



**DIGITAL GREEN ENTREPRENEURSHIP IN THE RENEWABLE ENERGY SECTOR:
A SYSTEMATIC LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS OF
TECHNOLOGICAL INNOVATION FOR SDG 7 (AFFORDABLE AND CLEAN ENERGY)
AND SDG 13 (CLIMATE ACTION)**

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DOI: <https://doi.org/10.63544/jbii.v5i10.268>

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Article History:

Received: 25.09.2026

Accepted: 13.10.2026

Published: 26.10.2026

Abstract

Purpose – Digital technologies are reshaping how entrepreneurs identify, finance and scale green opportunities, yet the scholarship linking digital green entrepreneurship to renewable energy and climate outcomes remains fragmented. This study maps the intellectual structure, thematic evolution and SDG alignment of this emerging field.

Design/methodology/approach – A hybrid design combining bibliometric analysis and a PRISMA 2020-guided systematic literature review was applied to 176 Scopus-indexed journal articles (2013–2026). Performance analysis and science mapping followed the algorithms implemented in Biblioshiny (bibliometrix) and the network conventions of VOSviewer, covering annual growth, Bradford's and Lotka's laws, country collaboration, keyword co-occurrence, thematic mapping, trend topics and reference co-citation. Forty-three articles with an explicit energy (SDG 7) or climate (SDG 13) dimension were then synthesised qualitatively.

Findings – The field is young (average document age 2.45 years) and expanding rapidly (55.0% compound annual growth, 2018–2025), with 80.1% of output published from 2024 onwards. China dominates production (68 first-author articles) but shows low international collaboration (MCP ratio 0.18). Keyword co-occurrence reveals five clusters: twin transition and digitalisation; capabilities and circular innovation in SMEs; digital finance and low-carbon inclusive growth; green entrepreneurship in the digital economy; and an emerging energy startup and digital entrepreneurship frontier. Only 20 articles (11.4%) address energy explicitly and 36 (20.5%) address climate, indicating that SDG 7 remains under-researched relative to SDG 13. Originality/value – The study offers the first combined bibliometric-systematic account of digital green entrepreneurship framed around SDG 7 and SDG 13, proposes an integrative enabler-mechanism-outcome framework, and sets out a research agenda for energy-focused digital venturing.

Keywords: Digital Green Entrepreneurship, Renewable Energy, Energy Start-Ups, Technological Innovation, SDG 7, SDG 13, Bibliometric Analysis, VOSviewer, Biblioshiny, Systematic Literature Review

1. Introduction

The decarbonisation of energy systems is the single largest lever available for meeting the Paris Agreement objectives, and it sits at the intersection of two Sustainable Development Goals: SDG 7, which calls for universal access to affordable, reliable, sustainable and modern energy, and SDG 13, which calls for



urgent action to combat climate change and its impacts (United Nations, 2015). Sachs et al. (2019) describe the energy transition as one of six systemic transformations on which the whole 2030 Agenda depends. Transformations of this scale are not delivered by policy and incumbents alone; they also require entrepreneurs who recognise environmentally relevant market imperfections, commercialise new technologies and build business models that make clean energy cheaper and more accessible (Cohen & Winn, 2007; Dean & McMullen, 2007; Hockerts & Wüstenhagen, 2010).

At the same time, digital technologies have changed the nature of entrepreneurship itself. Platforms, data analytics, the Internet of Things, artificial intelligence and blockchain reduce the cost of experimentation, make outcomes and processes less bounded, and allow ventures to scale with fewer physical assets (Nambisan, 2017; Nambisan et al., 2019). Digital technologies also act as external enablers of new venture creation (von Briel et al., 2018) and give rise to digital entrepreneurial ecosystems that coordinate users, infrastructure and agents (Elia et al., 2020; Sussan & Acs, 2017). George et al. (2021) argue that the convergence of these two developments, which they call digital sustainability, offers entrepreneurs new tools for tackling climate change and sustainable development, but they also caution that the evidence base is thin and dispersed.

The renewable energy sector illustrates both the promise and the gap. Distributed solar generation, smart grids, peer-to-peer electricity trading, green hydrogen, energy-efficiency services and digitally enabled financing are all domains in which new ventures combine digital and green innovation. Recent studies analyse energy start-up creation and financing across countries using International Energy Agency data (Sitnicki et al., 2026a, 2026b, Afzal et al., 2026), propose data-driven entrepreneurship models for the green hydrogen economy (Wu & Li, 2024, Kamran & Afzal, 2025), and estimate how green digital infrastructure raises energy-utilisation efficiency (Zandi et al., 2026). Yet these contributions sit within a much larger literature on the digital economy, digital finance, green innovation and sustainable entrepreneurship whose links to energy and climate outcomes are rarely made explicit.

Three gaps motivate this study. First, although bibliometric reviews exist for green entrepreneurship and for digital entrepreneurship separately, the intellectual structure of their intersection, here termed digital green entrepreneurship, has not been mapped. Second, it is unclear how far this literature engages with renewable energy (SDG 7) as opposed to broader carbon and environmental outcomes (SDG 13). Third, researchers and policymakers lack an integrative framework that connects digital enablers, entrepreneurial mechanisms and SDG outcomes.

To address these gaps, the study combines bibliometric analysis with a systematic literature review, an approach recommended for young and fast-moving fields where quantitative mapping and qualitative interpretation complement each other (Donthu et al., 2021; Zupic & Cater, 2015). It answers four research questions:

- RQ1. What are the publication trends, core sources, productive authors and leading countries in digital green entrepreneurship research?
- RQ2. What is the conceptual and intellectual structure of the field, and how have its themes evolved?
- RQ3. To what extent, and through which mechanisms, does the literature link digital green entrepreneurship to SDG 7 and SDG 13?
- RQ4. Which research gaps and future directions emerge for technological innovation in renewable energy entrepreneurship?

The paper contributes in three ways. It provides a reproducible performance and science-mapping analysis of 176 Scopus-indexed articles. It quantifies the alignment of this literature with SDG 7 and SDG 13 and synthesises the 43 articles that address energy or climate directly. It develops an integrative enabler-mechanism-outcome framework and a research agenda. The remainder of the paper reviews the theoretical background (Section 2), describes the methodology (Section 3), reports performance results (Section 4) and science-mapping results (Section 5), presents the systematic synthesis (Section 6), discusses implications (Section 7), sets out the research agenda (Section 8) and concludes (Section 9).

2. Theoretical Background

2.1 Green and Sustainable Entrepreneurship



Green entrepreneurship refers to entrepreneurial action that creates economic value while reducing environmental degradation. Cohen and Winn (2007) and Dean and McMullen (2007) argue that environmental problems are market failures, such as externalities, imperfect information and flawed pricing, and that these failures constitute entrepreneurial opportunities. Shepherd and Patzelt (2011) broaden this view into sustainable entrepreneurship, which links “what is to be sustained” (nature, life-support systems and communities) with “what is to be developed” (economic and social gains). Schaltegger and Wagner (2011) distinguish eompreneurship, social entrepreneurship and sustainable entrepreneurship, and show how each connects to sustainability innovation. In energy markets, Hockerts and Wüstenhagen (2010) describe a co-evolution in which “emerging Davids” introduce radical clean technologies and “greening Goliaths” later scale them, a dynamic visible in solar, wind and storage.

At the firm level, the construct of green entrepreneurial orientation (GEO), meaning the innovative, proactive and risk-taking pursuit of environmental opportunities, is increasingly used to explain green innovation. Its theoretical roots lie in the resource-based view (Barney, 1991), the natural-resource-based view (Hart, 1995) and dynamic capabilities (Teece et al., 1997). These sources form one of the four co-citation clusters identified in Section 5.

2.2 Digital Entrepreneurship

Nambisan (2017) defines digital entrepreneurship through three elements: digital artifacts, digital platforms and digital infrastructure. He shows that these make entrepreneurial outcomes and processes less bounded and agency less predefined. Nambisan et al. (2019) extend the argument to innovation systems. Digital technologies can trigger, shape or resource new ventures as external enablers (von Briel et al., 2018). At the system level, the digital entrepreneurial ecosystem integrates digital infrastructure governance, digital user citizenship, digital marketplaces and digital entrepreneurship (Sussan & Acs, 2017), and collective intelligence reshapes how opportunities are discovered and exploited (Elia et al., 2020). Empirical work shows that digitalisation is associated with higher entrepreneurial activity and sustainable competitiveness across countries (Dabbous et al., 2023) and that digital entrepreneurship correlates with sustainable development indicators in the European Union (Herman, 2022).

2.3 Digital Green Entrepreneurship and the Renewable Energy Transition

Digital green entrepreneurship is defined here as the creation and scaling of ventures and business models that use digital technologies to generate environmental value, especially clean-energy and climate value, alongside economic returns. The concept combines the opportunity logic of sustainable entrepreneurship with the technological logic of digital entrepreneurship, consistent with the notion of digital sustainability (George et al., 2021, Abbas et al., 2025). In the renewable energy sector, it includes several kinds of venture:

- platform-based energy start-ups, such as peer-to-peer trading, virtual power plants and energy-as-a-service;
- data-driven efficiency and demand-response services;
- digitally financed renewable deployment, through fintech, crowdfunding and supply-chain finance;
- digital tools that accelerate the commercialisation of green technologies such as hydrogen and storage.

The literature points to three mechanisms through which digital green entrepreneurship can contribute to sustainability transitions. The first is capability building, for example through big-data analytics and knowledge sharing that strengthen green absorptive capacity and GEO (Makhloufi, 2024). The second is business-model and financing innovation, for example through digital platforms that relax financing constraints on green technology development (Reza-Gharehbagh et al., 2022, 2023). The third is system-level diffusion, for example through digital-economy effects on low-carbon inclusive development (Yang et al., 2023).

2.4 SDG 7 and SDG 13 as an Analytical Lens

SDG 7 comprises targets on universal access to modern energy (7.1), a substantially higher share of renewables (7.2), a doubled rate of energy-efficiency improvement (7.3), international cooperation and investment in clean-energy technology (7.4), and expanded and upgraded energy infrastructure in developing



countries (7.5). SDG 13 covers resilience and adaptation (13.1), the integration of climate measures into policies and planning (13.2), and education and capacity building (13.3). These targets give a structured way to assess which outcomes the literature actually measures. This study therefore codes each article for energy-related (SDG 7) and climate-related (SDG 13) content and uses the targets to organise the qualitative synthesis.

2.5 Positioning Against Prior Reviews

Several recent reviews in the corpus touch on parts of this domain, but none combines digital technology, green entrepreneurship and energy or climate outcomes in a single map (Table 1). Sklavos et al. (2022) map green entrepreneurship and digital transformation, but only for food-industry SMEs. Haji and Ismael (2026) review 157 publications on green entrepreneurship in organic-food SMEs and identify financing mechanisms and institutional support as recurring clusters. Ernez et al. (2026) analyse 504 documents on sustainable entrepreneurship and green innovation in emerging economies and, consistent with the present findings, report dispersed authorship and limited international collaboration. Dat and Thi Hue (2026) combine content analysis and bibliometrics to study how sustainable entrepreneurship ecosystems shape entrepreneurial intentions. Yang et al. (2025) map digital financial inclusion without an entrepreneurship focus. Thach et al. (2026) review green-technology commercialisation in Web of Science and highlight financing frictions and infrastructure constraints. The present study differs from all of these in three respects. Its object is the digital-green-entrepreneurship intersection rather than one of its parts. It codes every article for SDG 7 and SDG 13 relevance. It links the bibliometric structure to a qualitative synthesis of the energy- and climate-relevant evidence.

