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Intellectual Capital and Environmental Sustainability: A Bibliometric Approach on Its Foundations and Evolution

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ABSTRACT

This work presents a theoretical perspective based on a bibliometric analysis of the research on intellectual capital and environmental sustainability (IC&ES) during the period 1990–2022. Using the Web of Science as the reference database, 291 valid documents were collected and examined through a performance bibliometric analysis and a science mapping analysis based on co-word bibliographic networks, with SciMAT as the analytical tool. This study provides a comprehensive overview of the IC&ES literature from a holistic perspective, enabling the assessment of the increasing scholarly attention to this research topic. Through an in-depth analysis, the specific themes and thematic areas that shape the IC&ES literature are identified, along with their evolution dynamics and interrelationships. The main contribution lies in the identification of four thematic areas—Showing, Inventing, Profiting, and Greening—as well as these cross-fertilizing subdomains that illustrate the main trends and highlight the versatility of the intellectual capital concept and the interdisciplinary nature of the IC&ES field. The findings indicate that the literature on the topic is undergoing a growing specialization, marked by conflicting perspectives from which significant implications can be drawn.

1 | Introduction

The importance of intangibles in environmental discourse has long been highlighted in academic literature. Specifically, the term "intellectual capital" is characterized by its versatility (Subramaniam and Youndt 2005) and is at the base of firms' intangible assets and constitutes one of the essential elements on which the environmental sustainability of firms depends (Thangavel and Sridevi 2015). Throughout the first two decades of the 2000s, several contributions have opened a new line of research and further elaborated on the concept of green intellectual capital (Chang and Chen 2012; Chen 2008; Huang and Kung 2011), as the key construct on which the environmental stance of companies revolves (Yusliza et al. 2020). Green intellectual capital is understood as the sum of all knowledge, intangible assets, capabilities, experiences, or relationships contained in the firm's environmental management to achieve a competitive advantage (Delgado-Verde et al. 2014).

The consideration of environmental sustainability along with intellectual capital is in accordance with Hart's (1995) natural resource-based view (NRBV), and its subsequent development (Hart and Dowell 2011). Under this approach, the intellectual capital-environmental sustainability (IC&ES) nexus can be a source of competitive advantage (Chen 2008). In this way, through commitment and responsibility towards the natural

environment, companies may transform their intellectual capital endowment and achieve better economic and environmental performance (Hart 1995; López-Gamero et al. 2011) thanks to the role played by intangibles in the implementation of environmental management practices (Christmann 2000), circular economy strategies (Khan et al. 2020), supply chain strategies (McDougall et al. 2022) or human resource management practices (Ullah et al. 2023), among others.

Indeed, the IC&ES connection has notably attracted the interest of researchers (e.g., Albertini 2021; Asiaei, Bontis, et al. 2022; Chen 2008; Chuang and Huang 2015; Claver-Cortés et al. 2007; Delgado-Verde et al. 2014; Huang and Kung 2011; López-Gamero et al. 2011; Suki et al. 2023; Yong et al. 2019; Yusliza et al. 2020; Yusoff et al. 2019), triggering the emergence of recent examinations on the integration of these two issues through bibliometric analyses, mainly using systematic or structured literature reviews (Alvino et al. 2021; Di Vaio et al. 2024; Jiang et al. 2024; Secundo et al. 2020).

These works integrated both topics, enhancing our understanding of the role of intellectual capital in promoting sustainability in specific contexts such as sustainable development goals (Secundo et al. 2020), sustainable business models (Alvino et al. 2021), decarbonization (Di Vaio et al. 2024), or green entrepreneurship (Jiang et al. 2024). However, they lack a comprehensive perspective that captures the diverse contents and the evolving trajectories within the IC&ES literature over time, due to the absence of an integrative and interdisciplinary approach. Gaining an understanding of these aspects within the broader body of work is essential to determine the evolution, scope, and significance of the IC&ES connection.

To address this gap, our research adopts a holistic and longitudinal perspective that integrates knowledge from various disciplines and an elevated viewpoint that enables us to evaluate the impact and guide the direction of research areas. Following previous similar works (Abdallah et al. 2024; Alvino et al. 2021; Bellucci et al. 2021) we conduct a bibliometric mapping analysis from a holistic perspective, allowing us to assess the existing literature landscape, providing a clear understanding of the volume and impact of research over time, as well as identifying hidden and underexplored knowledge structures, like conceptual clusters, trends, and the evolution of scholarly work in the field. Unlike studies based exclusively on systematic or structured literature reviews, bibliometric mapping analysis offers both quantitative (Bornmann 2014) and qualitative analytical perspectives (Muñoz-Leiva et al. 2012). It involves the automatic processing of large volumes of bibliography using specialized software tools and the visual representation of the results (Van Eck and Waltman 2010; Cobo et al. 2012). The use of automatic algorithms in the process essentially ensures the rigor and objectivity of the analysis results, which subsequently require interpretation from an epistemological perspective (Zupic and Čater 2015). Bibliometric mapping analysis enables us to identify underexplored areas in the existing literature based on identified thematic areas (Oliveira et al. 2019; Mukherjee et al. 2022). This methodology facilitates the integration of multidimensional factors, allowing for the incorporation of dimensions such as sustainability into other conceptual frameworks and the identification of intersections between knowledge domains (Theodoraki et al. 2022).

To achieve this, we focus on the following research questions: What is the impact and distribution of the IC&ES research in the academic literature? What are and how have the fundamental conceptual building blocks of IC&ES literature evolved? What are the dynamics and current trends of the conceptual structure of the IC&ES field?

To that end, first, we show the status of IC&ES research and analyze the different trends and key concepts on which the IC&ES literature is built, as well as the cognitive and intellectual structure of the IC&ES connection. Conducting two bibliometric analyses—a performance analysis and a science mapping through co-word analysis from 1990 to 2022- we recognize the distribution of IC&ES publications, categorize the detected conceptual themes, and identify different thematic areas around which the literature has evolved.

Therefore, we contribute to the IC&ES literature in four main ways. First, with the analysis performance, we recognize the number of published documents and their temporal distribution, as well as the number of citations received. Also, we identify the WoS categories and the journals in which the most articles have been published, and the most influential journals in this research topic. Given that the terminology used in articles can often be confusing, particularly with terms like "environment" or "sustainable," it is important to clarify that our work specifically recognizes studies that are genuinely focused on IC&ES by document screening. Thus, our findings provide a clear view of the contributions and developments in the field, offering valuable insights into the impact and distribution of IC&ES research. Second, we contribute to the IC&ES literature by offering a comprehensive and structured approach to the conceptual evolution of the IC&ES nexus. This approach allows us not only to assess the evolution of literature and the key themes over time, but also, through the analysis of thematic areas, to show how specialized literature has utilized these key themes so far. This analysis provides a clear vision of their development and application, offering valuable insights into the progression and maturation of the IC&ES field. Third, we take the aforementioned versatility of the intellectual capital concept into the realm of environmental sustainability and identify the linkages between the different thematic areas, allowing us to carry out a fine-grained analysis that reveals the existence of blended and interdisciplinary conceptual subdomains. Finally, in fourth place, we present an up-to-date vision of the IC&ES literature, highlighting the field's evolution towards a certain specialization where the key themes are being developed independently within single thematic areas.

