

Sustainable Development and Business Strategy: A Bibliometric Mapping

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ABSTRACT

Purpose – This study maps conceptual and thematic relationships, dominant keywords, and temporal growth signals in a query-defined Scopus corpus where “sustainable development,” “business,” and “strategy” co-occur in title, abstract, or keyword fields. The query does not require the exact phrase “business strategy”.

Design/methodology/approach – Scopus records were retrieved on 2 June 2026. The corpus comprises 3,709 English-language journal articles published during 2020–2026. VOSviewer 1.6.19 was used for the archived network, overlay, and density maps. Keyword-growth indicators were recalculated separately from the existing Scopus CSV using a documented normalization map and complete-year windows (2020–2022 versus 2023–2025); incomplete 2026 was excluded. The original VOSviewer project/map file and thesaurus were unavailable, so the archived network metrics and clusters are not represented as a verified harmonized rerun.

Findings – The archived VOSviewer output reports 116 keyword nodes, 1,758 links, total link strength of 4,309, and eight clusters. The CSV-based growth audit identifies 30 keywords with at least 15 occurrences in 2020–2025 and normalized growth above 1.25, but none meets the additional mean-year threshold of at least 2024.30 after incomplete 2026 is excluded. These are growth signals rather than confirmed emerging themes.

Originality/value – The study provides a query-scoped descriptive map and separates archived network results from independently recalculated temporal indicators. It does not infer causality or claim to represent the entire sustainable-business-strategy field.

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1. Introduction

Sustainable development has become one of the central issues in contemporary business and management research. Since the adoption of the Sustainable Development Goals (SDGs), organizations have increasingly integrated economic, social, and environmental dimensions into business strategies to create long-term value and strengthen competitiveness (Gómez Pescador & Arzadun, 2025; Raman et al., 2024). Consequently, sustainable business strategy has evolved beyond traditional corporate social responsibility toward a more strategic approach encompassing Environmental, Social, and Governance (ESG), circular economy, green innovation, and stakeholder engagement (Chen et al., 2023; Tsang et al., 2023; Singh et al., 2025; Wongmahesak et al., 2025).

At the same time, the convergence of sustainability and digital innovation has accelerated research across multiple disciplines. Recent studies have examined digital transformation, artificial intelligence (AI), Industry 4.0, the Internet of Things (IoT), digital platforms, and smart manufacturing as enablers of sustainable business strategies, with implications for operational efficiency, supply-chain resilience, carbon neutrality, and organizational adaptability (Dwivedi et al., 2021; Hassani et al., 2020; Al-Emran & Griffy-Brown, 2023).

Despite the growth of publications, research on sustainable development and business strategy spans multiple conceptual and technological streams, including ESG, circular economy, digital transformation, green innovation, and sustainable business models. Bibliometric science mapping is useful for examining conceptual relationships among terms at scale, while different bibliometric techniques answer different questions about a field (Cobo et al., 2011; Zupic & Čater, 2015).

Accordingly, this study focuses on a query-defined Scopus corpus in which “sustainable development,” “business,” and “strategy” co-occur in title, abstract, or keyword fields. This scope is intentionally narrower than the complete sustainable business-strategy literature. The study uses author-keyword co-occurrence to map thematic/conceptual structure and temporal positioning; it does not claim to establish the intellectual foundations of the field, which would require citation or co-citation analysis.

The study has four objectives: (1) to map the conceptual and thematic structure of the query-defined corpus through author-keyword co-occurrence analysis; (2) to describe dominant keywords and assess candidate growth signals using explicit temporal indicators; (3) to examine temporal positioning without claiming a sequential thematic evolution; and (4) to propose future research directions grounded in observed patterns of scholarly attention. The study contributes a descriptive map of the defined corpus rather than a comprehensive account of the entire sustainable business-strategy field.

2. Literature Review & Research Framework

The study has four objectives: (1) to map the conceptual and thematic structure of the query-defined corpus through author-keyword co-occurrence analysis; (2) to describe dominant keywords and quantitatively assess candidate growth signals; (3) to examine temporal positioning and normalized keyword prevalence across complete publication-year windows; and (4) to propose future research directions grounded in observed patterns. Because the study is bibliometric rather than causal or survey-based, it does not formulate statistical hypotheses. Sustainable development has increasingly moved from a broad normative objective toward a strategic concern for organizations. Research on SDGs and business models indicates that sustainability is being integrated into organizational value creation and strategic decision-making (Gómez Pescador & Arzadun, 2025). The literature also links sustainability with

environmental performance, corporate governance, stakeholder engagement, and circular economy practices (Chen et al., 2023; Tsang et al., 2023; Uwuigbe et al., 2025).

2.2 Digital transformation and technology-enabled sustainability

Digital technologies are becoming increasingly relevant to sustainability-oriented strategy. AI, digital platforms, IoT, and Industry 4.0 can support data-driven decision-making, resource efficiency, resilience, and innovation (Dwivedi et al., 2021; Hein et al., 2020; Al-Emran & Griffy-Brown, 2023). More recent work points toward AI, machine learning, and Industry 5.0 as emerging research directions in which technological development is combined with environmental, organizational, and human-centered objectives (Ofosu-Ampong, 2024; Wongmahesak et al., 2025).

2.3 Research gap and analytical framework

Although sustainability research has expanded rapidly, the literature is dispersed across multiple conceptual and technological streams. Bibliometric mapping can describe relationships among author keywords, concentrations of scholarly attention, and temporal positioning within a defined corpus. The present study uses author-keyword co-occurrence as its principal analytical lens and combines network, overlay, and density visualizations. It does not claim to identify intellectual foundations, which would require citation, co-citation, or related citation-based analysis.

Because the study is bibliometric rather than causal or survey-based, it does not formulate statistical hypotheses. Instead, the analytical framework is organized around four objectives: conceptual/thematic mapping, description of dominant keywords, assessment of temporal positioning and normalized growth signals, and formulation of future research directions.

3. Methodology

3.1 Research design

This study employed a bibliometric research design to analyze publication patterns and keyword relationships in sustainable development and business strategy research. Bibliometric methods are appropriate for science mapping because they can reveal conceptual relationships and research concentrations across large bodies of literature (Cobo et al., 2011; Zupic & Čater, 2015). VOSviewer version 1.6.19 was used for network, overlay, and density visualization (van Eck & Waltman, 2010). PRISMA 2020 was used as a reporting framework for transparent documentation of the search and corpus-construction process; the study does not present itself as a systematic review with title/abstract or full-text eligibility screening (Page et al., 2021).

The data were retrieved from Scopus on 2 June 2026. The final search string was TITLE-ABS-KEY("sustainable development" AND business AND strategy) AND PUBYEAR > 2019 AND PUBYEAR < 2027 AND LIMIT-TO(DOCTYPE,"ar") AND LIMIT-TO(LANGUAGE,"English"). Because business and strategy are searched as separate terms, the query does not require the exact phrase "business strategy." Sequential scoping searches document retrieval refinement only: the initial sustainable-development query returned 273,038 records; adding business returned 19,234; adding strategy returned 5,515; and applying the final article, English-language, and 2020–2026 limits yielded 3,709 records. No alternative-query sensitivity search was conducted; conclusions are therefore limited to this query-defined corpus.