Table 1

Positioning of This Study Against Prior Reviews in the Corpus

Review	Scope	Data and method	Energy/SDG 7 focus	Gap here addressed
Sklavos et al. (2022)	Green entrepreneurship and digital transformation in food SMEs	Bibliometric	No	Sector-agnostic, energy-focused lens
Haji & Ismael (2026)	Green entrepreneurship and organic-food SMEs	157 publications; citation networks	No	Digital enablers and SDG coding
Ernez et al. (2026)	Sustainable entrepreneurship and green innovation	504 documents; Scopus and WoS	Limited	Explicit digital dimension

Note. Table reconstructed from the source text.

3. Methodology

3.1 Research Design

The study follows a hybrid review design. A bibliometric analysis maps the field quantitatively through performance analysis and science mapping (Donthu et al., 2021; Zupic & Cater, 2015). A systematic literature review then interprets the energy- and climate-relevant subset qualitatively (Tranfield et al., 2003). Reporting follows the PRISMA 2020 statement (Page et al., 2021).

3.2 Data Source and Search Strategy

Scopus was selected as the data source because it offers broad coverage of management, energy and environmental journals, including many outlets from emerging economies where much of this literature originates (Mongeon & Paul-Hus, 2016). The search was executed on 12 August 2026 in the title, abstract and keyword fields using the string reported in Table 2. Results were limited to English-language journal articles published between 2000 and 2026, and conference reviews, editorials, notes and errata were excluded. The full records, including cited references, were exported in CSV format. The earliest article retrieved dates from 2013, so the effective timespan is 2013–2026, with 2026 covering January to August only.

**Table 2***Search Protocol, Eligibility Criteria and Analytical Tools*

Item	Specification
Database	Elsevier Scopus (searched 12 August 2026)
Search string	TITLE-ABS-KEY (Digital GREEN Entrepreneurship) AND LIMIT-TO (LANGUAGE, “English”) AND (EXCLUDE (DOCTYPE, “cr”/“no”/“er”) OR LIMIT-TO (DOCTYPE, “ar”)) AND PUBYEAR > 1999 AND PUBYEAR < 2027
Timespan returned	2013–2026 (2026 partial, January–August)
Document type	Peer-reviewed journal articles (*n* = 176)
Inclusion criteria	English-language articles addressing the intersection of digital technologies, entrepreneurship and environmental/green outcomes
Exclusion criteria	Conference reviews, editorials, notes, errata; for the qualitative synthesis, records without an energy (SDG 7) or climate (SDG 13) dimension or outside the entrepreneurship–digital–green scope
Export format	CSV, full record (citation, bibliographic, abstract & keywords, funding, cited references)
Performance analysis	Annual growth, sources (Bradford’s law), authors (Lotka’s law), countries (SCP/MCP), citations — Biblioshiny/bibliometrix algorithms
Science mapping	Keyword co-occurrence, country co-authorship, reference co-citation (VOSviewer conventions: full counting, minimum thresholds); thematic map and trend topics (Biblioshiny conventions)
Qualitative synthesis	PRISMA 2020-guided screening and thematic coding of 43 SDG 7/13-relevant articles

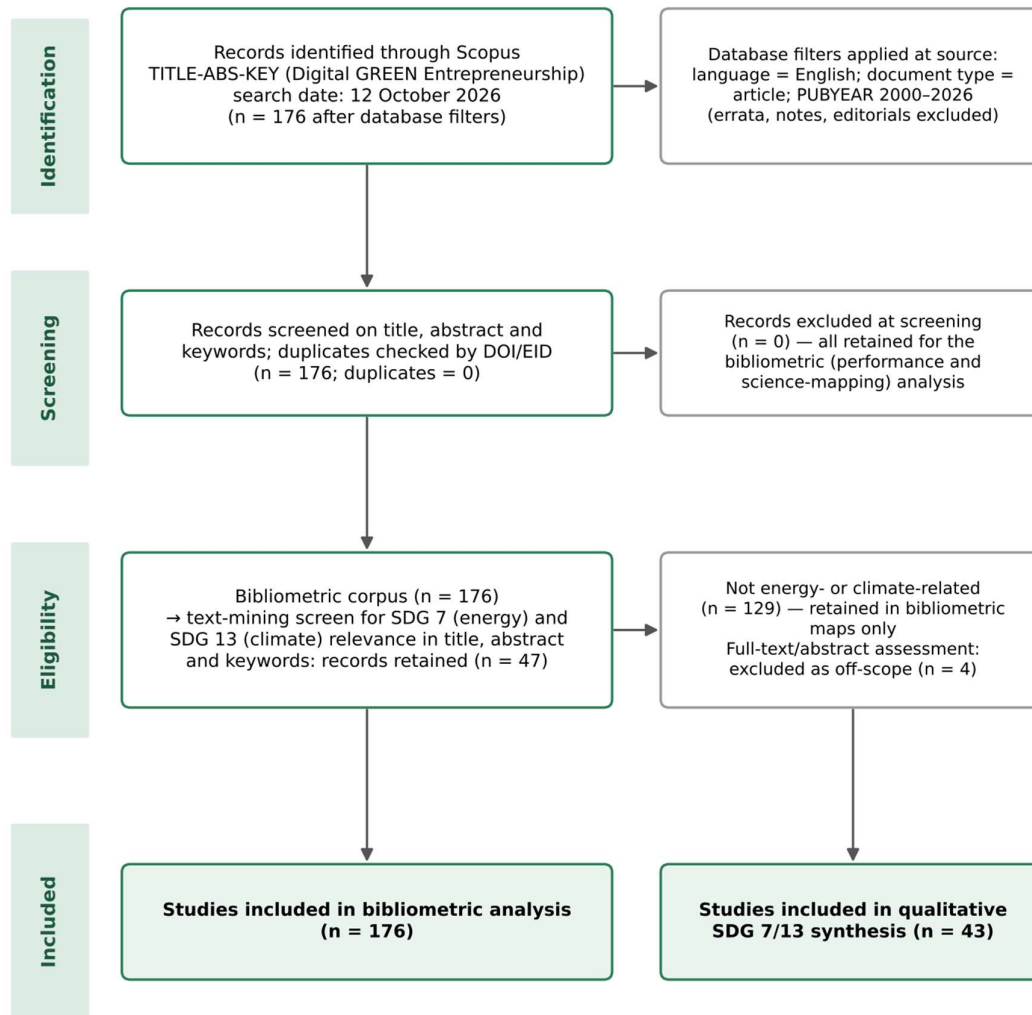
3.3 Screening and Selection

Figure 1 summarises the selection process. All 176 records passed the screening stage. No duplicates were found on DOI or Scopus EID, and every article addressed the digital-green-entrepreneurship intersection, so all were retained for the bibliometric analysis. For the systematic review, a dictionary-based text-mining screen of titles, abstracts and author and index keywords identified articles with an energy dimension (renewable, clean or green energy, solar, wind, photovoltaic, hydrogen, energy efficiency or saving, energy start-ups, energy consumption) or a climate dimension (climate, carbon, CO₂, emissions, greenhouse gases, decarbonisation, low-carbon, net-zero). This screen retained 47 articles. After reading their abstracts in full, four were excluded as outside the scope of digitally enabled green entrepreneurship: an urban stormwater-governance study, an educational serious game on raw materials, a study of financial-inclusion determinants and a study of tourism-emission linkages. The remaining 43 articles form the qualitative synthesis.



Figure 1

PRISMA 2020 Flow Diagram of the Study Selection Process



Note. Source: Authors' elaboration based on Scopus data. Figure content as supplied in the source file.

3.4 Bibliometric Techniques and Software

Performance analysis covered annual production and compound annual growth, sources and Bradford's law of scattering (Bradford, 1934), author productivity and Lotka's inverse-square law (Lotka, 1926), country output distinguishing single-country (SCP) from multiple-country (MCP) publications, and global citation counts.

Science mapping covered five analyses:

- author-keyword co-occurrence networks;
- an overlay visualisation of the average publication year of each keyword;
- a strategic thematic map based on Callon's centrality and density (Callon et al., 1991; Cobo et al., 2011);
- trend topics;
- a co-citation network of locally cited references.

The analytical procedures follow the algorithms implemented in Biblioshiny, the web interface of the bibliometrix R package (Aria & Cuccurullo, 2017), and the network conventions of VOSviewer (van Eck & Waltman, 2010; Waltman et al., 2010). These conventions are full counting, minimum-occurrence thresholds,



node size proportional to occurrences and edge width proportional to co-occurrence strength. Communities were detected with the Louvain modularity algorithm (Blondel et al., 2008). To ensure that every figure in this paper is traceable to the exported records, the computations were scripted in Python (pandas and NetworkX) directly on the Scopus export. The parameters reported in Table 16 (Appendix) allow every map to be regenerated in VOSviewer and Biblioshiny. Before mapping, author keywords were harmonised: synonyms and spelling variants were merged (for example, digitalisation, digitization and digitalization; SDG and sustainable development goals; SME and SMEs).

3.5 Qualitative Synthesis

The 43 synthesis articles were coded inductively and deductively on five dimensions: research stream, digital technology or mechanism, energy or climate outcome, SDG target, and method and context. Coding proceeded in two rounds. The first round assigned open codes from abstracts and keywords. The second consolidated these codes into five themes, which were cross-checked against the bibliometric keyword clusters to triangulate the quantitative and qualitative evidence.

3.6 Validity and Reliability

Several steps were taken to strengthen the validity of the results. First, the search date, string and filters are reported in full so that the dataset can be reconstructed. Second, keyword harmonisation was performed with an explicit thesaurus of synonym pairs, applied identically to all mapping analyses, so that differences in spelling did not split concepts across clusters. Third, network thresholds (minimum occurrence of three for co-occurrence and of three local citations for co-citation) follow common practice for corpora of this size and were tested against a threshold of two for the thematic map, which produced substantively similar groupings. Fourth, Louvain clustering was run with a fixed random seed to ensure that the partitions are reproducible. Finally, the qualitative themes were triangulated against the quantitative clusters, and the 47 records flagged by the text-mining screen were all read in full at abstract level before inclusion decisions were made.

4. Results: Performance Analysis

4.1 Main Information

Table 3 summarises the dataset. The 176 articles were published in 120 journals by 516 authors and together cite 11,799 references. The corpus has accumulated 3,380 citations, a mean of 19.20 and a median of 4 per article, and has an h-index of 27. The gap between the mean and the median reflects a highly skewed distribution dominated by a few influential papers. Collaboration is the norm: there are 3.20 co-authors per article, only 28 articles (15.9%) are single-authored, and 30.11% involve international co-authorship. Some 108 articles (61.4%) are available in open access, which suggests that the field's knowledge is relatively accessible to practitioners and policymakers in emerging economies.