2 | Data Set and Method

This paper employs two methods of bibliometric analysis to explore research on IC&ES: performance analysis and science mapping analysis using a co-word analysis (Toukabri and Toukabri 2025). These analyses are used in a complementary way (Cobo et al. 2015; Heradio et al. 2016). While the first

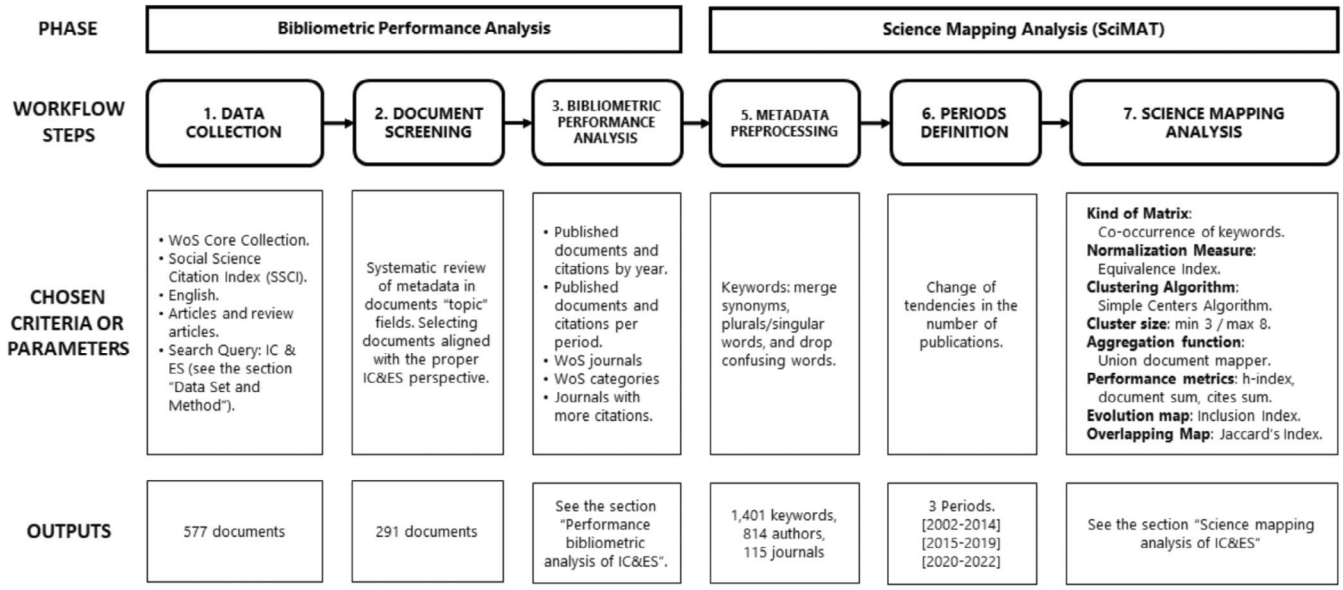

FIGURE 1 | Science mapping analysis methodology workflow. *Source:* Own elaboration.

provides information about the most productive or impacting academic agents and the distribution of publications or citations over time, the second allows for the identification of conceptual subdomains of a research field and their interrelationships and evolution (see the method process scheme in Figure 1). Bibliometric mapping analysis offers a holistic understanding of research volume and impact over time, which is essential for identifying conceptual clusters, trends, and the evolution of scholarly work, as well as for detecting unexplored knowledge areas, while also facilitating the integration of multidimensional factors like sustainability into intellectual capital conceptual frameworks (Oliveira et al. 2019; Mukherjee et al. 2022; Theodoraki et al. 2022).

The first step in carrying out a bibliometric analysis is to collect data. This study used Web of Science (WoS) Core Collection as the bibliometric database, following many other bibliometric studies (Cobo et al. 2015; Dumay et al. 2015; Forliano et al. 2021; Mahajan et al. 2024; Paridhi and Arora 2023). Specifically, the Social Science Citation Index (SSCI) was consulted since articles of IC&ES are primarily included in these citation databases. Taking into account that a significant number of specialized studies on intellectual capital explicitly include intangible assets or related concepts in their definitions (Buenechea-Elberdin 2017; Paoloni et al. 2020; Secundo et al. 2020; Di Vaio et al. 2024), and acknowledging that these terms are often used interchangeably in the literature (Baima et al. 2020; Cuozzo et al. 2017), we follow the search strategies adopted in previous literature reviews on IC (Pedro et al. 2018). Therefore, we consider intellectual capital to be conceptually aligned with knowledge and other terms related to intangible assets. In addition, we want to collect documents dealing with the environmental dimension of sustainability (Montiel and Delgado-Ceballos 2014) for which we need to identify terms that the literature considers equivalent to (natural) environment. These terms are green, ecological (Bansal and Roth 2000), environmental, eco (Albino et al. 2009) and their derivatives. Thus, we consider similar terms environmental sustainability (Dangelico and Pujari 2010), ecological sustainability (Shrivastava 1995), and green sustainability (Lee 2009). As a result, we launched the following data query:

> *TS* = ((“*intellectual capital*” *or* “*intangible assets*” *or* “*intangible capital*” *or* “*intangible resources*” *or* “*knowledge resources*”) *AND* (“*environmental**” *or* “*natural environment*” *or* “*green*” *or* “*eco*” *or* “*ecol**” *or* “*sustainab**”)).

In the query, “TS” searches selected terms in the title, abstract, and keywords fields for each data record. The corpus was restricted to articles and reviews in English. The search was conducted on 20 June 2022 and returned 577 records from 1990 to 2022. After an exhaustive review and dropping all documents not fitting the scope of our study in IC&ES, we finally got 291 documents to work with. Subsequently, a bibliometric performance analysis is performed on this final set of documents to identify actors and entities with outstanding bibliographic performance (Noyons et al. 1999).

In the second analysis phase, we make a science mapping analysis (Figure 1). Science mapping helps to capture the cognitive structure of our research field properly (Small 1999). It can also be used to study the evolution of the different themes (or clusters) detected in our research field, which provides stimulating and useful information for gaining new insights for future research (Börner et al. 2003). To make it, the raw data from WoS was downloaded and imported into SciMAT (Cobo et al. 2015). SciMAT is a free, open-source software tool that provides modules for managing the database and its entities. It also allows users to visualize the results graphically through bibliometric performance analysis grouped by conceptual themes, conceptual maps organized by periods, and the temporal evolution of conceptual themes.