The sequential counts above are search-refinement results, not exclusions produced by screening. The final 3,709 records were therefore treated as the query-defined bibliometric corpus. No title/abstract or full-text manual relevance screening was conducted after the final query. Eligibility was defined by the final Scopus query itself: journal article, English language,

publication year 2020–2026, and co-occurrence of the three search concepts in title, abstract, or keyword fields.

Table 1. Search Refinement and Query-Defined Corpus Construction

Stage	Search criteria	Number of documents
Scoping search	TITLE-ABS-KEY("sustainable development")	273,038
Refinement 1	TITLE-ABS-KEY("sustainable development" AND business)	19,234
Refinement 2	TITLE-ABS-KEY("sustainable development" AND business AND strategy)	5,515
Final corpus	Article + English + 2020–2026 + final query	3,709

Source: Authors' analysis of Scopus search results retrieved on 2 June 2026.

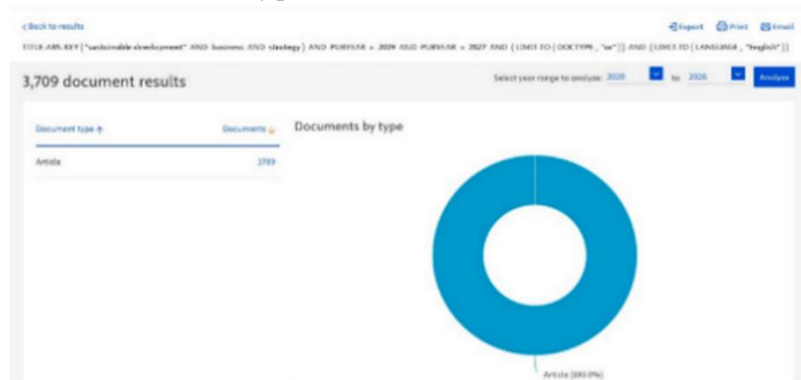
3.3 Corpus Construction and Selection

The final dataset was not manually screened for topical relevance. This distinction is important because adding search terms and database filters changes the retrieval set but does not constitute study-level exclusion. The final 3,709 publications were retained automatically because they met the final query-defined eligibility conditions. Accordingly, the manuscript no longer describes an unobserved relevance assessment, and the flow diagram reports search refinement rather than a conventional PRISMA exclusion count. PRISMA 2020 is cited as a transparency/reporting framework for documenting identification and inclusion logic. The final corpus and all analytical results were generated from the same Scopus export dated 2 June 2026.

3.4 Document Type, Keyword Processing, and Analytical Procedure

Only journal articles were retained by the final Scopus query. The export was analyzed using VOSviewer 1.6.19, with author keywords as the unit of analysis, full counting, and a minimum occurrence threshold of five. The archived VOSviewer output reports 116 retained keyword nodes, 1,758 links, total link strength of 4,309, and eight clusters. The original VOSviewer project/map file, original thesaurus, and clustering-resolution setting are not available in the retained materials; accordingly, these archived network statistics are reported as previously obtained results and are not described as a newly reproduced harmonized run. For the separate CSV-based growth audit, keywords were lowercased, whitespace-normalized, and harmonized using the explicit mapping in Appendix B. This normalization was applied to keyword-frequency and growth calculations only; it was not applied retroactively to the archived VOSviewer map or its cluster assignments.

Figure 1. Distribution of Document Types in the Final Dataset



Source: Authors' analysis of Scopus search results retrieved on 2 June 2026.

Figure 1 shows the document-type composition of the final Scopus corpus. The final query was restricted to journal articles (document type: Article), resulting in 3,709 records for the bibliometric analysis. This restriction was applied directly through the Scopus query and should not be interpreted as a manual screening or exclusion process.

3.5 Bibliometric Mapping and Temporal Indicators

Three VOSviewer visualizations were used: network visualization to describe keyword co-occurrence and the archived clusters, overlay visualization to position keywords by average publication year, and density visualization to describe relative concentration. These visualizations alone do not establish thematic evolution. The separate CSV-based growth audit compares an early period (2020–2022) with a late period (2023–2025), excluding incomplete 2026. For keyword k and period t , prevalence is $p(k,t) = c(k,t) / N(t)$, where $c(k,t)$ is the number of articles in period t containing keyword k and $N(t)$ is the total number of corpus articles in that period. The normalized growth ratio is $G(k) = p(k,late) / p(k,early)$. If $c(k,early)=0$, the ratio is not calculable and is not treated as infinite growth. The early-period denominator is 1,127 articles and the late-period denominator is 2,206 articles. Thirty keywords had at least 15 occurrences in 2020–2025 and $G(k)>1.25$; however, no keyword met the additional mean-publication-year threshold of ≥ 2024.30 after incomplete 2026 was excluded. These are reported as growth signals, not as themes satisfying the original combined emergence rule.

4. Results and Discussion

4.1 Network visualization and thematic clusters

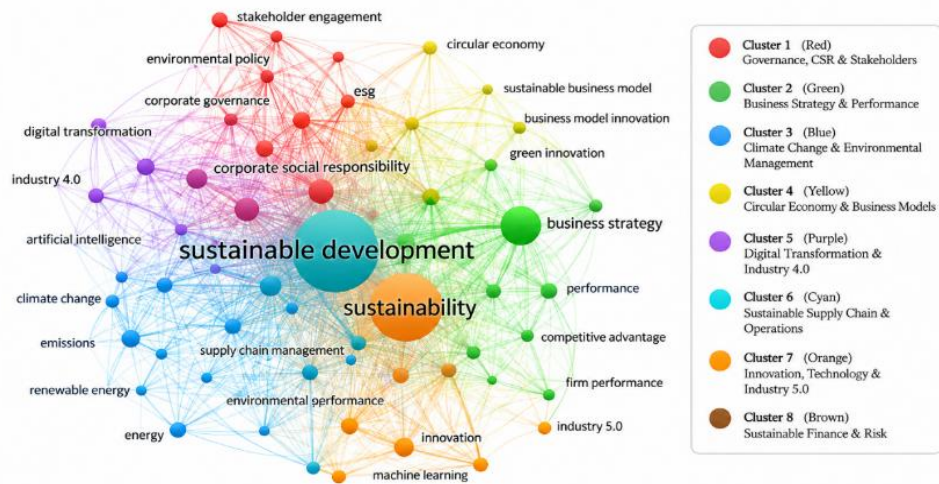
The archived VOSviewer network reports 116 retained author keywords, 1,758 links, and eight clusters. The most connected reported terms include Sustainable Development, Sustainability, Circular Economy, Corporate Social Responsibility, Business Strategy, Climate Change, ESG, Digital Transformation, and Artificial Intelligence. These archived results describe the network retained from the earlier analysis. Because the original VOSviewer project/map file and thesaurus are unavailable, and keyword variants listed in Appendix A were not harmonized in that archived output, the network statistics and cluster assignments should not be interpreted as the result of a verified harmonized rerun. Keyword co-occurrence supports interpretation of conceptual/thematic proximity; it does not establish intellectual foundations or causal mechanisms.

