oriented innovations and employment generation in developing economies.

Cluster 2: Economic Growth, Policy, and Energy-Environment Nexus

Key Keywords: sustainable development goals (SDGs), technological innovation, economics, energy consumption, carbon emissions, finance, investments, energy policy, environmental economics, carbon dioxide, environmental sustainability, policy making, risk assessment, rural areas, trade openness.

This cluster captures the macroeconomic and policy-oriented aspects of digital transformation and sustainability. Keywords like economic growths and technological innovation reflect the economic rationale for integrating digitalization into national development agendas. The strong link with energy consumption, carbon emissions, and environmental sustainability underscores the global emphasis on aligning digital and economic transformation with environmental objectives (SDG 7, SDG 12, and SDG 13). Cluster 2 represents the governance-policy-environmental dimension, highlighting how policies and investments mediate the digital economy's impact on sustainability. However, *Rural areas* and *risk assessment* have low occurrences, suggesting limited empirical research on rural and risk-oriented policy frameworks in digital transitions. Future work can explore rural digital inclusion policies, energy efficiency initiatives, and risk-based governance models to ensure equitable progress toward sustainable development.

Cluster 3: Digital Transformation and Technological Advancement

Key Keywords: digital innovation, digitalization, digital economy, artificial intelligence, fintech, green technology innovation, systematic literature review, information technology, management, big data, automation, blockchain, research and development, digital divide.

This cluster is dominated by digital transformation and technology-driven concepts, representing the technological foundation of SDG-related skill development. The prominence of *digital innovation* (163 occurrences) indicates that technology is viewed as the primary enabler of economic modernization and inclusive growth. The co-occurrence of *AI*, *blockchain*, and *big data* suggests a growing interest in emerging technologies and their societal implications. Cluster 3 embodies the technological ecosystem, how innovation and digitalization drive sustainable practices, productivity, and data-based decision-making. But it can be observed that *digital divide* and *green technology innovation* have relatively low occurrences, pointing to a lack of emphasis on equitable access and green digitalization. In future, scholars could examine digital inequality, ethical AI, and green tech adoption to ensure that technological growth benefits marginalized communities.

Cluster 4: Sustainability, Green Economy, and Socioeconomic Development

Key Keywords: economic growth, sustainability practices, green economy, developing economies, green development, natural resources, sustainable economic development, climate change, education, governance approach, mineral resources, urban development, commerce.

This cluster emphasizes the socioeconomic and ecological dimensions of sustainability, closely tied to the SDGs. Keywords such as *green economy* and *sustainability practices* show the global

concern for balancing economic expansion with environmental preservation. The appearance of *education* and *developing economies* links sustainable growth with human capability building, which directly supports SDG 4 and SDG 8. Cluster 4 reflects sustainable transition and policy integration, where economic, social, and environmental factors intersect to support inclusive and green development. Keywords that are less frequently occurred are *education* and *commerce*, indicating insufficient attention to educational strategies and market-based mechanisms for sustainable transformation.

Further studies can focus on education-based sustainability models, green commerce, and the integration of sustainability metrics into business strategies.

Cluster 5: Digital Skills, Inclusion, and Governance

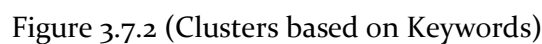
Key Keywords: digital technologies, digital literacy, e-governance, digital skills, financial inclusions, digital financial services, smart cities, digital competencies, digital infrastructure, structural equation modeling, quality education.

This cluster encapsulates the social inclusion and skill-building aspect of digitalization. The strong representation of digital literacy and digital skills highlights the relevance of human capital in realizing the potential of digital transformation for achieving SDGs. Keywords like e-governance and smart cities suggest that public institutions and urban digital infrastructures are essential for promoting digital inclusivity and sustainability. Cluster 5 captures the human-digital interface, focusing on how digital competencies and governance can empower societies toward sustainable futures. Digital literacy and digital competencies appear underrepresented, showing that skill-building, though crucial, is yet to receive proportional scholarly attention. There is a pressing need to analyze digital skill gaps, capacity-building initiatives, and policy frameworks that promote inclusive digital literacy, especially in developing and rural regions.

Cluster 6: Twin Transition and Advanced Technology Integration

Key Keywords: twin transition, platforms, digital services, digital capabilities, digital trade.

This cluster, though relatively smaller, represents the emerging intersection of digitalization and sustainability, often referred to as the “twin transition.” The term captures how environmental and digital transformations reinforce each other. Keywords like *digital trade* and *digital platforms* show the growing role of technology in international cooperation and economic globalization. Cluster 6 symbolizes the future-oriented research frontier, linking Industry 4.0, green innovation, and digital trade in a unified sustainability framework. Keywords, *digital capabilities* and *digital trade* have few occurrences, highlighting early-stage exploration of this topic. Future scholars can explore how twin transitions reshape global value chains, promote green entrepreneurship, and enhance digital skills for sustainability.



Despite the growing scholarly interest, the analysis highlights several research gaps:

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- c. **Scarcity of empirical and comparative studies:** Much of the existing literature is conceptual or policy-oriented, with limited cross-country or longitudinal analyses on how digitalization and skill formation jointly influence sustainable economic performance.
- d. **Low representation of governance, ESG, and institutional frameworks:** Keywords like *governance approach*, *ESG performance*, and *public policy* show relatively weaker link strengths, indicating an opportunity to integrate governance mechanisms into future sustainability-skill models.

5. Research Implications and Policy Recommendations

This bibliometric review highlights how digital skill development has become a strategic driver for achieving SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth). The findings carry important implications for theory, methodology, and policy.