After the data was imported to SciMAT and before the analysis, a pre-processing procedure was performed by applying a deduplication process on the keywords set. We grouped similar

keywords (e.g., single, and plural words; acronyms and their equivalent terms; or similar terms such as "sustainable intangible capital" and "sustainable intellectual capital") and removed general words with ambiguous or broad meanings, such as "perspective," "view," or "model," to enhance the data quality.

We use "co-word" analysis as the network extraction method (Callon et al. 1983). It allows us to measure the association strengths of publications' keywords in a specific research field and, thus, to discover the main concepts it includes and their inter-relationships from the co-occurrence frequency of pairs of keywords between documents (Olawumi and Chan 2018). Through this algorithm, these concepts build a semantic map by which the cognitive structure of a research field can be studied (Börner et al. 2003).

This analysis phase creates the so-called "clusters" or "themes," formed by nodes, representing the topics of the related keywords, creating a network. Each theme can be analyzed to study its content concerning the different nodes or conceptual groups that comprise it. The aggregation function chosen for calculating the performance indicators is "union document mapper," which returns the algebraic union of the set of documents associated with the nodes in the cluster (Cobo et al. 2012), that is, this function counts once each document appears in the cluster nodes. Following similar works (e.g., Cobo et al. 2011), each theme has descriptive performance data, presented in Tables 3–5, corresponding to the three time periods obtained in the analysis. Regarding the performance measures, we consider several indicators, such as the number of documents, *h*-index, *growth-managed index* (GMI), the average number of citations, and the sum of all citations for each cluster. Following González-Masip (2023), we calculate two normalized measures to compare the clusters' documents' quality performance in a better way: the average number of citations and the so-called GMI. For each cluster, the average of citations is calculated by dividing the total sum of citations by the number of unique documents. GMI is calculated by dividing the square of its *h*-index value by its documents count $\left(GMI = \frac{(h-index)^2}{docsCount}\right)$ (see Appendix). A GMI value close to the *h*-index value indicates that the bibliometric performance of all documents in the cluster is outstanding.

The themes are organized in strategic diagrams (Figure 2), positioned according to the centrality and density dimensions (Callon et al. 1983). While each cluster has a value for the "centrality index" and the "density index", the strategic diagram is made by both normalized indices, ranging from 0 to 1. The value 0.5 coincides in both cases with the axis of the quadrant. Callon's centrality measures the strength of external ties to other themes, and Callon's density measures the internal links among all keywords describing the research theme (Cobo et al. 2011). The so-called "motor themes" are located in the upper half of the range in both indexes and, therefore, in the upper right quadrant of the diagram. In this sense, motor themes play a key role in the strategic diagram because they are well developed (high density) and are important for the research field structure (high centrality) because they are externally connected to concepts applicable to different topics (Cobo et al. 2011).

In addition, for analyzing the evolution of IC&ES research themes, we pay attention to thematic areas, groups of evolved themes across different periods, which provide interesting information about conceptual evolution (Cobo et al. 2011). This study established three consecutive periods to show the conceptual evolution of the IC&ES in the science mapping analysis. We found a few publications in the early years and a significant concentration in recent ones, so the first period consists of more years than the following ones (2002–2014, 2015–2019, and 2020–2022).

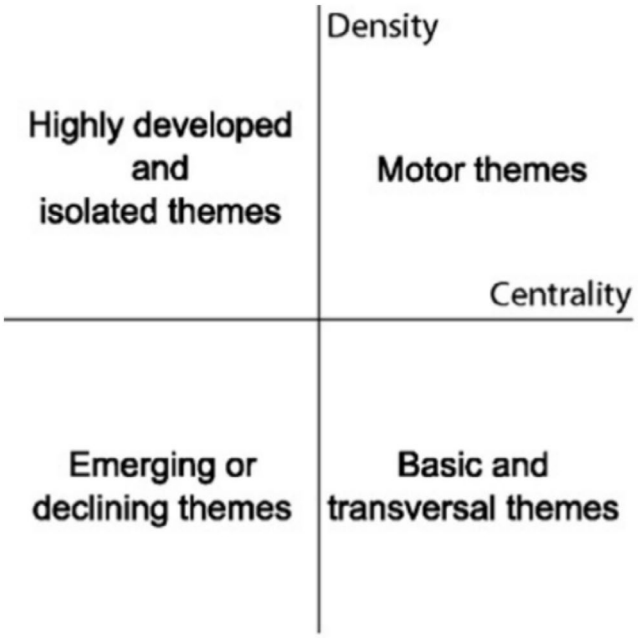

FIGURE 2 | Strategic diagram. *Source:* Cobo et al. (2011).

3 | Results

This section deals with performance bibliometric analysis and science mapping. Applying both analyses provides a deeper and broader understanding of the IC&ES research field by considering quantitative and impact measures together with detected themes and thematic areas and their evolution.

3.1 | Performance Bibliometric Analysis of IC&ES

Articles in the IC&ES research domain started to be published in 2002, with a total of 291 documents between the years 2002 and 2022. We used performance bibliometric analysis to show the distribution of documents per year and by period, the distribution of citations by year (sum of citations received by papers published in a specific year), the journals that have published most papers and in what categories, all of those according to WoS database, as well as journals whose articles have received more citations.

The distribution of publications by year shows that it has been growing significantly (Figure 3). From 2002 to 2014, the number of publications per year was below 10. From 2015, the number ranged from 13 to 49 publications, with constant growth on

average (notice that 2022 only covers half of the year in the measurement of the number of documents).

The distribution of citations per year shows, for each year, the cumulative number of citations received by all papers published in that year. It highlights 3 years with a particularly high number of citations (2010, 2016, and 2019). In 2010, with only five publications, a seminal article by Surroca et al. (2010) has the most citations (1048); however, in the other 2 years, the citations are more distributed among all documents. The number of citations has more than doubled since the beginning of the second period (2015), with an upward trend, reflecting an increased interest in the IC&ES research topic. The periods 2020, 2021, and 2022 (which only cover half of the year) show a drop in the number of citations, suggesting that the average period of development and publication of papers that may cite papers published since 2020 is approximately more than two and a half years.

Concerning the published documents per period (Figure 4), in the first period (2002–2014), 46 articles were published on IC&ES; in the second one (2015–2019), 112 articles; and in the third one (2020–2022), 133 publications. Publications in the third period represent almost 50% (45.7%) of the total 291 publications, meaning there is a significant increase in academic interest in the IC&ES field. The seminal nature of the publications in the first period (2002–2014), with the highest citation/publication ratio and the lag in citations referencing new publications in the third period, can be appreciated.

Table 1 shows the WoS journals with the most papers published on the IC&ES research topic.

Table 2 shows which WoS Categories have the most articles published on the IC&ES research topic. The top five WoS categories have almost a hundred publications, ranging from 87 to 103, far ahead of the rest.