Table 3

Main Information About the Dataset (Biblioshiny "Main Information" Equivalent)

Description	Result
Timespan	2013–2026
Sources (journals)	120
Documents (articles)	176
Annual growth rate 2018–2025 (CAGR)	55.01%
Average document age (years)	2.45
Average citations per document	19.2
Median citations per document	4
Total citations (Scopus "Cited by")	3,380
h-index of the corpus	27
Cited references	11,799
Author keywords (unique)	734
Index keywords (unique)	597
Authors	516
Single-authored documents	28



Description	Result
Co-authors per document	3.2
International co-authorship (%)	30.11%
Open-access documents	108 (61.4%)

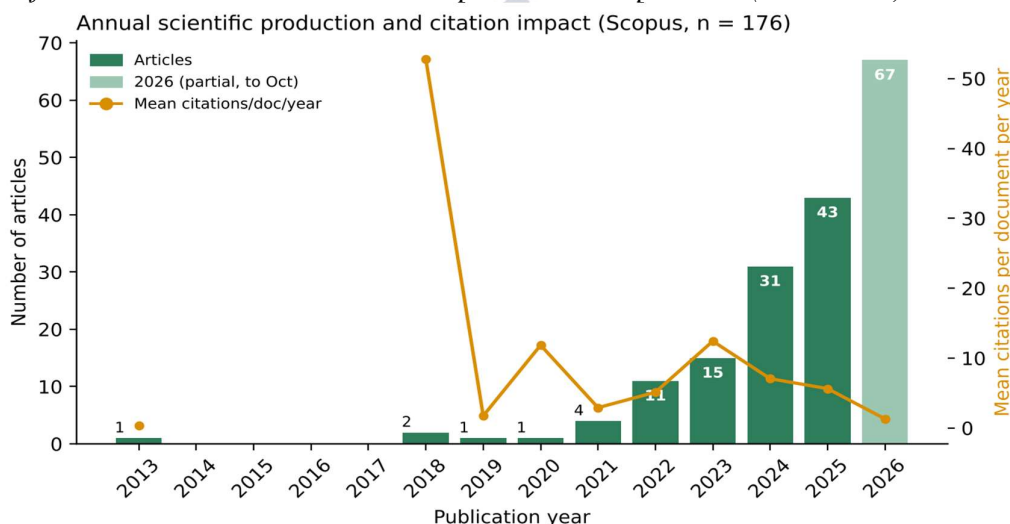
4.2 Annual Scientific Production

The field is recent and accelerating (Figure 2; Table 4). Apart from a single 2013 article, publications began in 2018, and output remained at one to four articles a year until 2021. Production then rose to 11 articles in 2022, 15 in 2023, 31 in 2024 and 43 in 2025, a compound annual growth rate of 55.0% between 2018 and 2025. With 67 articles indexed by mid-August, 2026 is already the most productive year on record. In total, 141 articles (80.1%) were published from 2024 onwards.

Citation impact follows a different curve. Mean citations per article per year peaks in 2018, an effect driven by a single highly cited paper (Li, 2018), and then stabilises at five to 12 citations per year for 2022–2024 cohorts. The low citation counts of 2025–2026 articles reflect citation windows that are still open rather than lower quality. The pattern is typical of an emerging field in which the volume of output grows faster than its citation base.

Figure 2

Annual Scientific Production and Mean Citations per Document per Year (2013–2026)



Note. Source: Scopus; computed with Biblioshiny-equivalent routines. Figure content as supplied in the source file.

Table 4

Annual Scientific Production and Citation Structure

Year	Articles	Cumulative	Total citations	Mean TC/article	Mean TC/year
2013	1	1	5	5	0.36
2018	2	3	950	475	52.78
2019	1	4	14	14	1.75
2020	1	5	8	8	1.86
2021	4	9	70	17.5	2.92
2022	11	20	282	25.64	5.13
2023	15	35	746	49.73	12.43
2024	31	66	657	21.19	7.06
2025	43	109	485	11.28	5.64
2026*	67	176	88	1.31	1.31

Note. *2026 partial year (January–August).



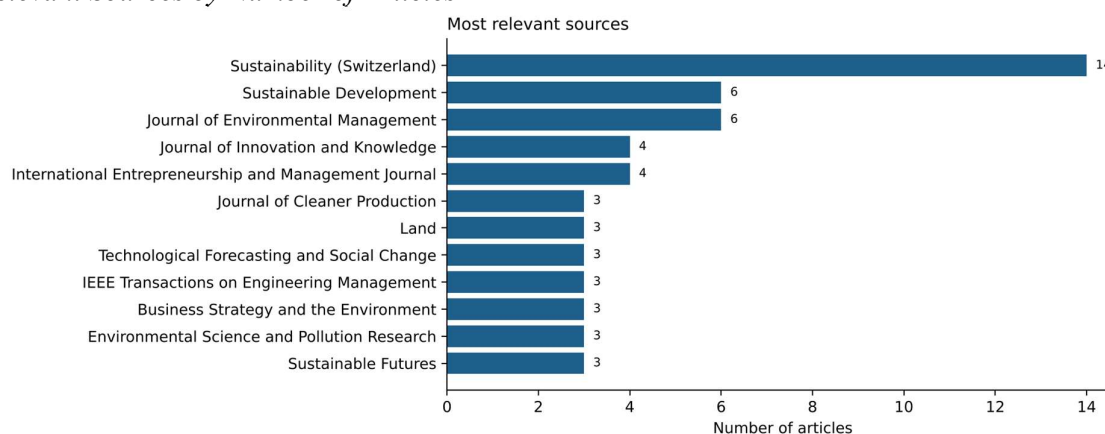
4.3 Most Relevant Sources and Bradford's Law

Articles are widely scattered across journals (Figure 3; Table 5). *Sustainability (Switzerland)* is the most productive outlet with 14 articles, followed by *Sustainable Development* and the *Journal of Environmental Management* (six each), and the *Journal of Innovation and Knowledge* and the *International Entrepreneurship and Management Journal* (four each). Productivity and influence diverge, however. *Technological Forecasting and Social Change* published only three articles but accumulated 1,065 citations, and the *Journal of Cleaner Production* (three articles, 274 citations) and the *Journal of Environmental Management* (six articles, 223 citations, h-index 6) are the most influential outlets relative to their output.

Bradford's law confirms the dispersion. The core zone contains 14 journals publishing 59 articles, the second zone 47 journals and 58 articles, and the third zone 59 journals and 59 articles. A source ratio of 14:47:59 across the three zones and the fact that 95 journals (79.2%) published only a single article indicate a field without a dedicated home journal. It draws simultaneously on entrepreneurship, environmental-management, energy-economics and technology-management outlets.

Figure 3

Most Relevant Sources by Number of Articles



Note. Source: Scopus. Figure content as supplied in the source file.

Table 5

Most Relevant Sources, Local Impact and Bradford Zone

Source	Articles	Citations	h-index	Bradford zone
<i>Sustainability (Switzerland)</i>	14	87	4	Zone 1 (core)
<i>Sustainable Development</i>	6	11	2	Zone 1 (core)
<i>Journal of Environmental Management</i>	6	223	6	Zone 1 (core)
<i>Journal of Innovation and Knowledge</i>	4	58	3	Zone 1 (core)
<i>International Entrepreneurship and Management Journal</i>	4	39	3	Zone 1 (core)
<i>Journal of Cleaner Production</i>	3	274	3	Zone 1 (core)
<i>Land</i>	3	3	1	Zone 1 (core)
<i>Technological Forecasting and Social Change</i>	3	1,065	3	Zone 1 (core)
<i>IEEE Transactions on Engineering Management</i>	3	67	3	Zone 1 (core)
<i>Business Strategy and the Environment</i>	3	10	2	Zone 1 (core)

Note. Table reconstructed from the source text.

4.4 Authors and Lotka's Law

Individual productivity is low (Table 6). Liu X. leads with four articles, followed by eight authors with three articles each, among them Sitnicki M.W. and Podosynnikov S., whose 2026 series on energy start-ups forms a distinctive cross-country research programme. In terms of impact, Li L. (963 citations) dominates owing to the 2018 study of China's manufacturing strategy. Dabbous, Barakat and Kraus (175 citations), Mondal, Singh and Gupta (145) and Makhoulfi (113) follow.



Table 7 and Figure 4 compare the observed author's distribution with Lotka's law. Of the 516 authors, 479 (92.8%) contributed a single article, against roughly 60% expected under the classical law. The steeper-than-Lotka decay indicates a community of occasional contributors that has not yet consolidated a core of specialised researchers. This is another marker of an emerging and interdisciplinary field.

Table 6

Most Productive and Most Cited Authors

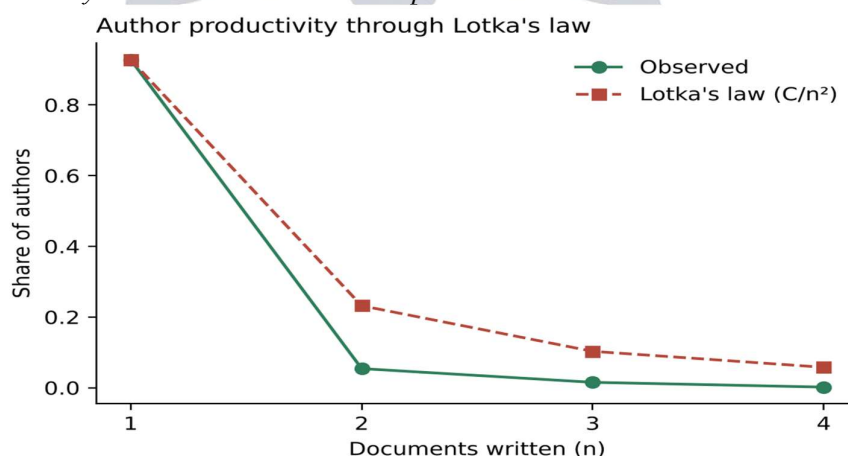
Author (productivity)	Articles	Fractionalised	Citations
Liu X.	4	1.12	32
Li Y.	3	0.83	27
Sitnicki M.W.	3	0.59	13
Wang X.	3	0.83	17
Liu Y.	3	1.08	53
Liu J.	3	1.33	19
Zhang L.	3	1.08	20
Li L.	3	1.59	963
Podosynnikov S.	3	0.65	4
Sobko O.	2	0.4	10

Author (impact)	Citations
Li L.	963
Dabbous A.	175
Barakat K.A.	175
Kraus S.	175
Mondal S.	145
Singh S.	145
Gupta H.	145
Makhloufi L.	113
Reza-Gharehbagh R.	104
Hafezalkotob A.	104

Note. Author names as indexed by Scopus; common Chinese surnames (e.g., Li L., Liu X.) may aggregate homonymous authors, a known limitation of name-based counts.

Figure 4

Observed Author Productivity Versus Lotka's Inverse-Square Law



Note. Source: Scopus. Figure content as supplied in the source file.