Table 2. Source: Authors' analysis using archived VOSviewer 1.6.19 output and Scopus data.

Cluster	Keywords (n)	Representative keywords	Aggregate Keyword TLS
1	19	sustainable development, corporate social responsibility, climate change, environmental sustainability, renewable energy, social responsibility, economic growth, tourism	1908
2	26	sustainability, innovation, sdgs, strategy,	2262

3	19	entrepreneurship, resilience, business, competitiveness circular economy, business model, industry 4.0, business models, business model innovation, circular business models, barriers, sustainable business models sustainable development goals, bibliometric analysis, stakeholder theory, systematic literature review, rural development, indonesia, institutional theory business strategy, smes, environmental performance, environment, eco-innovation, sustainable performance, governance, business performance sustainable development goals (sdgs), esg, corporate sustainability, green innovation, stakeholder engagement, corporate governance, financial performance, csr digital transformation, artificial intelligence, covid-19, digitalization, digital technologies, e-commerce, digital economy, construction industry value creation, social enterprise, social entrepreneurship	1237
4	7		524
5	10		615
6	22		1451
7	10		524
8	3		103

Figure 2. Network Visualization of Author Keywords

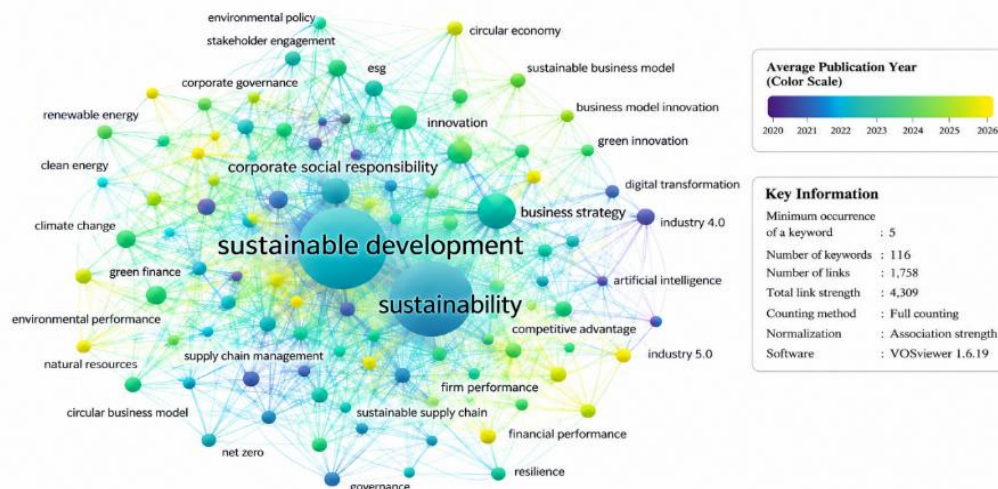


The eight clusters are retained as archived co-occurrence groupings. Their labels and representative terms are interpretive summaries based on the keyword information available in the earlier submission, not an exact reconstruction of the original VOSviewer clustering procedure. The original project/map file, thesaurus, and clustering-resolution setting were not retained, so an independent researcher cannot reproduce the exact eight-cluster assignment from the manuscript alone. We therefore distinguish the archived VOSviewer results from the separate CSV-based keyword normalization and growth audit, and avoid presenting the interpretive cluster labels as a newly reproduced network solution.

4.2 Overlay visualization and temporal positioning

The overlay visualization positions keywords according to their average publication year. Established high-frequency terms include Sustainable Development, Sustainability, Circular Economy, Business Strategy, and Climate Change. Relatively recent terms include ESG, Greenwashing, ESG Performance, Machine Learning, Sustainable Performance, Sustainable Business Models, Industry 5.0, Sustainable Finance, Artificial Intelligence, and Digital Transformation. These patterns should be read as temporal positioning of scholarly attention, not as proof that one thematic configuration evolved into another.

Figure 3. Overlay Visualization of Author Keywords



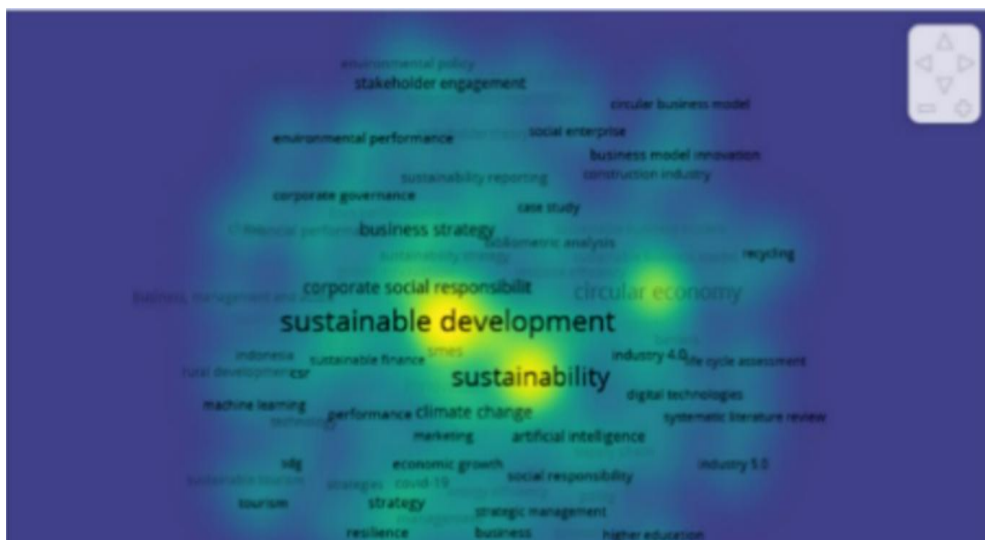
Source: Authors' analysis using VOSviewer 1.6.19 and Scopus data.

The relatively recent positioning of Artificial Intelligence and Machine Learning in the archived overlay indicates that these terms have comparatively recent average publication years within the retained map. Industry 5.0 is likewise positioned among newer technology-related terms. These patterns identify areas of scholarly attention, but they do not establish a transition from reactive to predictive practice or any causal effect of these technologies.

4.3 Density visualization

Density visualization shows that Sustainable Development and Sustainability occupy the most concentrated areas, followed by Climate Change, Corporate Social Responsibility, Circular Economy, and Business Strategy. Artificial Intelligence, Machine Learning, Industry 5.0, Digital Technologies, and Sustainable Finance appear in comparatively less concentrated areas. Density is interpreted as relative concentration in the archived VOSviewer map; lower density does not by itself establish emergence, and these archived density patterns were not recalculated using the CSV normalization map.