Finally, Figure 5 shows journals whose articles on the IC&ES research topic have received more citations in the WoS Core Collection. Journals ranked in the top 25 have 41 or more citations, and journals in the top 10 have citations higher than 250.

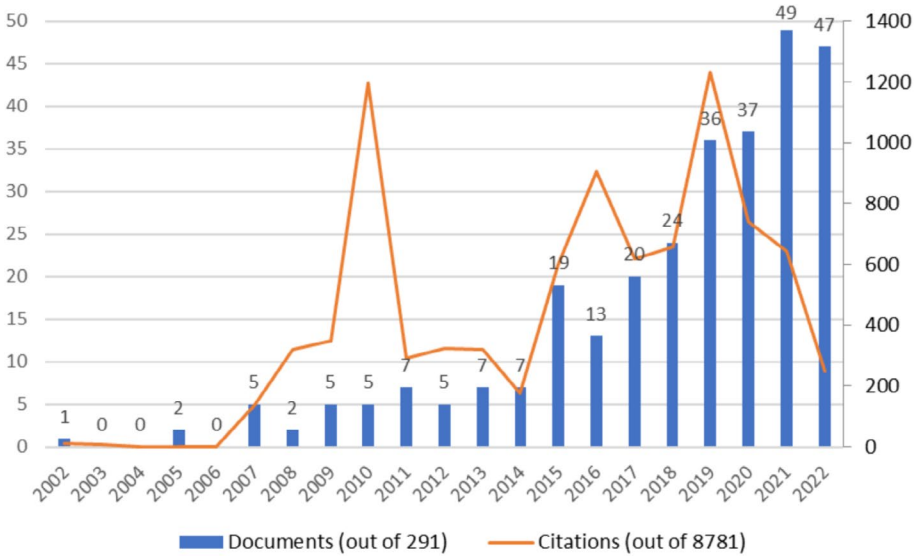

FIGURE 3 | Published documents and citations by year in the IC&ES research topic. *Source:* Own elaboration.

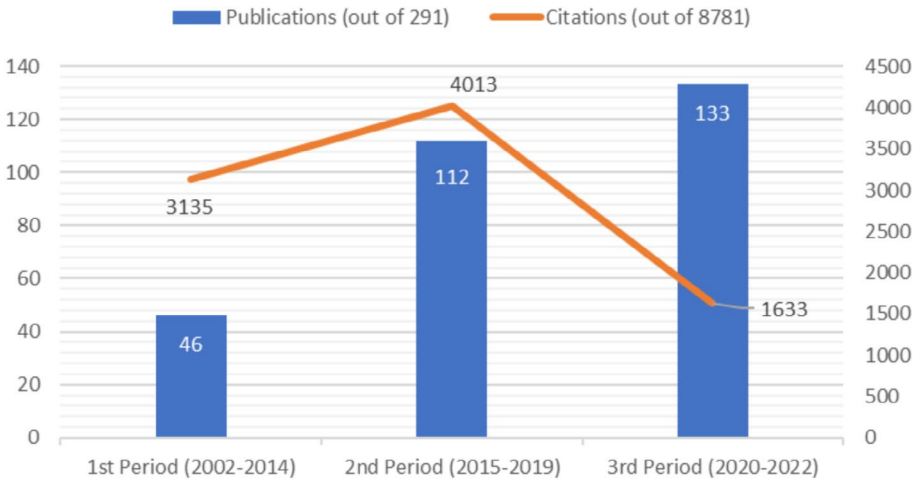

FIGURE 4 | Published documents and citations per period. *Source:* Own elaboration.

TABLE 1 | WoS journals where IC&ES research themes are published.

	Journal	Documents (out of 291)
1	*Sustainability*	57
2	*Journal of Intellectual Capital*	32
3	*Journal of Cleaner Production*	20
4	*Business Strategy and the Environment*	12
5	*Amfiteatru Economic*	9
6	*Corporate Social Responsibility and Environmental Management*	9
7	*Technological Forecasting and Social Change*	7
8	*International Journal of Environmental Research and Public Health*	6
9	*Journal of Business Ethics*	4
10	*Management Decision*	4
	Other journals	131

Source: Own elaboration.

TABLE 2 | WoS categories where IC&ES research themes are published.

	Category	Documents
1	Management	103
2	Business	99
3	Environmental Science	88
4	Environmental Studies	93
5	Green and Sustainable Science and Technology	87
6	Economics	30
7	Engineering, Environmental	24
8	Business, Finance	14
9	Regional and Urban Planning	14
10	Hospitality, Leisure, Sport and Tourism	8

Source: Own elaboration.

3.2 | Science Mapping Analysis of IC&ES

3.2.1 | Content Analysis of Published Works

The following section details the findings from the science mapping analysis. For each period, we focus on the motor themes, due to their importance, to finally indicate some relevant details about the performance measures that must be highlighted from our point of view. For easier reading, we have adopted a systematic notation: uppercase for clusters/themes (e.g., SUSTAINABILITY), italics for keywords/nodes (e.g., *stakeholder engagement*), and title case for thematic areas from the Conceptual Evolution Map (e.g., Greening).

3.2.1.1 | First Period (2002–2014). The first period under analysis shows the relevance of four research themes: FIRM, COMPETITIVE ADVANTAGE, CORPORATE SOCIAL RESPONSIBILITY, and SUSTAINABILITY (Figure 6a). The first two research themes are motor clusters. They get the two highest citation counts and *h*-index in the period (Table 3).

The cluster FIRM, with the highest citation count and *h*-index in the period, obtains the highest density score. The keywords that make up this cluster include preferentially topics related to *intangible assets*, but also to *eco-innovation*, *environmental management*, *environmental performance*, and *competitiveness*, which reflects the importance of the role of the green intellectual capital in the connection between the environmental stance of the firms and the generation of organizational outcomes (Jirakraisiri et al. 2021; Yadav et al. 2017).

The COMPETITIVE ADVANTAGE cluster has the highest centrality score in this period, showing a great external cohesion with other themes. This cluster is exclusively focused on the attainment of business performance in its various forms, and the related topics (*resource-based view*, *green intellectual capital*, *stakeholder*, *firm performance*, *organizational culture*, and *social responsibility*) are always oriented to that end (Nunes et al. 2021; Shahzad et al. 2022; Surroca et al. 2010; Vale et al. 2022; Yu et al. 2017).

Regarding the other clusters' performance measures in the first period (Table 3), some additional comments can be made. CORPORATE SOCIAL RESPONSIBILITY is an emerging/isolated theme, and SUSTAINABILITY is an emerging/basic-transversal theme. CORPORATE SOCIAL RESPONSIBILITY has a higher number of citations than SUSTAINABILITY. Despite both having the same *h*-index value, the GMI of SUSTAINABILITY is higher (8.00) than that of CORPORATE SOCIAL RESPONSIBILITY (7.11), as the former has better bibliometric performance in terms of citations of all its constituent documents.