Table 7

Author Productivity Distribution Compared With Lotka's Law

Articles per author (n)	Number of authors	Observed proportion	Lotka's (C/n^2) expected
1	479	92.83%	92.83%
2	28	5.43%	23.21%
3	8	1.55%	10.31%
4	1	0.19%	5.80%

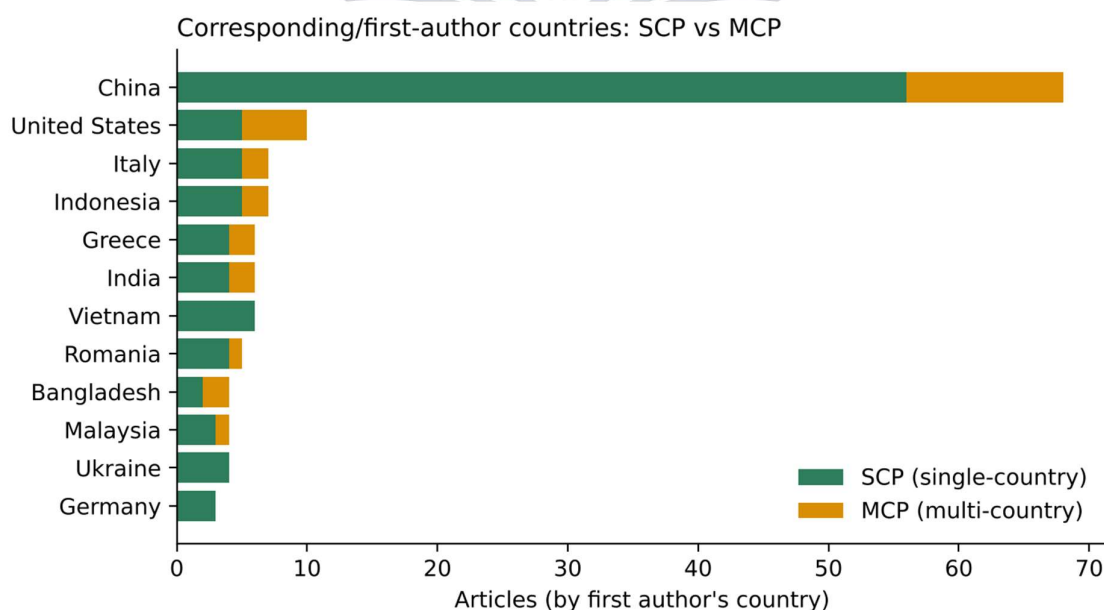
4.5 Countries and International Collaboration

Research is concentrated geographically (Figure 5; Table 8). China accounts for 68 first-author articles (38.6% of the corpus) and appears in the affiliations of 71 articles, but its MCP ratio of 0.18 shows that most Chinese studies are domestic, typically provincial or city-level panel analyses. The United States ranks second with 10 articles and has the highest citation impact (97.3 citations per article, partly because of Li, 2018), as well as an MCP ratio of 0.50. Indonesia, Italy, India, Greece, Vietnam, Romania, Bangladesh, Malaysia and Ukraine complete the top group. The prominence of emerging and transition economies, including Indonesia, Vietnam, Bangladesh, Ukraine and Uzbekistan, is notable and reflects strong policy interest in leapfrogging toward green growth through digitalisation.

The country co-authorship network (Figure 6) comprises 56 countries connected by 129 links. Louvain clustering identifies an Asian cluster centred on China, Malaysia, India, Indonesia and Vietnam; a transatlantic and Eastern European cluster linking the United States, Poland, Ukraine, Germany, Slovakia and Lithuania; a cluster around Italy, France, Canada, Australia and South Africa; and a Mediterranean-Gulf cluster linking Spain, Greece, Saudi Arabia and Jordan. The strongest bilateral links are Poland–United States (6 joint articles), China–Malaysia (5), Poland–Ukraine (4) and Ukraine–United States (4). Africa and Latin America are almost absent despite their large renewable-energy potential and energy-access deficits, a gap discussed in Section 8.

Figure 5

Most Productive Countries by First-Author Affiliation, Split Into Single-Country (SCP) and Multiple-Country (MCP) Publications



Note. Source: Scopus. Figure content as supplied in the source file.



Table 8

Most Productive Countries (First/Corresponding Author) and Collaboration Pattern

Country	Articles	SCP	MCP	MCP ratio	Citations	Citations/article
China	68	56	12	0.18	943	13.87
United States	10	5	5	0.50	973	97.3
Italy	7	5	2	0.29	93	13.29
Indonesia	7	5	2	0.29	17	2.43
Greece	6	4	2	0.33	35	5.83
India	6	4	2	0.33	180	30
Vietnam	6	6	0	0	10	1.67
Romania	5	4	1	0.21	36	27.2
Bangladesh	4	2	2	0.50	29	7.25
Malaysia	4	3	1	0.25	24	6
Ukraine	4	4	0	0	23	5.75

4.6 Most Cited Articles

Table 9 lists the ten most globally cited articles. They fall into three groups:

- Macro-level studies of digitalisation and industrial transformation. These include Li (2018) on “Made-in-China 2025” and Industry 4.0, Dabbous et al. (2023) on digitalisation, entrepreneurial activity and sustainable competitiveness, and Wang and Guo (2024) on digital technology and local environmental governance.
- Firm-level studies of green entrepreneurial capabilities. Examples are Makhloufi (2024) on big-data analytics, knowledge sharing, green absorptive capacity and GEO, and Al Halbusi et al. (2025) on GEO, green knowledge management and digital transformation as drivers of sustainable innovation and the circular economy.
- Studies linking digitalisation to circular and low-carbon outcomes. Mondal et al. (2023) examine digitally enabled green entrepreneurship in waste management, Findik et al. (2023) treat Industry 4.0 as an enabler of circular practices in European SMEs, Feng et al. (2024) study inclusive green growth, Ye et al. (2020) analyse entrepreneurs switching to green digital businesses, and Chang (2022) estimates the effect of digital finance on agricultural carbon emissions.

None of the ten most cited articles focuses primarily on renewable energy, which anticipates the SDG 7 gap documented in Section 6.

Table 9

Ten Most Globally Cited Articles in the Corpus

Article	Title (abridged)	Source	TC	TC/yr
Li L. (2018)	China’s manufacturing locus in 2025: With a comparison of “Made-in-China 2025” and “Industry 4.0”	<i>Technological Forecasting and Social Change</i>	949	105.44
Dabbous A. et al. (2023)	The impact of digitalization on entrepreneurial activity and sustainable competitiveness: A panel data analysis	<i>Technology in Society</i>	175	43.75
Mondal S. et al. (2023)	Green entrepreneurship and digitalization enabling the circular economy through sustainable waste management	<i>Journal of Cleaner Production</i>	145	36.25
Makhloufi L. (2024)	Do knowledge sharing and big data analytics capabilities matter for green absorptive capacity and green entrepreneurship orientation?	<i>Industrial Management and Data Systems</i>	113	37.67



Article	Title (abridged)	Source	TC	TC/yr
Feng Y. et al. (2024)	Fostering inclusive green growth in China: Identifying the impact of the regional integration strategy	<i>Journal of Environmental Management</i>	99	33
Findik D. et al. (2023)	Industry 4.0 as an enabler of circular economy practices: Evidence from European SMEs	<i>Journal of Cleaner Production</i>	96	24
Al Halbusi H. et al. (2025)	Greening the future: Analyzing green entrepreneurial orientation, green knowledge management and digital transformation	<i>European Journal of Innovation Management</i>	95	47.5
Wang H. & Guo J. (2024)	New way out of efficiency-equity dilemma: Digital technology empowerment for local government environmental governance	<i>Technological Forecasting and Social Change</i>	94	31.33
Ye Q. et al. (2020)	Entrepreneurs and environmental sustainability in the digital era: Regional and institutional perspectives	<i>International Journal of Environmental Research and Public Health</i>	83	11.86
Chang J. (2022)	The role of digital finance in reducing agricultural carbon emissions: Evidence from China's provincial panel data	<i>Environmental Science and Pollution Research</i>	80	16

4.7 Subject Areas and Funding

The Scopus subject classification of the corpus confirms the field's interdisciplinary character. An article can belong to several areas. Business, Management and Accounting is the largest area (74 articles), followed by Social Sciences (72), Environmental Science (60), Economics, Econometrics and Finance (39), Energy (30), Computer Science (27), Decision Sciences (24) and Engineering (22). That Energy ranks only fifth, at 17.0% of articles, is consistent with the limited SDG 7 alignment reported in Section 6.

Funding acknowledgements point in the same direction. The most frequent sponsors are the National Natural Science Foundation of China and the National Social Science Fund of China (10 articles each), followed by the European Commission and China's National Office for Philosophy and Social Sciences (five each) and the Horizon 2020 Framework Programme (three). Only one acknowledgement names the International Energy Agency. Research funding for this topic therefore comes mainly from general science and social-science agencies rather than from energy-sector bodies. This may help explain why studies favour regional economic outcomes over technology- and venture-level energy outcomes.

5. Results: Science Mapping

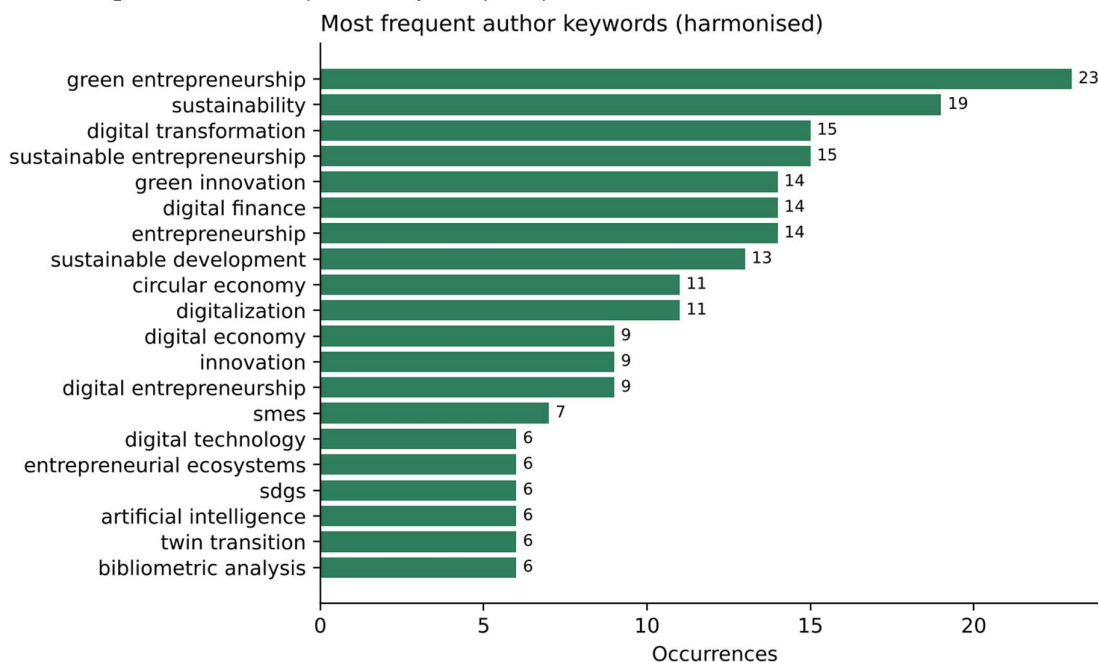
5.1 Keyword Frequency and Co-Occurrence Network

After harmonisation, the corpus contains 734 unique author keywords. The most frequent are green entrepreneurship (23), sustainability (19), digital transformation (15), sustainable entrepreneurship (15), green innovation (14), digital finance (14), entrepreneurship (14), sustainable development (13), circular economy (11) and digitalization (11) (Figure 7). Energy-specific terms are rare: energy start-ups occurs five times and energy-saving technologies three times, and renewable energy does not reach the three-occurrence threshold for author keywords.



Figure 7

Twenty Most Frequent Author Keywords After Synonym Harmonisation



Note. Source: Scopus. Figure content as supplied in the source file.

With a minimum occurrence of three, the co-occurrence network contains 40 keywords connected by 190 links, with a total link strength of 257 (Figure 8). Modularity-based clustering yields five clusters (Table 10):

- **Cluster 1 – Twin transition, digitalisation and the SDGs.** This cluster groups sustainability, digital transformation, digitalization, twin transition, SDGs, entrepreneurial ecosystems and e-commerce. It captures the macro-narrative that the digital and green transitions are mutually reinforcing and must be governed together.
- **Cluster 2 – Capabilities, SMEs and circular or sustainable innovation.** This cluster connects sustainable entrepreneurship, circular economy, SMEs, green entrepreneurial orientation, dynamic capabilities, artificial intelligence and start-ups. It reflects firm-level research grounded in resource-based and capability theories.
- **Cluster 3 – Digital finance and low-carbon inclusive growth.** This cluster combines digital finance, sustainable development, rural entrepreneurship, green total factor productivity (GTFP), inclusive green growth, agricultural carbon emissions and China. It is dominated by Chinese regional panel econometrics and is the cluster most directly tied to SDG 13.
- **Cluster 4 – Green entrepreneurship in the digital economy.** This cluster is centred on the most frequent keyword, green entrepreneurship, and links it to the digital economy, digital technology, green finance, financial inclusion and energy-saving technologies. It is the main bridge to SDG 7 through energy efficiency.
- **Cluster 5 – Energy start-ups and digital entrepreneurship.** This cluster links green innovation, digital entrepreneurship, energy start-ups, non-linear effects and panel data analysis. It represents the newest and most explicitly energy-focused research front.