Figure 4. Density Visualization of Research Topics



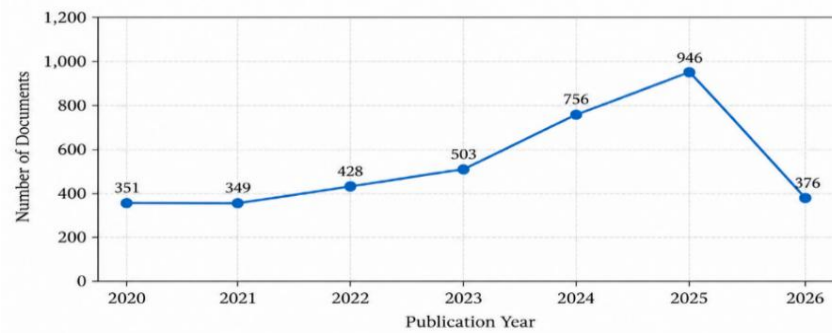
Source: Authors' analysis using VOSviewer 1.6.19 and Scopus data.

The density visualization shows the relative concentration of research topics within the keyword co-occurrence network. Higher-density areas are mainly associated with established and frequently occurring sustainability concepts, particularly Sustainable Development and Sustainability. Other topics, including Artificial Intelligence, Machine Learning, Industry 5.0, and Circular Business Models, appear in comparatively lower-density areas. This lower density indicates a smaller relative concentration of co-occurring keywords in the network and should not, by itself, be interpreted as evidence of emerging research themes. The identification of emerging and strengthening themes is therefore based on the additional quantitative indicators of keyword occurrence, average publication year, and normalized frequency growth presented in Section 4.11.

4.4 Publication trends, sources, and research productivity

The final corpus contains 3,709 articles published from 2020 through 2026. The annual counts in the Scopus CSV are 350 (2020), 349 (2021), 428 (2022), 504 (2023), 756 (2024), 946 (2025), and 376 (2026). The 2026 figure is incomplete because the export was retrieved on 2 June 2026. Overall output increased across the observed window, but the partial 2026 count should not be compared directly with complete publication years.

Figure 5. Annual Publication Output, 2020-2026

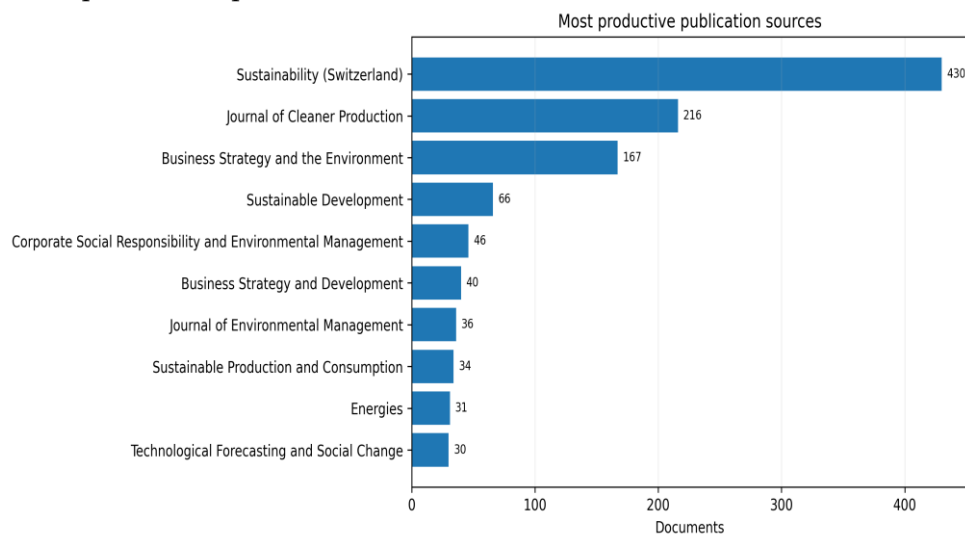


Publication output increased overall across the complete years 2020–2025. The 2026 count is partial and is reported for corpus transparency only; it is excluded from temporal-growth calculations.

4.5 Most Productive Publication Sources

Publication counts are interpreted as productivity rather than scholarly influence. The most productive sources were Sustainability (430 articles), Journal of Cleaner Production (216), and Business Strategy and the Environment (167), followed by Sustainable Development (66) and Corporate Social Responsibility and Environmental Management (46). Citation-based influence was not analyzed in this study; therefore the revised heading avoids the term “most influential”.

Figure 6. Most productive publication sources

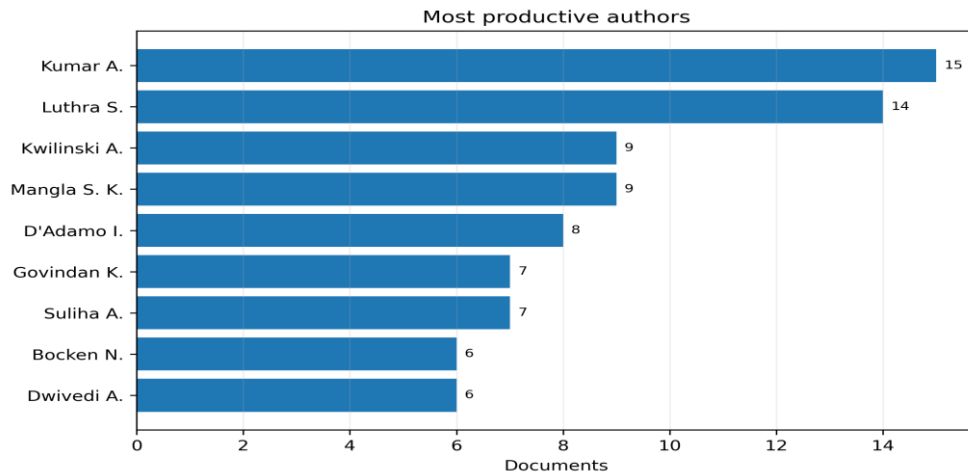


Source: Scopus export retrieved 2 June 2026, processed by the authors.

4.6 Most Productive Authors

Author counts are interpreted as publication productivity, not scholarly influence. The Scopus analysis identified Kumar A. (15 publications), Luthra S. (14), Kwilinski A. (9), Mangla S. K. (9), and D’Adamo I. (8) among the leading contributors. The result identifies active contributors but does not establish author impact, quality, or intellectual leadership.