3.2.1.2 | Second Period (2015–2019). The second period under analysis includes 12 research themes. According to the strategic diagram in Figure 6b, the clusters DISCLOSURE, CORPORATE SOCIAL RESPONSIBILITY, SUSTAINABLE DEVELOPMENT, and ENVIRONMENTAL PROTECTION are considered motor themes.

The cluster DISCLOSURE gets the highest citations count in the period (2109 citations), the greatest *h*-index (24 points), and the highest centrality score because of its great external cohesion. Highlighting the influence of environmental transparency on corporate innovation, this cluster is connected to several topics like *governance*, *environmental disclosure*, and *innovation* (Li et al. 2022). However, the more intense connection appears with the *intellectual capital* topic that plays a fundamental role because of its strong relationship with the measurement of the

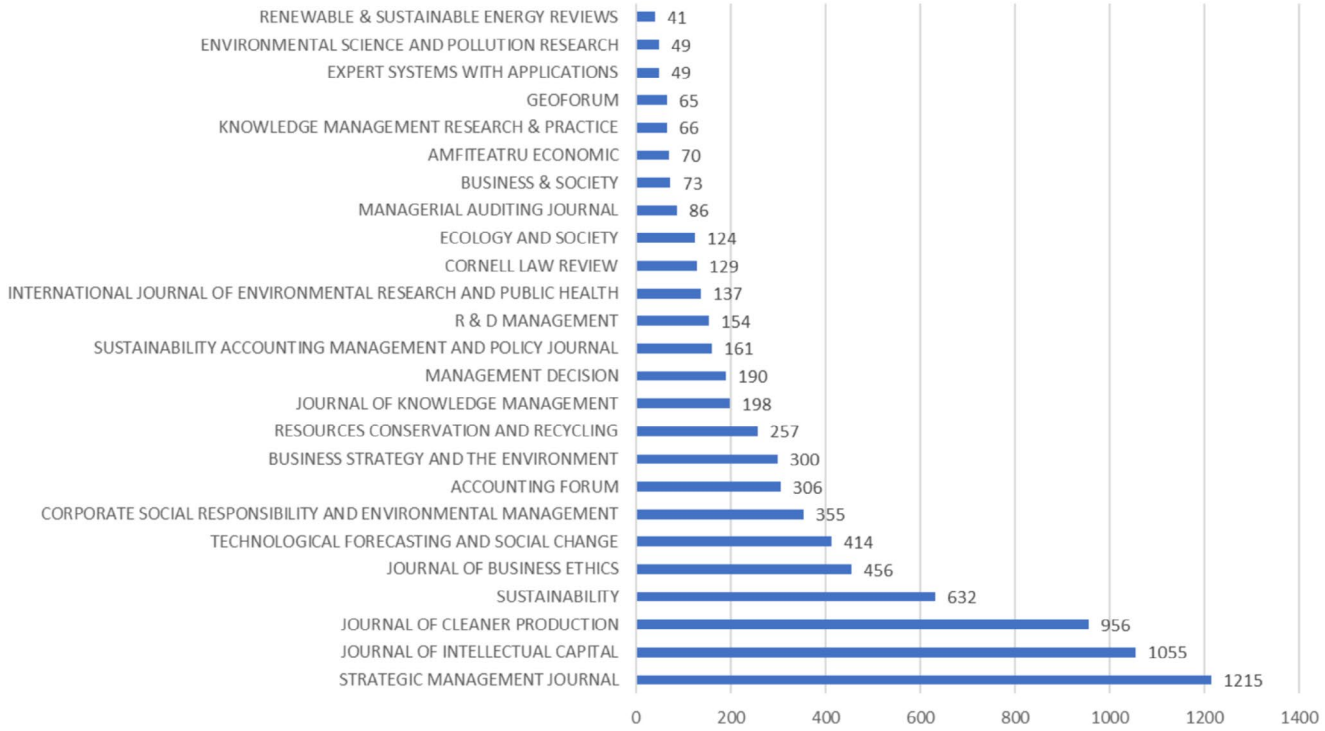

FIGURE 5 | Journals with the most citations in the WoS core collection. *Source:* Own elaboration.

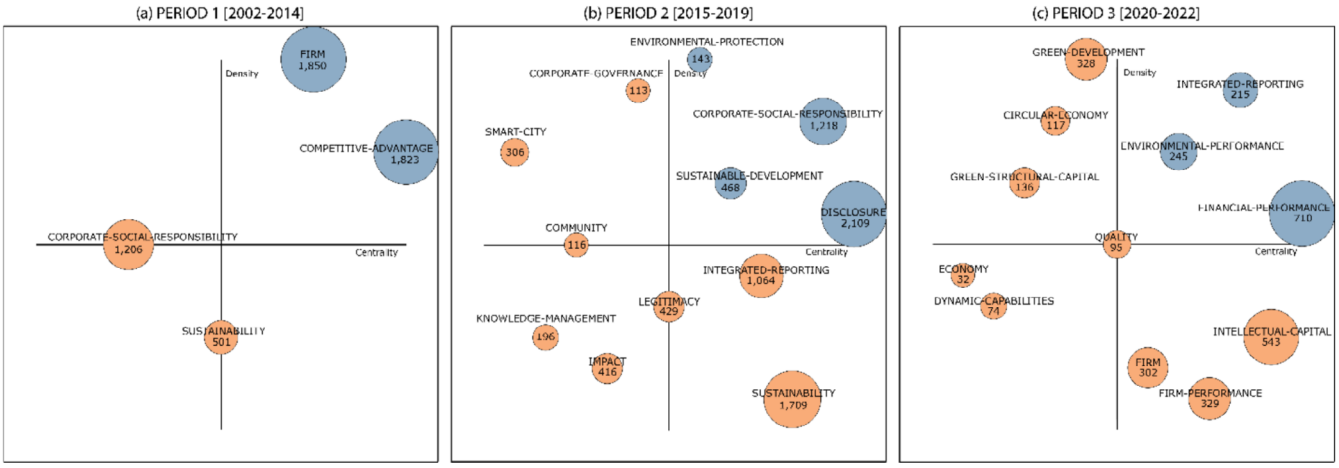

FIGURE 6 | Strategic diagrams by periods (citations count). *Blue clusters represent motor themes. *Source:* Own elaboration.

TABLE 3 | Performance measures for the themes in 2002–2014 period.

Themes	Docs count	*h*-index	GMI	AvgCitations	Sum citations
FIRM	16[a]	13[a]	10.56[a]	115.63	1850[a]
COMPETITIVE ADVANTAGE	11	11[a]	11.00[a]	165.73[a]	1823[a]
CORPORATE SOCIAL RESPONSIBILITY	9	8	7.11	134.00[a]	1206
SUSTAINABILITY	8	8	8.00	62.63	501
Average Values	**11.00**	**10.00**	**9.20**	**119.49**	**1345.00**

Note: In column 1, Motor themes are highlighted in bold. Aggregation function: Union document mapper.
Abbreviations: AvgCitations: average citations of documents in the cluster; *DocsCount*: number of documents in the cluster; GMI: Growth-Managed Index ((*h*-index)^2/docsCount); SumCitations: aggregated citations of documents in a cluster.
[a]Above average value in its column: performance over average.
Source: Own elaboration.