In terms of total link strength, which measures how strongly a keyword is connected to the rest of the network, green entrepreneurship (37), sustainability (34), digital transformation (30), digitalization (27), innovation (25), entrepreneurship, green innovation and sustainable development (23 each) are the most central nodes. The strongest pairwise links connect green entrepreneurship with sustainability and digital

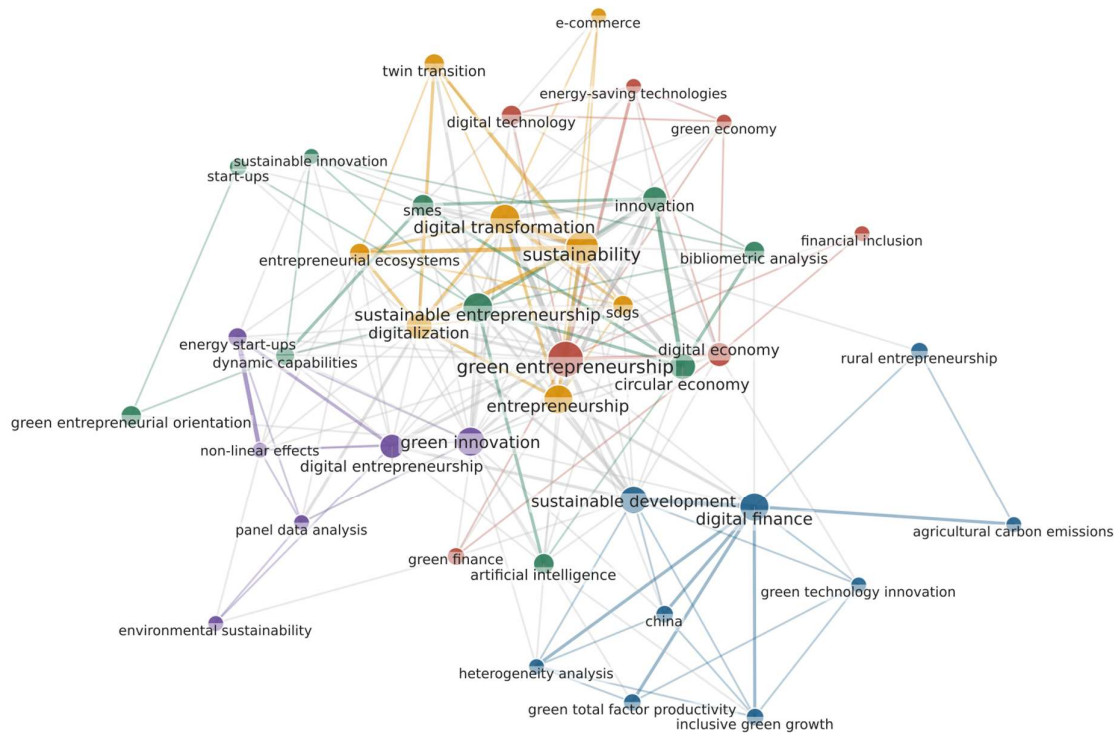


transformation, and digital finance with sustainable development and green total factor productivity. Energy start-ups have a total link strength of 11 despite only five occurrences, which indicates that this young keyword is already well connected to digital entrepreneurship, green innovation and non-linear institutional effects.

Figure 8

Author-Keyword Co-Occurrence Network (VOSviewer Conventions: Full Counting, Minimum Occurrence = 3; Node Size = Occurrences; Edge Width = Co-Occurrence Strength; Colours = Clusters)

Author-keyword co-occurrence network (min. occurrence = 3; 40 items)



Note. Source: Scopus. Figure content as supplied in the source file.

Table 10

Keyword Co-Occurrence Clusters (Min. Occurrence = 3; 40 Items, 190 Links)

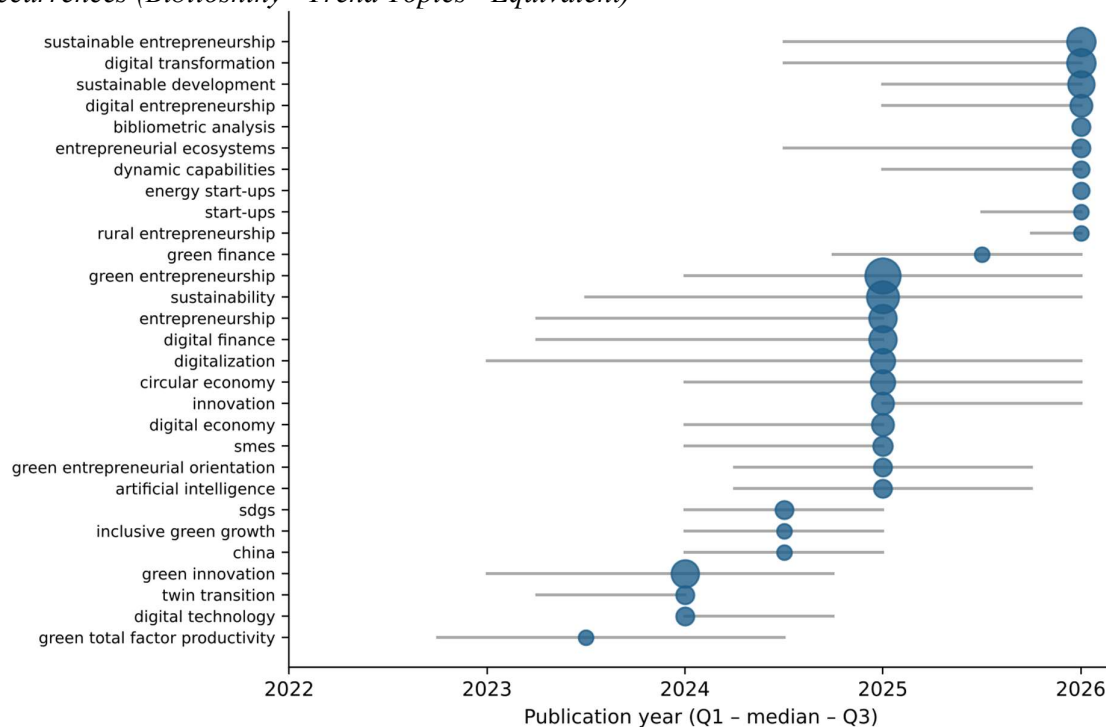
Cluster	Keywords (occurrences)	Mean pub. year
C1: Twin transition, digitalisation & SDGs	sustainability (19); digital transformation (15); entrepreneurship (14); digitalization (11); sdgs (6); twin transition (6); entrepreneurial ecosystems (6); e-commerce (3)	2024.5
C2: Capabilities, SMEs & circular/sustainable innovation	sustainable entrepreneurship (15); circular economy (11); innovation (9); smes (7); bibliometric analysis (6); artificial intelligence (6); green entrepreneurial orientation (6); dynamic capabilities (5); start-ups (4); sustainable innovation (3)	2025.2
C3: Digital finance & low-carbon inclusive growth	digital finance (14); sustainable development (13); rural entrepreneurship (4); inclusive green growth (4); green total factor productivity (4); china (4); heterogeneity analysis (3); green technology innovation (3); agricultural carbon emissions (3)	2024.6





Figure 10

Trend Topics: First Quartile, Median and Third Quartile of Publication Years for Keywords With at Least Four Occurrences (Biblioshiny “Trend Topics” Equivalent)



Note. Source: Scopus. Figure content as supplied in the source file.

5.3 Thematic Map

The strategic map (Figure 11; Table 11) positions eight themes, detected with a minimum keyword frequency of two (83 keywords), by their centrality, or relevance to the field, and density, or internal development.

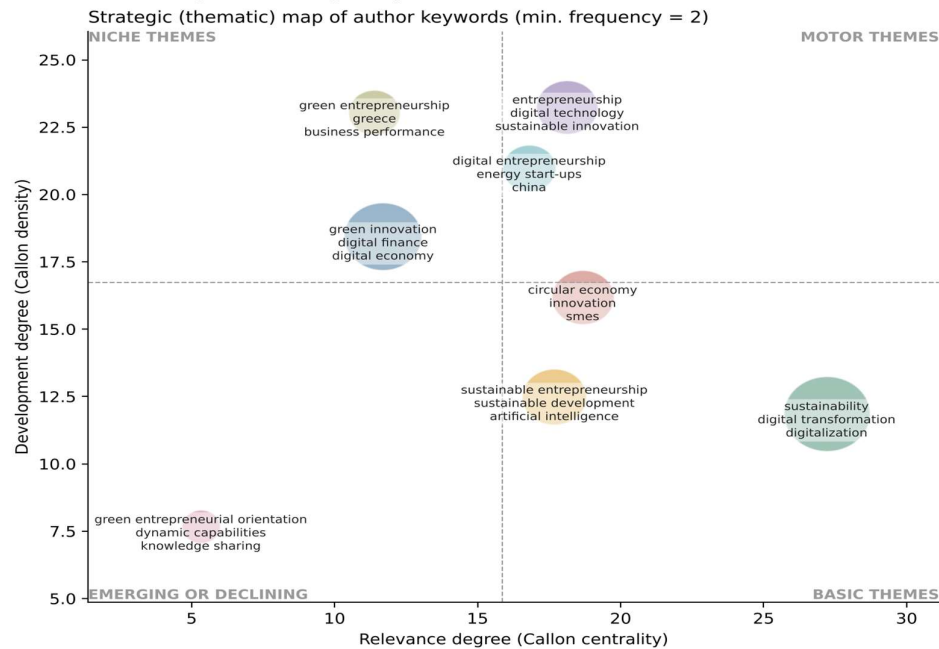
- **Motor themes** are both central and well developed. They are (i) entrepreneurship, digital technology, e-commerce, energy-saving technologies and green economy, and (ii) digital entrepreneurship, energy start-ups, China, economic freedom and carbon emissions. That a digitally enabled energy-start-up theme already occupies the motor quadrant, despite its recency, signals a fast-consolidating research front.
- **Basic themes** are central but less developed. They are (i) sustainability, digital transformation, digitalization, the SDGs, twin transition and entrepreneurial ecosystems; (ii) sustainable entrepreneurship, sustainable development, artificial intelligence and green funding; and (iii) circular economy, innovation, SMEs, Industry 4.0 and sustainable business models. These are the transversal foundations on which the field is built.
- **Niche themes** are well developed but peripheral. They are (i) green innovation, digital finance, the digital economy, GTFP, inclusive green growth and agricultural carbon emissions, which together form the Chinese econometric stream, and (ii) a firm-performance stream around green entrepreneurship, COVID-19 and regression analysis.

Emerging or declining themes have low centrality and density. Green entrepreneurial orientation, dynamic capabilities, knowledge sharing, green entrepreneurial intention and ESG performance fall here. Because the trend analysis dates these keywords to 2025–2026, they are best read as emerging rather than declining.



Figure 11

Strategic (Thematic) Map of Author Keywords Using Callon Centrality and Density (Biblioshiny Conventions; Bubble Size = Keyword Frequency)



Note. Source: Scopus. Figure content as supplied in the source file.