Figure 7. Most productive authors



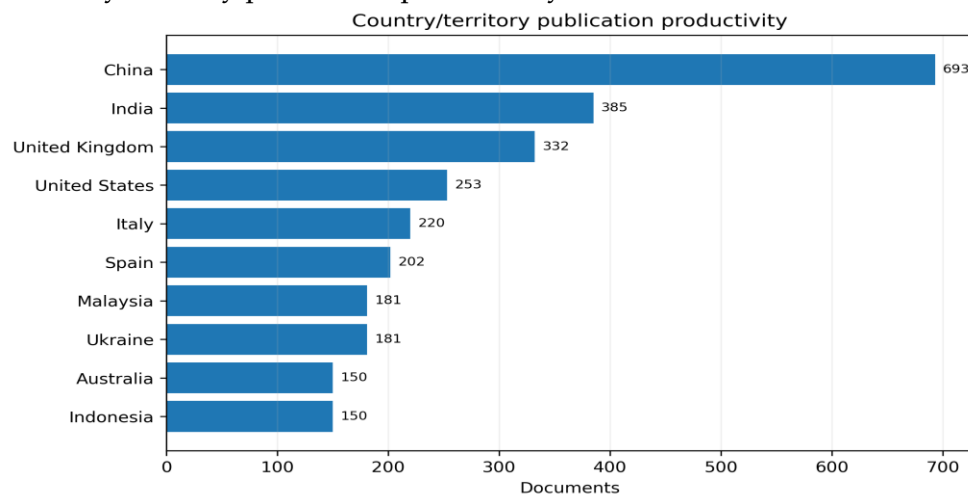
Source: Scopus export retrieved 2 June 2026, processed by the authors.

Kumar A. was the most prolific author with 15 publications, followed by Luthra S. with 14 publications, while Kwilinski A. and Mangla S. K. each contributed nine publications. The presence of these authors indicates the development of research communities focusing on sustainability, circular economy, innovation, and organizational strategy.

4.7 Country, institutional, and subject-area contributions

Country counts represent publication productivity and are non-mutually exclusive because a publication may include authors from multiple countries. China recorded the highest number of publications (693), followed by India (385), the United Kingdom (332), the United States (253), Italy (220), Spain (202), Malaysia (181), Ukraine (181), Australia (150), and Indonesia (150). The distribution indicates broad geographic participation in the query-defined corpus, but it should not be interpreted as a ranking of research quality or impact.

Figure 8. Country/territory publication productivity



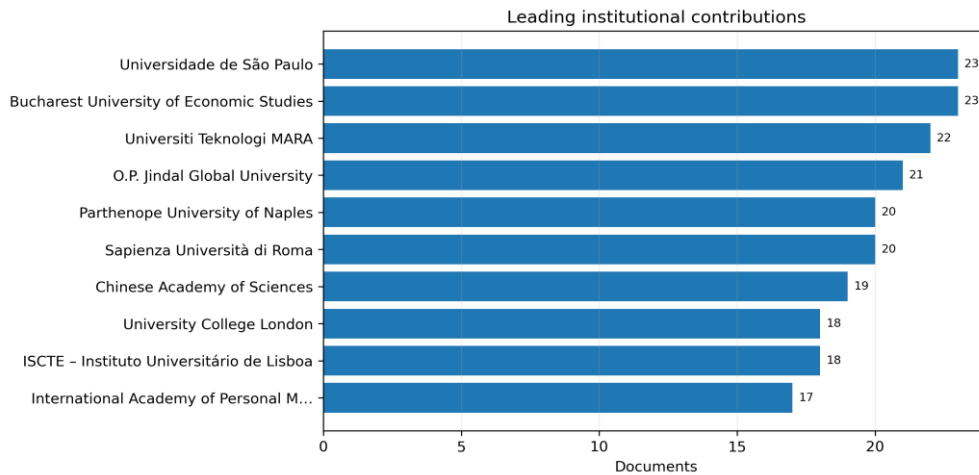
Source: Scopus export retrieved 2 June 2026, processed by the authors.

China recorded the highest number of publications with 693 articles, followed by India with 385, the United Kingdom with 332, and the United States with 253. Indonesia was also among the ten most productive countries. The distribution demonstrates that sustainable development and business strategy have become a global research agenda involving both developed and emerging economies.

4.8 Leading Institutional Contributions

Institutional counts are likewise productivity indicators. Universidade de São Paulo and Bucharest University of Economic Studies each contributed 23 publications, followed by Universiti Teknologi MARA (22) and O.P. Jindal Global University (21). These results identify institutions with comparatively high output in the corpus but do not establish institutional influence or research quality.

Figure 9. Leading institutional contributions



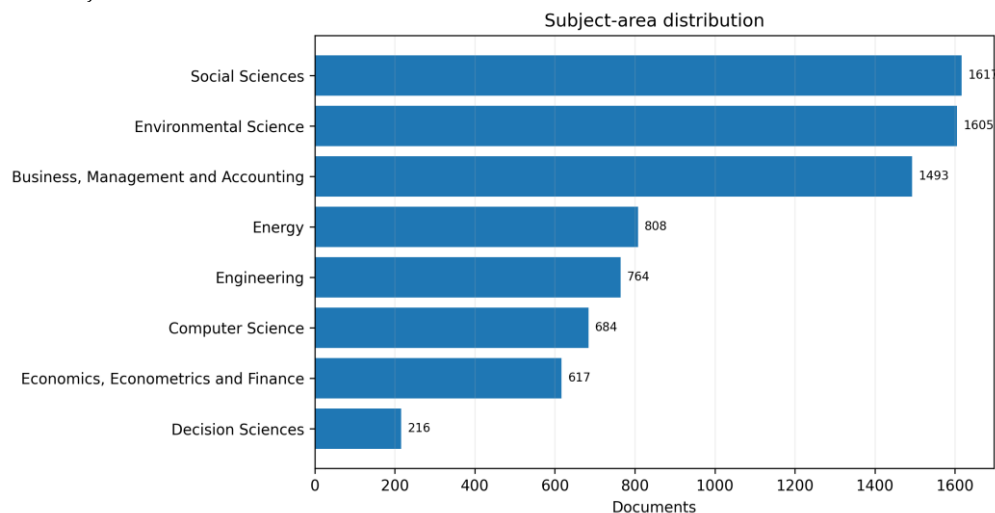
Source: Scopus export retrieved 2 June 2026, processed by the authors.

Universidade de São Paulo and Bucharest University of Economic Studies were the most productive institutions, each contributing 23 publications. This result highlights the role of universities and research institutions in developing interdisciplinary knowledge and strategic solutions for sustainability.

4.9 Subject-Area Distribution

Scopus subject areas are also non-mutually exclusive because one publication can be indexed in multiple subject categories. The largest recorded categories were Social Sciences (1,617 documents), Environmental Science (1,605), Business, Management and Accounting (1,493), Energy (808), Engineering (764), Computer Science (684), Economics, Econometrics and Finance (617), and Decision Sciences (216). The sum of these categories can exceed the 3,709-document corpus because of multi-assignment.