TABLE 4 | Performance measures for the themes in 2015–2019 period.

Themes	Docs count	*h*-index	GMI	AvgCitations	Sum citations
DISCLOSURE	69[a]	24[a]	8.35[a]	30.57	2109[a]
SUSTAINABILITY	41[a]	18[a]	7.90[a]	41.68[a]	1709[a]
CORPORATE SOCIAL RESPONSIBILITY	33[a]	20[a]	12.12[a]	36.91[a]	1218[a]
SUSTAINABLE DEVELOPMENT	23[a]	13[a]	7.35	20.35	468
INTEGRATED REPORTING	17	14[a]	11.53[a]	62.59[a]	1064[a]
IMPACT	13	10	7.69[a]	32.00	416
KNOWLEDGE MANAGEMENT	10	7	4.90	19.60	196
LEGITIMACY	9	8	7.11	47.67[a]	429
COMMUNITY	8	7	6.13	14.50	116
SMART CITY	6	6	6.00	51.00[a]	306
ENVIRONMENTAL PROTECTION	6	6	6.00	23.83	143
CORPORATE GOVERNANCE	6	5	4.17	18.83	113
Average Values	**20.08**	**11.50**	**7.40**	**33.29**	**690.58**

Note: In column 1, Motor themes are highlighted in bold. Aggregation function: Union document mapper.
Abbreviations: AvgCitations: average citations of documents in the cluster; *DocsCount*: number of documents in the cluster; GMI: Growth-Managed Index ((*h*-index)^2/docsCount); SumCitations: aggregated citations of documents in a cluster.
[a]Above average value in its column: performance over average.
Source: Own elaboration.

TABLE 5 | Performance measures for the themes in 2020–2022 period.

Cluster	Docs count	*h*-index	GMI	AvgCitations	Sum citations
FINANCIAL PERFORMANCE	80[a]	14[a]	2.45	8.88	710[a]
INTELLECTUAL CAPITAL	65[a]	13[a]	2.60	8.35	543[a]
FIRM	38[a]	11[a]	3.18[a]	7.95	302[a]
FIRM PERFORMANCE	35[a]	12[a]	4.11[a]	9.40[a]	329[a]
ENVIRONMENTAL PERFORMANCE	28	9[a]	2.89[a]	8.75	245
GREEN DEVELOPMENT	21	9[a]	3.86[a]	15.62[a]	328[a]
INTEGRATED REPORTING	17	7	2.88[a]	12.65[a]	215
GREEN STRUCTURAL CAPITAL	16	5	1.56	8.50	136
QUALITY	12	6	3.00[a]	7.92	95
CIRCULAR ECONOMY	10	5	2.50	11.70[a]	117
DYNAMIC CAPABILITIES	10	3	0.90	7.40	74
ECONOMY	6	3	1.50	5.33	32
Average Values	**28.17**	**8.08**	**2.60**	**9.37**	**260.50**

Note: Motor themes are highlighted in bold. Aggregation function: Union document mapper.
Abbreviations: AvgCitations: average citations of documents in the cluster; *DocsCount*: number of documents in the cluster; GMI: Growth-Managed Index ((*h*-index)^2/docsCount); SumCitations: aggregated citations of documents in a cluster.
[a]Above average value in its column: performance over average.
Source: Own elaboration.

non-financial information and the intangible assets (Davey et al. 2017; Fontana et al. 2019).

The CORPORATE SOCIAL RESPONSIBILITY (CSR) cluster demonstrates the strongest equilibrium between centrality and density during this period. Its relatively high and comparable density and centrality scores place this theme in a prominent position on the diagonal of the quadrant on the strategic diagram. Contributions in this cluster are, among others, the topics *environmental management, environmental performance*, or

resource-based view, with the keyword *financial performance* being the most abundant and outstanding. Its DocsCount, *h*-index, GMI, and AvgCitations values show high bibliometric performance. All of them are within the highest quartile in this period. Most works within this cluster revolve around two aspects. On the one hand, the instrumental nature of CSR, either exploring its impact in terms of financial performance or firm market value (Hawn and Ioannou 2016; Nikolaou 2019), and on the other, the exploration of CSR relationships with the environmental outcomes of the firm like sustainable intangible capital and environmental responsibility (Nikolaou 2019; Zaragoza-Sáez et al. 2023).

The SUSTAINABLE DEVELOPMENT cluster has balanced values between centrality and density (it is also positioned on the diagonal of the quadrant). Drawing on topics like *collaboration*, *stakeholder engagement*, *human resource management*, and, very prominently, *bioeconomy*, the contributions within this cluster support the vision of knowledge management or intellectual capital as key drivers of sustainable development (Cavicchi 2017; Cavicchi and Vagnoni 2017; Massaro et al. 2018; Mikalauskiene and Atkociuniene 2019; Sandhawalia and Dalcher 2015).

The last motor theme within this period is the ENVIRONMENTAL PROTECTION cluster. This theme has high density, revolving exclusively around the environmental control approach characterized by prioritizing the response to the requirements of environmental legislation (in contrast to the environmental prevention approach). The topics under consideration in this cluster include primarily *competitiveness*. From its perspective, environmental commitment may result in a loss of competitiveness. The contributions within this cluster try to analyze how companies can adapt to the legal environmental requirements and, at the same time, achieve tangible and intangible benefits (Popescu and Banța 2019; Popescu 2019).

Regarding performance measures (Table 4), four themes could be highlighted: DISCLOSURE, SUSTAINABILITY, CORPORATE SOCIAL RESPONSIBILITY, and INTEGRATED REPORTING. They show an outstanding number of citations ("SumCitations"), over the average value in this period. Despite some of these themes being basic-transversal ones, we again will focus our analysis on the motor themes.

Regarding the performance measures (Table 4) of the clusters under analysis in this second period, some additional comments can be made. Due to their transversality, the basic clusters SUSTAINABILITY and INTEGRATED REPORTING have an above-average number of citations, average citations, and *h*-index in this period. The bibliometric performance of the documents in INTEGRATED REPORTING is high, as it has the second-highest GMI value (11.53), as its *h*-index (14) is close to the possible limit (17 documents) of the cluster, and the highest average number of citations (62.59) in the period. It is particularly interesting that the SMART-CITY cluster, which, while being isolated, has the second-highest AvgCitations value of the period (51.00) and the maximum possible GMI (6.00) for its *h*-index (the GMI value cannot be higher than the *h*-index). It is followed by the emerging/basic-transversal LEGITIMACY cluster, which has the third-best AvgCitations value (47.67) in this period and a GMI (7.11) close to its *h*-index value (8).