Table 11

Thematic Map: Clusters, Callon Indices and Strategic Quadrant

Theme (leading keywords)	Centrality	Density	Freq.	Quadrant
sustainability; digital transformation; digitalization; sdgs; twin transition	27.2	11.87	86	Basic themes
green innovation; digital finance; digital economy; rural entrepreneurship; inclusive green growth	11.69	18.44	70	Niche themes
sustainable entrepreneurship; sustainable development; artificial intelligence; vocational education; generative ai	17.68	12.48	48	Basic themes
circular economy; innovation; smes; bibliometric analysis; green finance	18.67	16.19	45	Basic themes
entrepreneurship; digital technology; sustainable innovation; e-commerce; green economy	18.13	23.25	44	Motor themes
digital entrepreneurship; energy start-ups; china; panel data analysis; environmental sustainability	16.8	20.98	33	Motor themes
green entrepreneurship; greece; business performance; regression analysis; covid-19	11.39	23.04	31	Niche themes
green entrepreneurial orientation; dynamic capabilities; knowledge sharing; green entrepreneurial intention; esg performance	5.32	7.67	17	Emerging or declining themes

Note. Centrality = $10 \times \Sigma$ external equivalence-index links; density = $100 \times \Sigma$ internal links / number of keywords (Cobo et al., 2011). Quadrants split at the mean centrality (15.86) and mean density (16.74).

5.4 Thematic Evolution

Splitting the corpus into two periods shows how its emphasis has shifted. The 2013–2023 period has 35 articles and is led by green innovation, sustainability, digital finance, digitalization and green



entrepreneurship. The 2024–2026 period has 141 articles and is led by green entrepreneurship (19), digital transformation (14), sustainable entrepreneurship (14), sustainability (14) and sustainable development (11). Over time, the focus has moved from digital finance and green innovation as macro-economic drivers toward digital transformation and entrepreneurship as the organising lens, and from a narrow green framing toward a broader sustainable-entrepreneurship framing explicitly connected to the SDGs.

5.5 Co-Citation Analysis: The Intellectual Base

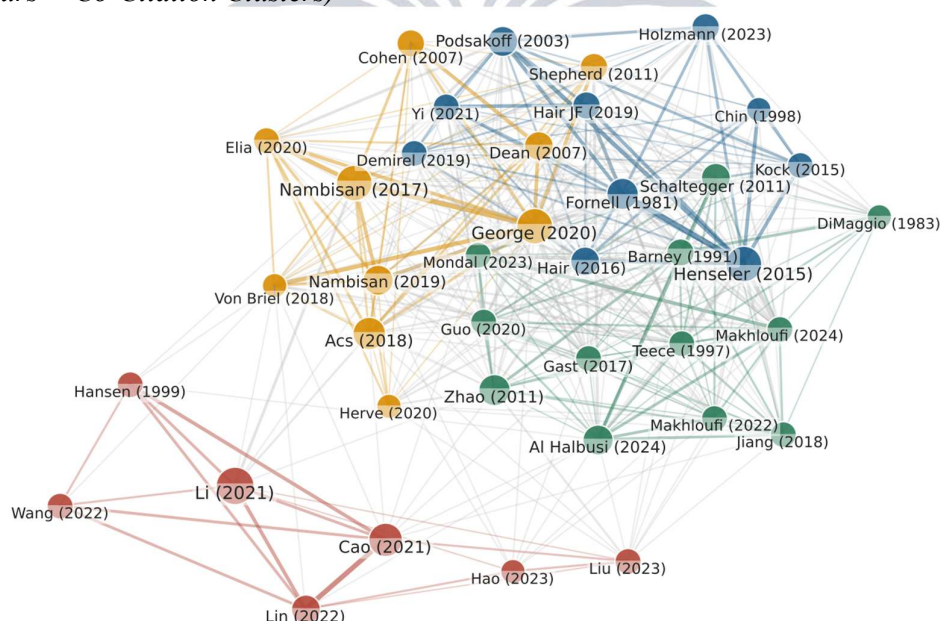
The 176 articles cite 11,799 references. The co-citation network of the most locally cited references (Figure 12; Table 12) reveals four intellectual clusters:

- **CC1, capabilities and green entrepreneurial orientation.** This cluster contains the resource-based view (Barney, 1991), dynamic capabilities (Teece et al., 1997), institutional isomorphism (DiMaggio & Powell, 1983), sustainable-entrepreneurship categories (Schaltegger & Wagner, 2011) and recent GEO studies (Al Halbusi et al., 2025; Makhloufi, 2024; Mondal et al., 2023).
- **CC2, PLS-SEM methodology.** This cluster includes Fornell and Larcker (1981), Henseler et al. (2015), Hair et al. (2016, 2019) and Podsakoff et al. (2003). It shows that a large share of firm-level research relies on survey-based structural equation modelling.
- **CC3, digital and sustainable entrepreneurship foundations.** This cluster contains Nambisan (2017), Nambisan et al. (2019), George et al. (2021), Cohen and Winn (2007), Dean and McMullen (2007), Shepherd and Patzelt (2011), von Briel et al. (2018) and Elia et al. (2020). This is the conceptual core that defines digital green entrepreneurship.
- **CC4, digital economy and finance econometrics.** This cluster consists of Chinese studies on the digital economy and digital finance, together with Hansen's (1999) threshold-regression model. It underpins the regional panel studies of Cluster 3.

The most locally cited items are a Chinese digital-economy study (17 citations), Nambisan (2017), George et al. (2021) and Henseler et al. (2015) with 15 citations each, and a Chinese digital-finance study (13). The weak links between CC3 and CC4 show that theory-driven entrepreneurship research and macro-econometric research on the digital economy have so far developed largely in parallel.

Figure 12

Co-Citation Network of the Most Locally Cited References (Minimum 3 Local Citations; Node Size = Local Citations; Colours = Co-Citation Clusters)



Note. Source: Scopus cited-reference field. Figure content as supplied in the source file.



Table 12

Most Locally Cited References and Co-Citation Clusters

Cited reference	Title (as indexed in reference lists)	Local citations	Co-citation cluster
Li (2021)	Digital economy	17	CC4 Digital economy econometrics
Nambisan (2017)	Digital Entrepreneurship: Toward a Digital Technology Perspective of Entrepreneurship	15	CC3 Digital & sustainable entrepreneurship
George (2020)	Digital Sustainability and Entrepreneurship: How Digital Innovations Are Helping Tackle Climate Change and Sustainable Development	15	CC3 Digital & sustainable entrepreneurship
Henseler (2015)	A New Criterion for Assessing Discriminant Validity in Variance-Based Structural Equation Modeling	15	CC2 PLS-SEM methods
Cao (2021)	Digital finance	13	CC4 Digital economy econometrics
Acs (2018)	Entrepreneurship	12	CC3 Digital & sustainable entrepreneurship
Zhao (2011)	Entrepreneurial orientation	11	CC1 Capabilities & GEO
Fornell (1981)	Evaluating structural equation models with unobservable variables and measurement error	11	CC2 PLS-SEM methods
Al Halbusi (2024)	Greening the Future: Analyzing Green Entrepreneurial Orientation	10	CC1 Capabilities & GEO
Podsakoff (2003)	Common method biases in behavioral research: A critical review of the literature and recommended remedies	10	CC2 PLS-SEM methods
Nambisan (2019)	The Digital Transformation of Innovation and Entrepreneurship: Progress	10	CC3 Digital & sustainable entrepreneurship
Lin (2022)	How does digital finance influence green technology innovation in China?	9	CC4 Digital economy econometrics
Hair (2016)	A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)	9	CC2 PLS-SEM methods
Schaltegger (2011)	Sustainable entrepreneurship and sustainability innovation: Categories and interactions	9	CC1 Capabilities & GEO

6. Systematic Review: Digital Green Entrepreneurship for SDG 7 and SDG 13

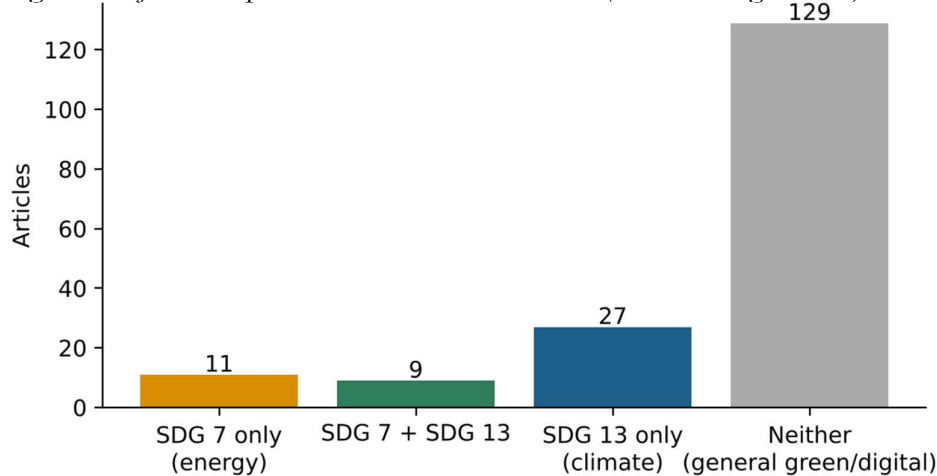
6.1 SDG Alignment of the Corpus

The text-mining screen shows that SDG alignment is limited and uneven (Figure 13). Only 20 articles (11.4%) contain an explicit energy dimension (SDG 7) and 36 (20.5%) a climate dimension (SDG 13). Nine articles address both, 11 address energy only and 27 address climate only. The remaining 129 articles (73.3%) discuss green or sustainable outcomes in general terms without measuring energy or climate variables. Table 13 and Figure 14 cross-tabulate the coded research streams with the two SDGs. The energy dimension appears mainly in the digital-platforms and energy-start-ups stream (12 articles) and in the ecosystems, policy and institutions stream (13 articles). The climate dimension is concentrated in the digital-economy, carbon and regional-growth stream (26 articles) and the ecosystems, policy and institutions stream (32 articles).



Figure 13

Alignment of the Corpus With SDG 7 and SDG 13 (Text-Mining Screen)



Note. Figure content as supplied in the source file.

Table 13

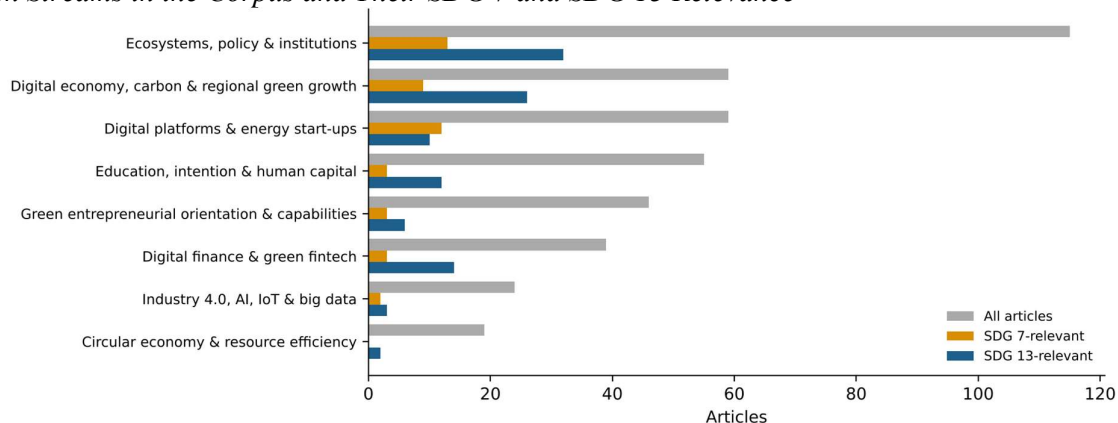
Thematic Coding of the Corpus and Alignment With SDG 7 and SDG 13

Research stream (coding dictionary)	Articles	SDG 7-relevant	SDG 13-relevant	Citations
Ecosystems, policy & institutions	115	13	32	1,418
Digital platforms & energy start-ups	59	12	10	772
Digital economy, carbon & regional green growth	59	9	26	917
Education, intention & human capital	55	3	12	699
Green entrepreneurial orientation & capabilities	46	3	6	672
Digital finance & green fintech	39	3	14	1,458
Industry 4.0, AI, IoT & big data	24	2	3	314
Circular economy & resource efficiency	19	0	2	250

Note. Streams are coded by dictionary matching on title, abstract and keywords; one article can belong to several streams.