Figure 10. Subject-area distribution



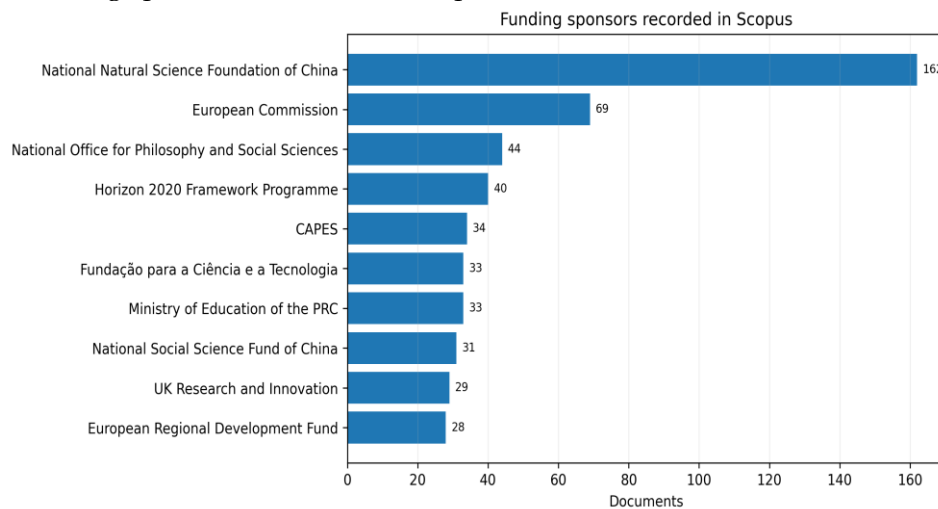
Source: Scopus export retrieved 2 June 2026, processed by the authors.

The largest subject-area contributions were Social Sciences (1,617 documents), Environmental Science (1,605), and Business, Management and Accounting (1,493), followed by Energy (808), Engineering (764), Computer Science (684), Economics, Econometrics and Finance (617), and Decision Sciences (216). These categories are not mutually exclusive because Scopus can assign a single publication to multiple subject areas. The counts therefore demonstrate broad disciplinary coverage without implying that the categories represent separate, additive subsets of the corpus.

4.10 Funding Sponsors and Research Support

Funding information represents funding acknowledgements recorded in Scopus, not a complete measure of global research investment. Multiple sponsors can be associated with one publication and funding metadata can be incomplete. The National Natural Science Foundation of China was the leading recorded sponsor (162 publications), followed by the European Commission (69) and the National Office for Philosophy and Social Sciences (44). These figures therefore indicate recorded sponsorship within the database rather than the total financial contribution to the field.

Figure 11. Funding sponsors recorded in Scopus



Source: Scopus export retrieved 2 June 2026, processed by the authors.

The funding metadata recorded in Scopus show the National Natural Science Foundation of China as the most frequently acknowledged sponsor, appearing in 162 publications, followed by the European Commission (69), National Office for Philosophy and Social Sciences (44), Horizon 2020 Framework Programme (40), CAPES (34), Fundação para a Ciência e a Tecnologia (33), Ministry of Education of the People's Republic of China (33), National Social Science Fund of China (31), UK Research and Innovation (29), and European Regional Development Fund (28). These figures represent funding acknowledgements recorded in the Scopus metadata and should not be interpreted as a complete measure of total research investment.

4.11 Keyword growth signals and future research directions

The CSV-based temporal analysis was conducted separately from the archived VOSviewer network to examine changes in keyword prevalence across complete publication-year periods. The analysis compared the early period of 2020–2022 with the late period of 2023–2025 and excluded 2026 because the Scopus export was retrieved on 2 June 2026 and therefore did not represent a complete publication year. Keyword frequencies were normalized using the procedures described in Section 3.5 and Appendix B.

The analysis used three quantitative criteria to identify potential growth signals: (1) at least 15 keyword occurrences during 2020–2025, (2) a normalized growth ratio above 1.25, and (3) a mean publication year of at least 2024.30. The first two criteria identify keywords with sufficient frequency and increasing prevalence, whereas the third provides an additional temporal-positioning condition. The CSV audit identified 30 keywords that met the minimum occurrence and normalized-growth conditions. However, none of these keywords simultaneously satisfied the mean-publication-year threshold of 2024.30. Therefore, no keyword met all three conditions of the combined criterion.

Accordingly, the results are reported as keyword growth signals rather than confirmed emerging themes. This distinction is important because a keyword may show substantial growth without necessarily representing a newly established research theme. Similarly, a relatively recent average publication year does not by itself demonstrate thematic emergence. The overlay and density visualizations are therefore interpreted as complementary temporal and concentration indicators rather than substitutes for the CSV-based growth calculation.

Table 3. Source: Authors' calculation from the Scopus CSV retrieved on 2 June 2026.

Keyword (normalized)	Occurrences 2020–2025	Average year 2020–2025	Early count 2020–2022	Late count 2023–2025	Normalized growth ratio / status
esg	73	2024.14	6	67	5.70; combined rule: No
greenwashing	14	2024.07	1	13	6.64; n < 15
esg performance	23	2024.17	1	22	11.24; combined rule: No
machine learning	13	2023.38	4	9	1.15; combined rule: No
sustainable performance	19	2023.95	2	17	4.34; combined rule: No
sustainable business models	16	2023.50	4	12	1.53; combined rule: No
industry 5.0	13	2024.08	0	13	Not calculable; early count = 0
sustainable finance	13	2024.08	1	12	6.13; n < 15
artificial intelligence	35	2023.54	11	24	1.11; combined rule: No
digital transformation	65	2023.83	12	53	2.26; combined rule: No

The growth ratios in Table 4 were calculated from changes in keyword prevalence rather than from raw keyword counts alone. Specifically, the normalized growth ratio compares the proportion of publications containing a keyword in the late period with its corresponding proportion in the early period. This adjustment accounts for the different numbers of publications in the two periods and provides a more appropriate basis for comparing temporal changes.

Several keywords illustrate different types of growth patterns. ESG recorded 73 occurrences and increased from 6 occurrences in 2020–2022 to 67 in 2023–2025, producing a normalized growth ratio of 5.70. ESG performance also showed substantial proportional growth, increasing from 1 to 22 occurrences. Digital transformation increased from 12 to 53

occurrences, with a normalized growth ratio of 2.26. These results indicate increasing prevalence within the query-defined corpus, but they do not establish that these topics constitute newly emerging themes in the broader literature.

Other keywords illustrate why the combined criterion is useful. Greenwashing, Industry 5.0, and Sustainable finance have relatively recent average publication years and substantial late-period representation, but their total occurrences remain below the minimum threshold of 15. For Industry 5.0, the early-period count is zero; consequently, a conventional growth ratio cannot be calculated because division by zero is undefined. Machine learning and Artificial intelligence have sufficient occurrences but do not meet the required combination of growth and temporal-positioning conditions. These differences demonstrate that recent publication activity, frequency, and proportional growth represent distinct dimensions of temporal analysis.

The archived VOSviewer overlay provides complementary evidence by positioning keywords according to their average publication year. ESG, digital transformation, artificial intelligence, Industry 5.0, sustainable finance, and related technology-oriented terms appear among comparatively recent positions in the archived map. However, these positions should be interpreted as temporal positioning within the retained keyword network rather than evidence of a sequential transition from earlier to newer research themes.