Theoretical Implications:

The study reveals the emergence of a *Digital Sustainability Paradigm*, where digital literacy, entrepreneurship, and innovation jointly enable sustainable and inclusive growth. Future theoretical models should integrate human capital, innovation systems, and sustainability transition perspectives to explain how digital competencies strengthen resilience and economic equity.

Methodological Implications:

Using Biblioshiny and VOSviewer proved effective for mapping research trends and networks. However, future bibliometric studies should broaden their scope by including multi-database searches, non-English sources, and mixed-method SLRs to deepen contextual insights and reduce geographic bias.

Policy Recommendations:

- *Invest in digital education infrastructure* to ensure equitable access, especially in underserved regions.
- *Embed sustainability-oriented digital skills* in higher and vocational education curricula.
- *Promote academia–industry–government collaboration* to align training with employability and innovation needs.
- *Foster inclusive digital governance* to bridge literacy and participation gaps.
- *Support the twin transition* by incentivizing green and digital technologies.
- *Encourage international collaboration* to integrate underrepresented regions into global knowledge networks.

Overall, the study underscores that digital skills are central to inclusive and sustainable development. Building collaborative, green, and digitally competent ecosystems will be crucial to realizing the transformative goals of SDG 4 and SDG 8.

6. Future Research Directions

To further strengthen the linkage between digital skills and sustainable development, future

research should focus on:

- **Explore the role of digital skill development** as a direct enabler of SDGs, especially in the context of emerging and rural economies.
- **Integrate ESG and governance perspectives** to examine how institutional quality and corporate responsibility mediate the relationship between digital transformation and sustainable development.
- **Adopt data-driven methodologies** such as panel data analysis, PLS-SEM, or machine learning to empirically measure the impact of digital literacy and innovation on SDG achievement.
- **Conduct region-specific and sectoral analyses**, focusing on education, agriculture, and small and medium enterprises (SMEs) to identify localized pathways for sustainable digital inclusion.
- **Expand interdisciplinary collaborations** linking economics, management, information systems, and environmental studies to create a holistic understanding of skill development in the digital era.
- **Conduct longitudinal analyses** examining how national digital education policies influence employment and innovation outcomes.

7. Conclusion

This bibliometric review provides an integrative assessment of global research at the intersection of *digital skill development* and the *Sustainable Development Goals (SDG 4 – Quality Education and SDG 8 – Decent Work and Economic Growth)*. Drawing on data from 402 peer-reviewed journal articles retrieved from Scopus, the study employed Biblioshiny and VOSviewer to analyze publication patterns, influential contributors, thematic clusters, and research trends from 2018 to 2025. The results reveal a rapidly expanding body of scholarship, with a marked acceleration in publications after 2022—reflecting the post-pandemic global emphasis on digital transformation, human capital resilience, and sustainability-aligned economic recovery.

At the geographical level, research productivity is dominated by China, Ukraine, and India, indicating strong regional leadership in advancing discourse on skills, digitalization, and sustainable development. However, limited representation from Africa, the Middle East, and Latin America signals uneven global engagement and underscores the need for enhanced international collaboration. The journal-wise trend highlights the multidisciplinary nature of the field, with major outlets such as *Resources Policy*, *Journal of Cleaner Production*, and *Technological Forecasting and Social Change* serving as key platforms bridging economics, management, innovation, and sustainability studies.

The author influence and institutional analyses demonstrate that emerging economies are not only active contributors but also sources of highly cited and influential research, suggesting a decentralization of academic leadership beyond traditional Western hubs. Institutions such as L.N. Gumilyov Eurasian National University, King Faisal University, and Kyiv National Economic University have become significant nodes in this evolving scholarly network. This trend reflects a broader global recognition of skill development as a cross-cutting enabler of sustainable growth, technological innovation, and social inclusion.

The keyword and cluster analyses further uncover the intellectual structure of the field, organizing it into six major thematic domains: (1) *Innovation, Entrepreneurship, and Human Capital Development*; (2) *Economic Growth, Policy, and Energy-Environment Nexus*; (3) *Digital Transformation and Technological Advancement*; (4) *Sustainability, Green Economy, and Socioeconomic Development*; (5) *Digital Skills, Inclusion, and Governance*; and (6) *Twin Transition and Advanced Technology Integration*. Collectively, these clusters illustrate how the discourse on digital skills has evolved from isolated educational concerns to a complex, interdisciplinary framework linking technology, governance, environmental sustainability, and economic progress.

Despite its growth, the field remains fragmented and geographically concentrated. Notably, research on digital inclusion, green digitalization, rural skill development, and governance frameworks remains underexplored. Future research should therefore emphasize cross-regional comparative analyses, longitudinal assessments of policy effectiveness, and integrative models that link digital skill ecosystems with sustainability transitions. Methodologically, combining bibliometric mapping with qualitative systematic reviews can further deepen understanding of how digital competencies contribute to inclusive education and decent work.

In conclusion, this study demonstrates that digital skill development has emerged as a cornerstone for achieving the twin goals of educational quality and sustainable economic growth envisioned in SDG 4 and SDG 8. By revealing the intellectual, institutional, and thematic evolution of this research domain, the paper contributes to the ongoing academic and policy dialogue on building a digitally competent, inclusive, and sustainable global workforce. Strengthening collaboration across regions, disciplines, and institutions will be essential to bridge existing gaps and translate research insights into actionable strategies that align digital transformation with the broader sustainability agenda.

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