Figure 14

Research Streams in the Corpus and Their SDG 7 and SDG 13 Relevance



Note. Source: Authors' coding. Figure content as supplied in the source file.



6.2 Theme A: Energy Start-Ups, Institutions and Financing Ecosystems (SDG 7.2, 7.a, 7.b)

The most explicitly SDG 7-oriented stream is a 2026 cluster of cross-country panel studies that combine International Energy Agency start-up and funding data with institutional indicators. These studies treat the creation and financing of green and digital energy start-ups as the dependent variable:

- Sitnicki et al. (2026a) find that economic freedom shapes energy start-up dynamics through non-linear institutional effects that vary by investment stage.
- Sitnicki et al. (2026b) show that digitalisation, measured by the Digital Economy and Society Index, and entrepreneurial-ecosystem quality drive both the number and the funding of energy start-ups, with lagged and stage-specific effects.
- Sitnicki et al. (2026c) report that public R&D support and finance-related policy instruments in 37 European and neighbouring economies are associated with energy start-up activity, but with delayed and non-linear effects.
- Sitnicki et al. (2026d) relate energy-policy stringency to green digital energy start-ups across 47 countries.
- Bilan et al. (2026) show, using a panel of 144 economies, that governance quality and transparency create favourable conditions for green and digital energy start-ups.

These studies support SDG 7.2 by linking the entrepreneurial pipeline to renewable deployment, and SDG 7.a and 7.b by linking it to investment and technology upgrading. Complementary qualitative evidence comes from Ukrainian studies on integrating energy-saving technologies with the digital economy (Sobko et al., 2024a, 2024b) and on innovation parks as catalysts of digital transformation and energy efficiency (Krysovaty et al., 2025). Furuncu (2026) compares policy, financial and digital infrastructures in EU and Turkish green-entrepreneurship ecosystems. At the technology frontier, Wu and Li (2024) propose a data-driven framework for green-hydrogen start-ups.

6.3 Theme B: Digital and Green Finance as Carbon-Reduction Mechanisms (SDG 13.2, SDG 7.4)

A second stream analyses how digital finance, fintech and green-finance reforms affect carbon outcomes, often through entrepreneurship as a mediator:

- Chang (2022) finds that digital finance reduces agricultural carbon emissions in Chinese provinces, with threshold and moderating effects.
- Zhang and Li (2025) confirm the result at the city level and identify rural entrepreneurship and agricultural innovation as transmission channels.
- Cheng et al. (2023) show that digital financial inclusion raises green total factor productivity through innovation and entrepreneurship.
- Zhao et al. (2025) report that green-finance reform promotes regional industrial innovation and entrepreneurship, partly through digital transformation.
- Tian et al. (2026) link sci-tech finance pilots to pollution-carbon reduction synergy.

Cross-country evidence is more ambivalent. Li, Hoang et al. (2025) find that fintech can worsen climate quality while green entrepreneurship improves it. Luo and Lenton (2026) proxy green entrepreneurship with renewable and nuclear generation and show how it interacts with carbon finance in G20 economies. Li and Safi (2025) find that early-stage entrepreneurship raises emissions unless it is moderated by strong financial institutions. Taken together, digital finance appears to be a powerful but conditional enabler. Its climate benefits depend on whether credit is channelled into green ventures.

6.4 Theme C: Digital Economy, Data Infrastructure and Low-Carbon Regional Development (SDG 13.2, SDG 7.3)

Quasi-experimental studies of Chinese policy pilots provide the strongest causal evidence in the corpus:

- E-commerce demonstration-city policies reduced total CO₂ emissions in pilot cities by an estimated 7.89% (Zhang et al., 2024).



- Green data-centre pilots, a form of green digital infrastructure, increased energy-utilisation efficiency by about 27.5% of a standard deviation, partly by attracting digital talent and fostering green and digital innovation (Jiang et al., 2026). This is directly relevant to SDG 7.3.
- Public-data-platform openings improved green total factor productivity (Lv & Wang, 2026a).
- Digital rural pilots improved agricultural carbon productivity (Guo & Zhu, 2026).
- Return-entrepreneurship pilots reduced agricultural emissions in the Yangtze River Economic Belt (Luo et al., 2026).

Panel studies corroborate that the digital economy promotes low-carbon inclusive development with diminishing marginal effects (Yang et al., 2023), that digitalisation and entrepreneurship jointly support green development under low-carbon strategies (Zhang, 2024), and that digital entrepreneurial activity raises GTFP (Mao et al., 2025). Evidence beyond China is emerging. In E7 economies, the interaction of digitalisation and entrepreneurship produces an “institutional trilemma” for green-inclusive growth (Qiu & Rashid, 2026), and in G7 economies artificial intelligence without inclusion may undermine SDG progress (Mai et al., 2025).

6.5 Theme D: Firm-Level Adoption, Orientation and Business-Model Innovation (SDG 7.1, 7.2, 12)

Firm-level studies explain why and how entrepreneurs adopt digitally enabled green technologies:

- Polas et al. (2023) show, from a survey of 288 rural SMEs in Bangladesh, that environmental concern, perceived ease of use and attitude drive the adoption of green innovation, mediated by the intention to use green energy technology. This links digital-adoption theory directly to clean-energy uptake and SDG 7.1.
- Ye et al. (2020) model the push, pull and mooring factors behind entrepreneurs’ switch to green businesses in the digital era.
- Liu and Zhang (2024) show that entrepreneurial bricolage and business-model innovation raise the sustainable performance of digital ventures, especially when digital ecosystems empower them.
- Santolin et al. (2023) and Findik et al. (2023) identify digital enablers of circular practices in SMEs.
- Hota et al. (2026) document cost and regulatory barriers to digital green ventures.
- Thach et al. (2026) map the drivers and barriers of green-technology commercialisation, including financing frictions and infrastructure constraints.

The co-citation analysis shows that this stream relies heavily on PLS-SEM, which limits causal inference.

6.6 Theme E: Education, Digital Literacy and Youth Entrepreneurship (SDG 13.3)

A smaller stream addresses human-capital enablers. Cocu et al. (2025) integrate technology-enabled green-entrepreneurship education into engineering curricula. Dissanayake et al. (2026) analyse 450 South Asian start-up, incubator and policy documents and find that digital discourse grew faster than green-innovation discourse after COVID-19. Xu et al. (2026) review 52 studies and show that farmers’ digital literacy acts as an enabler, a mediator and a potential barrier in green-technology adoption. These contributions correspond to SDG 13.3 (education and capacity building) but remain largely descriptive.

Table 14

Synthesis of SDG 7- and SDG 13-Relevant Evidence (n = 43)

Theme	Representative studies	Digital mechanism	Energy/climate outcome	SDG targets	Dominant methods
A. Energy start-ups & ecosystems	Sitnicki et al. (2026a–d); Bilan et al. (2026); Sobko et al. (2024a, b); Wu & Li (2024); Furuncu (2026)	DESI digitalisation, ecosystems, R&D support, governance	Number and funding of green/digital energy start-ups	7.2, 7.a, 7.b	Cross-country panels (FE, PPML), qualitative policy analysis
B. Digital & green finance	Chang (2022); Zhang & Li (2025); Cheng et al. (2023);	Digital/inclusive finance, fintech,	Agricultural and total CO ₂ , GTFP,	13.2, 7.a	Provincial/city panels,



Theme	Representative studies	Digital mechanism	Energy/climate outcome	SDG targets	Dominant methods
C. Digital economy & infrastructure	Zhao et al. (2025); Luo & Lenton (2026); Li & Safi (2025)	green-finance reform	environmental quality		threshold, CS-ARDL, MMQR
	Zhang et al. (2024); Jiang et al. (2026); Yang et al. (2023); Lv & Wang (2026a); Guo & Zhu (2026); Qiu & Rashid (2026)	E-commerce, green data centres, public data, digital villages	CO2 reduction, energy-utilisation efficiency, low-carbon growth	13.2, 7.3	Staggered DID, DML, spatial models
D. Firm adoption & business models	Polas et al. (2023); Ye et al. (2020); Liu & Zhang (2024); Hota et al. (2026); Thach et al. (2026)	Technology acceptance, bricolage, digital ecosystems	Green-energy technology adoption, sustainable performance	7.1, 7.2, 12.6	Surveys, PLS-SEM, bibliometrics

6.7 Methodological and Contextual Profile of the Evidence

The 43 synthesised articles have accumulated 530 citations, and 30 of them (69.8%) were published in 2025–2026. This shows that the energy- and climate-relevant evidence base is even younger than the corpus as a whole. Methodologically, the evidence is dominated by econometric designs. Eighteen articles use panel regressions (fixed effects, threshold, spatial or Poisson pseudo-maximum-likelihood models), eight exploit difference-in-differences or other quasi-experimental designs, and five apply time-series or quantile methods such as ARDL, NARDL and method-of-moments quantile regression. Survey-based structural equation models (six), qualitative case or content analyses (six) and reviews or text-mining studies (six) are less common. Only two articles use machine-learning or data-driven designs, which is striking for a field concerned with digital technologies.

Contextually, 17 articles study China, 14 adopt cross-country or multi-country designs (G7, G20, E7, ASEAN or global samples), six focus on Europe, three on South Asia and two on Ukraine. The over-representation of Chinese regional data explains why carbon outcomes (SDG 13) are better measured than renewable-energy outcomes (SDG 7). Provincial and city statistics on emissions and green productivity are readily available, whereas venture-level data on renewable deployment are not. The cross-country energy start-up studies show that harmonised international data, such as IEA start-up and funding statistics, can begin to close this gap.

6.8 Mapping the Evidence to SDG Targets

Mapping the 43 articles to SDG targets shows a clear asymmetry. For SDG 7, the evidence clusters around target 7.2 (renewable share) and target 7.a (investment and technology cooperation) through the energy start-up studies, and around target 7.3 (energy efficiency) through the studies of energy-saving technologies and green digital infrastructure. Target 7.1 (universal access) is addressed by only one study, on rural Bangladeshi SMEs adopting green energy technology (Polas et al., 2023), and target 7.b (infrastructure in developing countries) is addressed only indirectly. For SDG 13, target 13.2 (integrating climate measures into policy) dominates through evaluations of digital and green-finance pilot policies; target 13.3 (education and capacity) is covered by the education stream; and target 13.1 (resilience and adaptation) is almost entirely absent. The result is a literature that measures mitigation far more often than access or adaptation, even though energy access and climate resilience are where digital entrepreneurship in developing countries may matter most.