The CSV-based analysis therefore provides a more explicit quantitative assessment of changes in keyword prevalence between complete-year periods. It identifies areas in which scholarly attention increased within the query-defined corpus, while the archived VOSviewer analysis provides information on keyword connectivity, clustering, and temporal positioning. The two analytical outputs are complementary but should not be treated as interchangeable.

The results also suggest several areas for future investigation. These include AI and sustainability-related decision-making and environmental risk management; Industry 5.0 and human-centered sustainability; sustainable digital transformation; ESG, corporate governance, and sustainable finance; circular business models; sustainable supply-chain resilience; and carbon-neutrality and net-zero strategies. These areas are proposed as candidate research directions based on patterns of keyword occurrence, connectivity, and temporal positioning. They should not be interpreted as a validated ranking of emerging themes or as evidence of causal relationships.

Overall, the CSV-based growth audit strengthens the transparency of the bibliometric analysis by separating changes in keyword prevalence from the archived VOSviewer network. The findings show that several sustainability-, ESG-, and technology-related keywords experienced increased prevalence during 2023–2025 compared with 2020–2022. Nevertheless, because no keyword satisfied all three elements of the combined criterion, the study reports these findings conservatively as growth signals rather than confirmed emerging themes.

4.13 Theoretical implications

The primary theoretical contribution is descriptive and integrative. First, the corpus is demonstrably multidisciplinary, with strong representation from Social Sciences, Environmental Science, and Business, Management and Accounting. Second, the co-occurrence network places digital transformation, artificial intelligence, Industry 4.0/5.0, ESG, and governance in proximity to established sustainability concepts. These relationships suggest opportunities for theoretical integration, but keyword proximity should not be interpreted as evidence that technology causes better sustainability outcomes. Third, the emerging-theme indicators provide a transparent basis for proposing future research on ESG,

AI, sustainable finance, circular business models, and human-centered digital sustainability. These are research propositions derived from patterns of scholarly attention.

A second theoretical implication concerns the relationship between sustainability and digital transformation. Artificial Intelligence, Machine Learning, Industry 4.0, and Industry 5.0 appear among relatively recent or strengthening keywords and are connected to sustainability-related terms in the network. This positioning provides a basis for future theoretical work linking sustainability strategy, digital transformation, innovation, and organizational resilience. The present bibliometric evidence does not establish a conceptual progression from sustainability as an objective to sustainability as a data-enabled capability; that proposition requires longitudinal conceptual analysis and empirical testing. A third implication concerns the strategic role of ESG and corporate governance. The network shows connectivity among ESG-related themes, business strategy, environmental performance, and governance. This provides a useful basis for examining whether and under what institutional conditions ESG becomes integrated into strategic decision-making. Again, the bibliometric evidence establishes scholarly connectivity, not causal relationships with risk, investment, reputation, or competitiveness. Finally, Circular Business Models, Sustainable Supply Chain Resilience, Carbon Neutrality, and Net-Zero Strategies provide identifiable opportunities for extending sustainability and circular-economy research into more integrated organizational settings. Future studies can test the mechanisms, boundary conditions, and measurable outcomes associated with these themes.

4.14 Practical implications for business and entrepreneurship

The practical implications are framed cautiously as areas for managerial inquiry rather than demonstrated effects. The strong concentration of sustainability, circular economy, climate change, CSR, and business strategy suggests that these topics are central to the literature and may warrant integrated managerial attention. The relatively recent positioning of AI, machine learning, digital technologies, ESG, sustainable finance, and Industry 5.0 indicates areas in which organizations and entrepreneurs may examine opportunities for technology-enabled sustainability. However, the bibliometric evidence does not demonstrate that adopting these technologies improves resource efficiency, supply-chain visibility, financial performance, or resilience. Such propositions require focused empirical and qualitative research.

4.15 Integrated research agenda

The evidence supports five cautious research directions. First, AI and machine learning can be examined in relation to sustainability decision-making, environmental risk prediction, and resource optimization, with outcomes tested empirically. Second, Industry 5.0 can be studied through human-centered sustainability, employee well-being, resilience, and technology-human integration. Third, digital technologies can be linked to circular business models and traceability, but studies should test whether these capabilities generate measurable sustainability outcomes. Fourth, ESG, sustainable finance, governance, and transparency warrant research on how governance and resource-allocation mechanisms operate across institutional contexts. Fifth, cross-country and cross-disciplinary studies can examine whether the observed keyword patterns correspond to different institutional, policy, and market mechanisms. These directions extend the bibliometric map into empirical research rather than treating keyword proximity as substantive evidence.

Finally, the country and institutional patterns support a comparative research agenda rather than a claim that particular national contexts influence sustainable business transformation. China, India, the United Kingdom, the United States, and Indonesia are among the leading

contributing countries in the corpus. Future studies can compare how technological capabilities, institutions, policies, and market conditions shape sustainable business strategies across different economies and whether the thematic patterns observed here correspond to distinct empirical mechanisms.

5. Conclusion

This study maps 3,709 Scopus-indexed journal articles retrieved on 2 June 2026 in which “sustainable development,” “business,” and “strategy” co-occur in title, abstract, or keyword fields. The search does not require the exact phrase “business strategy,” and no manual relevance screening or alternative-query sensitivity search was conducted; findings are limited to this query-defined corpus. The archived VOSviewer analysis reports 116 retained author-keyword nodes, 1,758 links, total link strength of 4,309, and eight clusters. These network values remain archived results because the original project/map file and thesaurus were unavailable for verification after harmonization. The separate CSV-based growth audit compares 2020–2022 with 2023–2025, excluding incomplete 2026, and finds growth signals but no keywords meeting the former combined emergence rule. The study offers a descriptive map and cautious research agenda, not a complete map of the field or evidence of causal effects.

The contribution of the study is descriptive and methodological: it defines the query-based corpus, distinguishes retrieval refinement from manual screening, specifies the keyword-growth formula and time windows, and separates archived VOSviewer network results from CSV-based growth calculations. The research agenda should be treated as a set of propositions for empirical testing rather than conclusions about which technologies or strategies are effective in organizations.

6. Limitations and Future Research

The study has several limitations. First, the corpus is query-defined: the three terms occur in title, abstract, or keyword fields, but the query does not require the exact phrase “business strategy.” No alternative-query sensitivity search or manual title/abstract/full-text relevance screening was conducted, so findings should not be generalized beyond the retrieved corpus. Second, the analysis relies on Scopus and author-supplied keywords. Third, the archived VOSviewer network and its eight clusters were not regenerated after applying the normalization rules used in the CSV-based growth audit; the original project/map file, thesaurus, and clustering-resolution setting were not retained. Consequently, the 116-node, 1,758-link, TLS 4,309, and eight-cluster values are archived results, while keyword growth indicators are separately recalculated from the CSV. Fourth, the 2026 publication year was incomplete at retrieval and was excluded from growth and mean-year calculations. These limitations should be considered when interpreting the map and candidate research directions. Future studies should combine Scopus with additional databases, apply citation, co-citation, or bibliographic-coupling techniques to examine intellectual foundations more directly, and conduct longitudinal thematic analyses using multiple time slices. Qualitative content analysis of influential and recent studies can then test whether the patterns identified by keyword mapping correspond to substantive theoretical developments. Empirical studies are also needed to examine the organizational mechanisms and outcomes associated with the emerging themes identified in this study.