3.2.1.3 | Third Period (2020–2022). The third period revolves around 12 topics, with the FINANCIAL PERFORMANCE, ENVIRONMENTAL PERFORMANCE, and INTEGRATED REPORTING motor theme clusters (Figure 6c). First, the FINANCIAL PERFORMANCE motor theme cluster shows the highest values of centrality, number of documents (80), *h*-index (14), and citations (710) in this third period (Table 5). On the other hand, it shows a relatively low *h*-index compared to the high number of publications, having a GMI value (2.45) far from its *h*-index value, which indicates that it concentrates many citations in very few papers. Also, its density index value is moderate, and therefore, the internal ties among all the keywords describing the theme are modest. Indeed, many theoretical streams and research lines during this period look at the concept of financial performance as the goal to be achieved. In this sense, in this period, the topics of *corporate social responsibility, sustainability*, and *impact* coexist with the concepts of *financial performance* and *competitive advantage*, both directly and indirectly through mediation or moderation relationships (Jell-Ojobor and Raha 2022; Mutuc and Cabrilo 2022; Ricci et al. 2020; Zaragoza-Sáez et al. 2023).

The ENVIRONMENTAL PERFORMANCE cluster shows a balance in its centrality and density values. It is important to highlight the prominent role played by the term *green intellectual capital* within the cluster. The need to align and orchestrate environmentally oriented resources and capabilities (*green intellectual capital*, *human resource management*, and *green human resource management*) to achieve environmental performance has an important presence within this cluster (Asiaei et al. 2023; Asiaei, Bontis, et al. 2022; Nisar et al. 2021; Yusliza et al. 2020).

The INTEGRATED REPORTING cluster exhibits the most robust balance between centrality and density during this period, positioning it highest along the diagonal of the strategic diagram. Due to its centrality, this cluster has important links with other themes, acting as an evolution of corporate reporting (Pistoni et al. 2018) and draws on topics like *disclosure, intellectual capital disclosure*, *firm value*, and the *audit committee*. As a result, it is very close to the concept of reporting quality, which constitutes a topic of great interest in the contributions during this period (Minutiello and Tettamanzi 2022; Raimo et al. 2021).

Some additional comments can be made about the performance measures of the clusters in this third period (Table 5). In general, low GMI values are observed in all clusters due to the presence of low *h*-index values in comparison to the number of documents for all the clusters in this period. As in the previous period, the basic-transversal clusters (INTELLECTUAL CAPITAL, FIRM, and FIRM PERFORMANCE in this case) rate above the average in some indicators: number of documents, *h*-index, and total citations. The INTELLECTUAL CAPITAL cluster's low *h*-index (13) relative to its substantial number of publications (65) results in a below-average GMI of 2.60 for this period, further indicating that a small subset of its papers attracts many citations. Among the rest of the clusters, the GREEN DEVELOPMENT cluster is particularly noteworthy for having a very high internal density-cohesion index (see its position in the diagram), the second-highest average citation value (15.62), and the best GMI index value in this period (3.86), therefore showing a good average quality of its documents. In this period, the worst-performing

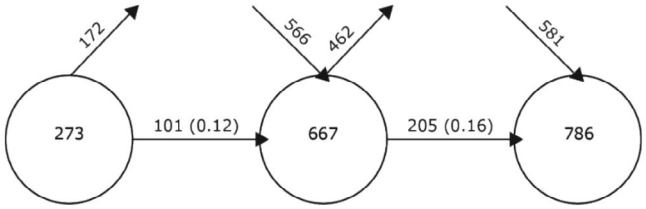

FIGURE 7 | Overlapping map on keywords' evolution in IC&ES topic research. *Source:* Own elaboration.

values correspond to the emerging-declining themes DYNAMIC CAPABILITIES and ECONOMY.

3.2.2 | Conceptual Evolution Map

As part of the analysis of the identified thematic areas, we examine the evolution of the number of used and shared keywords throughout the different periods (Figure 7) using an overlapping map (Cobo et al. 2011; Heradio et al. 2016)[1]. Starting with an initial set of 273 keywords in the first period, only 101 keywords persist in the second period, and 172 are discarded. The second period witnessed a substantial surge in keyword usage, reaching 667. However, these incorporations were not sustained, as only 205 of these keywords carried over to the third period, resulting in the removal of 462 keywords. In the third period, the total number of keywords used was 786, a modest increase of 119 compared to the preceding period. Interestingly, both the second and third periods saw a high influx of new keywords, with 566 and 581 incorporations, respectively, relative to the total number of keywords used in each period. Notably, the second period exhibited a high number of both new and transient keywords, indicating that a significant portion of the keywords used appeared in only that single period. This dynamic turnover of keywords suggests that the analyzed topic is undergoing a rapid and significant evolution in its terminology. Furthermore, the low similarity index values between periods (0.12 and 0.16) indicate a lack of consolidated terminology within the IC&ES community, even though there is a slight growth of terms across the three periods.

The analysis of the conceptual evolution across the three periods has enabled the identification of distinct research thematic areas. Based on the primary objective pursued by the analyzed contributions, four main thematic areas emerge, grouping the identified conceptual themes (Figure 8). These areas are differentiated by their central focus: the external projection of the IC&ES relationship (termed "Showing"), the innovative nature of this relationship ("Inventing"), the economic outcomes derived from it ("Profiting"), or the practical application of the environmental approach ("Greening"), as visually represented by the distinct shading in Figure 8 which delineates each thematic area. The thematic areas overlap in some cases, sharing themes that conceptually belong to both areas. The thematic area "Showing" is the only one starting in the second period, while the others cover the three periods. The "Inventing" thematic area is the only one that does not have any conceptually exclusive knowledge area not shared with any other thematic area.

On the evolution map, lines connecting two themes mean that they share at least one keyword. The solid lines connecting two themes mean that they share a keyword that names at least one of the two themes, while a dotted line means that the linked topics share keywords other than the theme name (Cobo et al. 2015). It can be observed how the topics move within each thematic area across the periods and how they connect to other themes or topics. The time evolution shows whether themes change their name or not, depending on which keyword is the most representative of the cluster at that time. Also, the movements of such topics among the quadrants of the strategic diagram (Figure 6) can help us understand how their evolution has been in those periods. The clusters CORPORATE-GOVERNANCE and COMMUNITY, in Period 2, and ECONOMY and CIRCULAR-ECONOMY, in Period 3, are not included in any thematic area and have been removed from the figure to simplify the graphical representation and its interpretation.