7. Discussion

7.1 An Integrative Framework

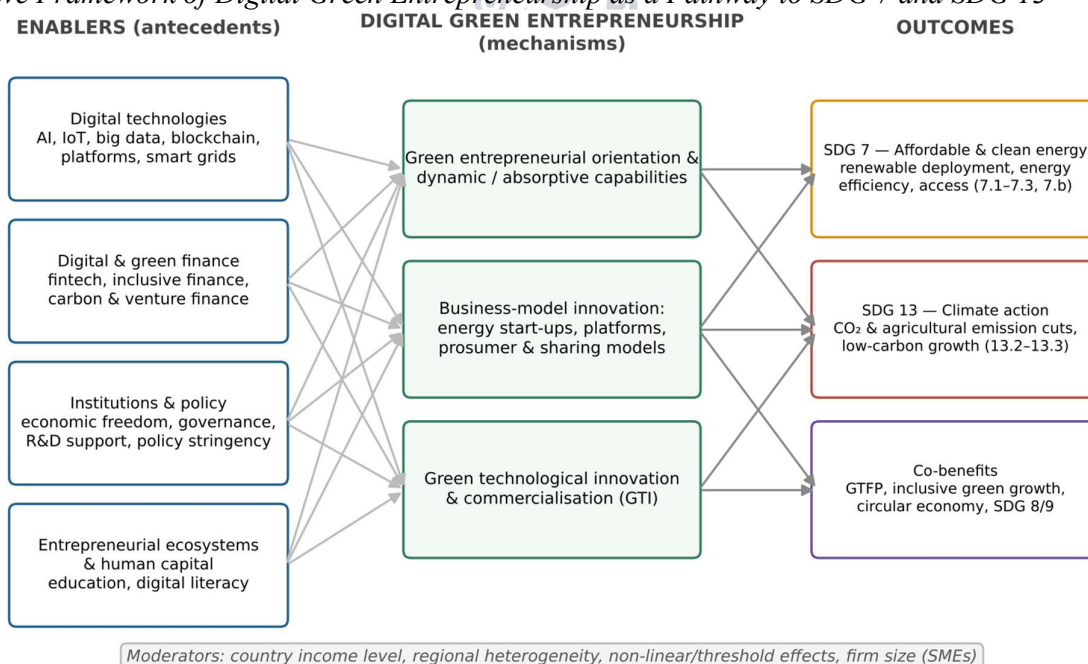
Combining the bibliometric clusters with the qualitative themes yields the enabler-mechanism-outcome framework shown in Figure 15. Four enablers feed three entrepreneurial mechanisms, which in turn feed three outcomes:

- **Enablers:** digital technologies (AI, IoT, big data, blockchain and platforms); digital and green finance; institutions and policy (economic freedom, governance, R&D support and policy stringency); and entrepreneurial ecosystems and human capital.
- **Mechanisms:** green entrepreneurial orientation and dynamic or absorptive capabilities; business-model innovation such as energy start-ups, platforms and prosumer models; and green technological innovation and commercialisation.
- **Outcomes:** SDG 7 (renewable deployment, efficiency and access), SDG 13 (emission reduction and low-carbon growth) and co-benefits such as GTFP, inclusive growth and the circular economy.

The framework also incorporates the moderators that recur in the evidence: national income level, regional heterogeneity, firm size and, especially, non-linear or threshold effects. Nonlinear effects are one of the newest keywords in the corpus.

Figure 15

Integrative Framework of Digital Green Entrepreneurship as a Pathway to SDG 7 and SDG 13



Note. Source: Authors' synthesis. Figure content as supplied in the source file.

7.2 Theoretical Implications

The findings carry four theoretical implications.

First, they give empirical shape to George et al.'s (2021) notion of digital sustainability. The field has grown from a handful of papers before 2021 to 176 articles, and its motor themes now include digital energy start-ups. At the same time, the co-citation structure shows two largely separate traditions: entrepreneurship theory (CC1 and CC3) and digital-economy econometrics (CC4). Integrating them, for example by theorising the micro-foundations behind macro-level digital-finance effects, is a key theoretical task.

Second, the dominance of green entrepreneurship as a keyword, combined with the scarcity of renewable energy, implies that much of the literature treats "green" as a generic environmental attribute. Energy is a sector with specific technological, regulatory and capital-intensity characteristics. These include



grid access, long payback periods, price volatility and policy dependence, and they condition entrepreneurial action in ways that generic models do not capture. The Sitnicki et al. (2026a–d) series shows the value of sector-specific data such as IEA start-up and investment statistics.

Third, the frequency of threshold, non-linear and heterogeneity findings suggests that digitalisation's environmental effects are contingent rather than linear. Rebound effects, energy demand from digital infrastructure and fintech-driven consumption (Li, Hoang et al., 2025) can offset the gains. Theories of digital green entrepreneurship should therefore specify the boundary conditions under which digital enablement translates into net decarbonisation.

Fourth, the emergence of GEO and dynamic capabilities as new themes, together with Makhoulfi (2024) and Al Halbusi et al. (2025), points to a capability-based micro-foundation. Big-data analytics, knowledge sharing and green absorptive capacity convert digital resources into green innovation.

7.3 Practical and Policy Implications

For entrepreneurs and investors in renewable energy, the evidence indicates that digital capabilities such as data analytics and platform design, combined with green orientation, are associated with superior innovation and sustainable performance. Access to finance, however, remains the binding constraint.

For managers of energy start-ups and incumbent utilities, the evidence suggests three priorities. The first is to invest in data-analytics and knowledge-sharing capabilities that build green absorptive capacity, since these capabilities mediate the conversion of digital resources into green innovation (Makhoulfi, 2024; Al Halbusi et al., 2025). The second is to use digital platforms and supply-chain finance arrangements to relax financing constraints, which the operations-research literature shows can make green technology development viable for capital-constrained ventures (Reza-Gharehbagh et al., 2022, 2023). The third is to monitor institutional conditions closely, because the effects of policy instruments on energy start-up funding appear with lags and can reverse beyond certain thresholds.

For policymakers, four implications follow. First, the evidence on public R&D support, policy stringency, governance quality and economic freedom (Bilan et al., 2026; Sitnicki et al., 2026a, 2026c, 2026d) suggests that stable, transparent and moderately stringent policy frameworks are more conducive to energy start-ups than ad-hoc subsidies. Because these effects are delayed and non-linear, policy evaluation horizons should be extended. Second, the Chinese pilot evaluations show that place-based digital infrastructure policies, such as green data centres, e-commerce cities and digital villages, can yield measurable efficiency and carbon gains and could be adapted elsewhere. Third, directing digital and inclusive finance toward clean-energy ventures, rather than consumption, is essential if fintech is to support SDG 13. Fourth, digital-literacy and entrepreneurship-education programmes (SDG 13.3) are necessary complements, especially for rural entrepreneurs in emerging economies.

7.4 Comparison with Prior Reviews

The present findings both confirm and extend earlier reviews. Like Erneiz et al. (2026), this study finds dispersed authorship and limited international collaboration, a pattern quantified here through the steep Lotka distribution and China's MCP ratio of 0.18. Like Haji and Ismael (2026), it identifies financing mechanisms and institutional support as recurring themes. It goes further in three ways. It shows that energy start-ups have very recently become a motor theme. It documents a structural separation between entrepreneurship theory and digital-economy econometrics in the co-citation network. It quantifies the SDG 7 deficit, with only 11.4% of articles measuring energy outcomes. Taken together, these results suggest that the field is moving from a generic "green" framing toward a sector-specific energy framing, but that this transition is still at an early stage.

8. Future Research Agenda

The gaps identified across the performance, science-mapping and synthesis results are translated into the research agenda in Table 15.



Table 15

Future Research Agenda for Digital Green Entrepreneurship in Renewable Energy

Gap identified	Evidence from this review	Suggested research questions	Suggested methods
Weak SDG 7 focus	11.4% of articles address renewable below threshold	How do digital platforms (P2P trading, virtual power plants, energy-as-a-service) affect renewable deployment and energy access?	Venture-level databases (IEA, Crunchbase), multiple case studies
Geographic concentration	China 38.6% of output; Africa and Latin America nearly absent	How does digital green entrepreneurship support off-grid solar and energy access in Sub-Saharan Africa and South Asia?	Comparative fieldwork, mobile-money and PAYG solar data
Theory–econometrics divide	Separate co-citation clusters CC1/CC3 vs CC4	Which entrepreneurial micro-mechanisms explain macro digital-finance–carbon effects?	Multilevel and mixed-methods designs
Causality at firm level	Reliance on cross-sectional PLS-SEM (CC2)	Does GEO causally drive clean-energy innovation in digital ventures?	Longitudinal panels, field experiments, DID
Rebound and digital footprint	Fintech can worsen climate quality; nonlinear effects	When do digital ventures produce net emission reductions after accounting for digital energy demand?	Life-cycle assessment combined with firm data
Frontier technologies	AI, blockchain and green hydrogen marginal in the corpus MCP ratio of China	How do AI and generative-AI tools reshape opportunity recognition and grid-service business models?	Case studies, text mining, simulation
Low collaboration	0.18; Lotka distribution steeper than expected	How can international and transdisciplinary collaboration be fostered?	Collaboration network analysis
Inclusiveness	Women, youth and rural entrepreneurs under-studied	How do gender and rural context condition digital green venture outcomes?	Surveys, intersectional analysis

Note. Table reconstructed from the source text.

Three directions deserve emphasis. First, research should move from “green” to “energy” by measuring renewable-energy outcomes such as installed capacity, access, efficiency and flexibility services at the venture level. Second, it should broaden its geography toward Africa, Latin America and South Asia, where energy-access deficits and leapfrogging opportunities are greatest. Third, it should adopt designs that reveal causal effects and account for life-cycle impacts, so that the net contribution of digitalisation to decarbonisation can be assessed rather than assumed.

9. Conclusion

This study combined bibliometric analysis and a systematic literature review to map digital green entrepreneurship in relation to renewable energy, SDG 7 and SDG 13. Analysis of 176 Scopus articles shows a young, rapidly expanding and fragmented field: 80.1% of articles were published after 2023, journals are widely dispersed, productivity follows a steeper-than-Lotka distribution and research is concentrated in China. Science mapping identifies five conceptual clusters and four intellectual traditions. Digital entrepreneurship and energy start-ups have emerged as a motor theme, while green entrepreneurial orientation and dynamic capabilities are emerging micro-foundations. The systematic synthesis of 43 articles reveals five mechanisms through which digital green entrepreneurship contributes to clean energy and climate action, but it also shows



that explicit renewable-energy outcomes (SDG 7) remain under-studied relative to carbon outcomes (SDG 13).

9.1 Limitations

The study has several limitations. It relies on a single database, Scopus. Extending the search to Web of Science Core Collection and merging the records with bibliometrix's duplicate-removal routine would improve coverage. The search string centred on the composite term "digital green entrepreneurship", and synonyms such as "cleantech start-up" or "energy venture" may retrieve additional energy-specific studies. Citation-based indicators disadvantage the many articles published in 2025–2026. Author-name ambiguity, particularly for common Chinese surnames, affects author-level counts. Finally, SDG coding relied on dictionary screening of titles, abstracts and keywords, which may under-detect energy content that appears only in full texts. Future reviews could address these limitations through multi-database searches, full-text coding and periodic updating as the field matures.

Author's Contributions

All authors participated in ideation, development, and writing the manuscript. All authors read and approved the final manuscript.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding Statement

The authors did not receive financial support from any funding agency or external organization for the research, authorship, or publication of this article.

Informed Consent

Informed consent was obtained from all participants prior to data collection. Participants were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time without any consequences. The confidentiality and anonymity of respondents were guaranteed throughout the research process.

Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request. The authors are committed to transparency and will provide detailed methodological information and analysis protocols upon request.

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