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Declaration of AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the authors used AI-assisted language tools to support language organization and editing. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Scientific Ethics Declaration

The authors declare that this study complies with scientific research ethics standards. The data were obtained from the Scopus database and analyzed using bibliometric methods. No human participants or confidential personal data were involved. The authors declare no conflict of interest and confirm that the cited sources have been appropriately acknowledged.

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Appendix A. Archived VOSviewer keyword-level table

This appendix preserves the 116 keyword nodes, occurrence counts, total link strength, average publication year, and cluster assignments reported in the archived VOSviewer output. It is not a harmonized network table: variants remain separate because the archived map was not regenerated with the normalization rules used for the CSV-based growth audit. The eight-cluster labels are retained as interpretive summaries and should not be treated as an exact reproducible reconstruction of the original clustering run.

Keyword	Occurrences	TLS	Average year	Cluster
sustainable development	759	993	2023.36	1
sustainability	540	796	2023.28	2
circular economy	282	444	2023.33	3
sustainable development goals	219	301	2023.19	4
corporate social responsibility	127	205	2022.71	1
innovation	101	198	2023.30	2
business strategy	101	197	2022.74	5
sustainable development goals (sdgs)	88	120	2023.51	6
esg	87	141	2024.44	6
sdgs	83	127	2023.80	2
climate change	81	143	2023.53	1
digital transformation	77	115	2024.17	7
strategy	72	155	2022.74	2
corporate sustainability	67	114	2022.90	6
green innovation	66	92	2024.21	6
smes	52	80	2023.63	5
environmental sustainability	49	69	2023.71	1
business model	48	57	2023.06	3
artificial intelligence	47	72	2024.17	7
entrepreneurship	47	97	2023.66	2
stakeholder engagement	47	112	2023.53	6
covid-19	47	75	2022.15	7
industry 4.0	46	81	2022.93	3
bibliometric analysis	45	84	2023.80	4
environmental performance	45	70	2023.56	5

corporate governance	45	108	2023.64	6
digitalization	45	85	2023.82	7
financial performance	41	76	2023.80	6
resilience	40	62	2023.08	2
business models	37	67	2023.19	3
business	37	78	2023.14	2
csr	37	75	2022.95	6
environment	36	69	2023.69	5
competitiveness	35	64	2023.54	2
supply chain	35	59	2022.66	2
sustainability reporting	34	67	2023.35	6
management	34	88	2022.94	2
renewable energy	34	43	2023.38	1
business model innovation	33	54	2022.91	3
supply chain management	32	40	2023.50	2
china	32	30	2023.56	6
environmental policy	31	74	2022.90	6
firm performance	30	55	2023.60	6
economic growth	29	39	2023.72	1
social responsibility	29	48	2022.66	1
circular business models	28	57	2023.61	3
tourism	28	41	2023.71	1
performance	27	56	2023.22	2
esg performance	26	31	2024.38	6
green economy	26	49	2023.00	1
environmental management	25	59	2023.64	1
barriers	25	44	2023.56	3
digital technologies	25	54	2024.04	7
sdg	25	50	2023.12	2
sustainability performance	25	43	2023.08	6
energy efficiency	25	29	2023.40	1
sustainable business models	24	40	2024.33	3
corporate social responsibility (csr)	24	60	2023.08	6
case study	24	43	2022.33	3
eco-innovation	24	31	2023.17	5
sustainable performance	24	39	2024.38	5

life cycle assessment	23	31	2023.17	3
sustainable business model	23	38	2022.70	3
recycling	22	46	2023.41	3
environmental	22	51	2024.05	6
governance	22	48	2024.00	5
dynamic capabilities	22	36	2023.73	3
triple bottom line	22	42	2023.55	2
business sustainability	22	25	2023.86	1
risk management	22	20	2023.36	2
strategic management	22	53	2023.23	2
digital economy	21	24	2023.86	7
machine learning	21	23	2024.38	6
e-commerce	21	27	2023.62	7
competitive advantage	21	45	2023.10	6
marketing	21	50	2022.81	2
stakeholder theory	21	50	2024.14	4
systematic literature review	21	30	2023.05	4
developing countries	21	31	2023.52	1
development	21	21	2023.14	2
waste management	20	42	2023.65	3
energy transition	20	36	2023.45	3
business performance	20	35	2023.70	5
value creation	19	42	2023.63	8
emerging markets	19	40	2023.74	6
covid-19 pandemic	19	25	2022.58	1
sustainable consumption	18	22	2024.06	3
policy	18	27	2023.56	2
green supply chain management	18	23	2023.94	5
higher education	18	34	2023.72	2
sustainable business	18	34	2022.50	6
economic development	18	24	2023.06	1
resource efficiency	17	49	2024.12	3
greenwashing	17	20	2024.41	1

structural equation modeling	17	23	2023.00	5
stakeholders	17	23	2022.94	1
sustainability strategy	17	37	2023.12	6
circular business model	17	27	2023.35	3
strategies	16	32	2023.62	2
rural development	16	19	2024.12	4
construction industry	16	31	2023.50	7
technology	16	33	2023.69	2
bioeconomy	16	23	2022.69	3
open innovation	16	28	2024.06	7
decision-making	16	25	2023.06	2
sustainable tourism	16	15	2023.25	1
efficiency	16	26	2023.31	2
indonesia	16	18	2023.56	4
social entrepreneurship	15	25	2023.53	8
industry 5.0	15	13	2024.33	7
system dynamics	15	15	2023.00	2
sustainable finance	15	23	2024.33	6
education for sustainable development	15	14	2023.27	2
institutional theory	15	22	2023.53	4
social enterprise	15	36	2023.13	8
business, management and accounting	15	27	2024.33	1

Appendix B. Keyword normalization used for the CSV-based growth audit

For the separate CSV-based frequency and growth calculations, keywords were lowercased and whitespace-normalized. Explicit mappings were: sdg, sdgs, sustainable development goal, and sustainable development goals (sdgs) → sustainable development goals; csr and corporate social responsibility (csr) → corporate social responsibility; business models → business model; business strategies → business strategy; strategies → strategy; stakeholders → stakeholder; and covid-19 pandemic → covid-19. Distinct constructs such as “sustainable business models” and “circular business models” were retained separately. These rules were applied to the CSV-based frequency and growth calculations only; they were not applied to the archived VOSviewer map, its link strength values, or its eight cluster assignments.