Table 6 shows some trajectories of targeted keywords over the three periods. The node *corporate social responsibility* evolves from a non-motor theme in Period 1 to a motor theme in Period 2. Finally, it is integrated into the FINANCIAL PERFORMANCE theme, losing its identity within this massive and motor theme that belongs to the Profiting area. The *competitive advantage* node follows a similar path, from a relevant position as a motor topic in Period 1 to becoming integrated into FINANCIAL PERFORMANCE in Period 3. In this case, the thematic area in all its trajectory is Profiting. The node *environmental performance* is constantly integrated into motor themes, always as part of the Greening area. However, while in Period 1 and Period 2 it shares its area with Profiting, in the last period it is exclusively Greening. The *green intellectual capital* node pivots from Profiting in Period 1 to a Greening profile in Period 3. Meanwhile, the *intellectual capital* node evolves from Greening-Profiting in Period 1 to Inventing-Showing in Period 3. Note that in Period 1 it was included in the CSR theme, but eventually in Period 3, it became the central node, naming its theme. The *sustainability* node is the central node, naming its theme, in Periods 1 and 2, positioned in the Inventing-Profiting area, transitioning finally in Period 3 into the motor theme FINANCIAL PERFORMANCE, with a strong Profiting profile. Finally, the *integrated reporting* node, which appears in the conceptual map in Period 2, gives its name to its theme in both periods, evolving from non-motor to motor theme, and always forming part of the Showing area. Next, in the discussion section, we will detail the internal rationale of the thematic areas mentioned above.

4 | Discussion

4.1 | Delineating the Thematic Areas in the IC&ES Literature

As recently mentioned, we have organized the themes under consideration into distinct thematic areas. These thematic areas address related issues and are characterized by an emphasis on a particular aspect of IC&ES literature. Thus, as indicated previously, the four thematic areas identified emphasize the external projection of the IC&ES relationship (Showing), the innovative character of this relationship (Inventing), the economic results derived from it (Profiting), or the practical application of the

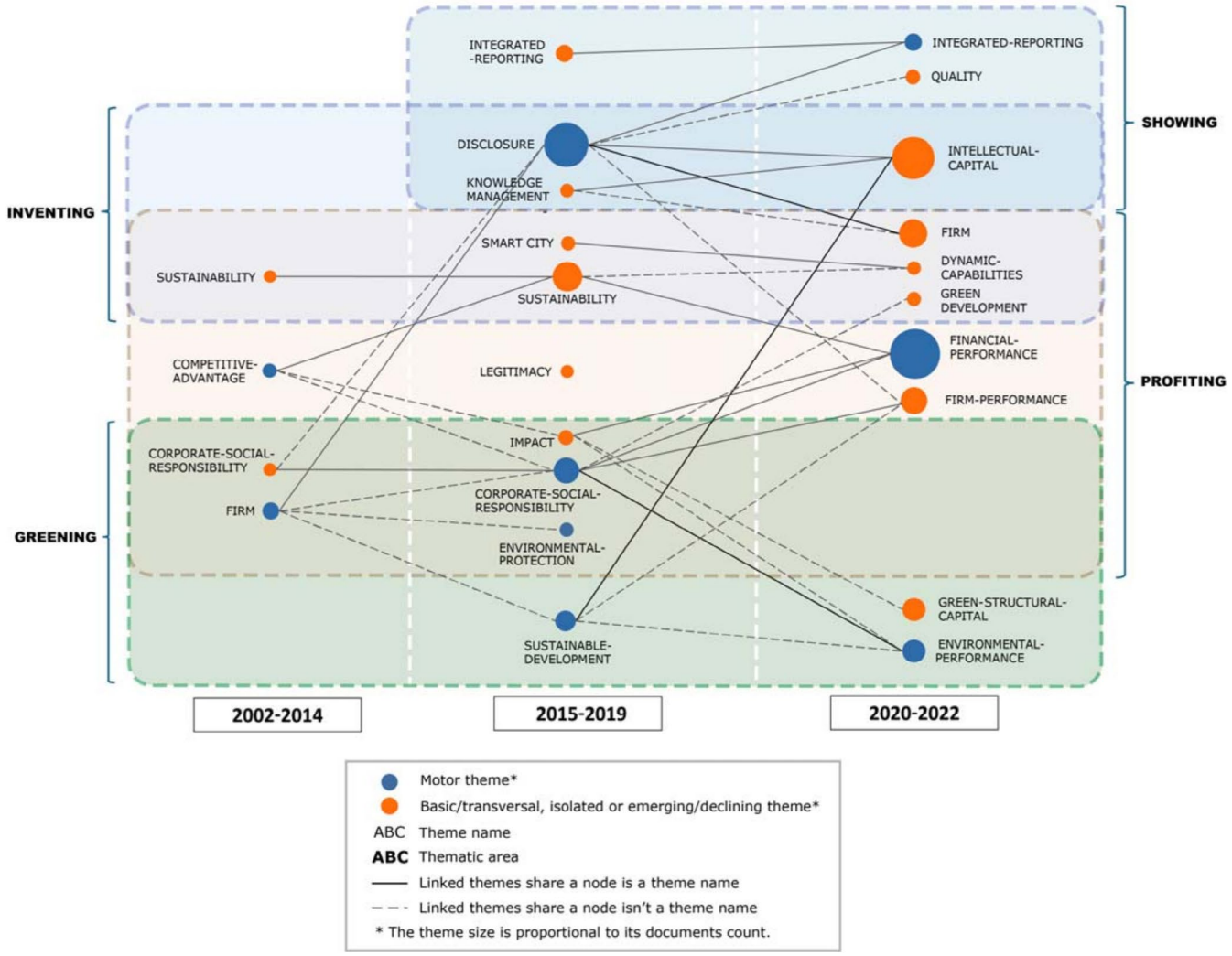

FIGURE 8 | Evolution map of IC&ES themes for the three periods. *Source:* Own elaboration.

environmental approach (Greening). Each of these thematic areas is explained below.

4.1.1 | Showing

The thematic area called Showing takes momentum in the second period and groups together themes dealing with aspects related to transparency, communication, and the external projection of firms. This theme has become one of the main areas of inquiry by the IC&ES scholars and has evolved around different key concepts and different theoretical foundations.

There are three reference themes in the evolution of this thematic area, namely DISCLOSURE, INTEGRATED REPORTING, and INTELLECTUAL CAPITAL, the latter playing a prominent role since it is not only integrated into the main Theme DISCLOSURE in the second period, but also becomes a main theme in the third period (Figure 9).

The starting point within this thematic area is the DISCLOSURE theme in the second period, which, as already mentioned, is characterized by being strongly linked to the concept of *intellectual capital*. The prominence of the DISCLOSURE theme in the second period also reaches other terms that comprise it, such as *environmental disclosure* or *corporate governance*, showing the interest of researchers to deepen the transparency of the environmental repercussions of businesses activities and the importance of corporate governance issues in carrying out this exercise of transparency (Guerrero-Villegas et al. 2018).

However, the DISCLOSURE theme loses visibility in the third period. It no longer appears linked to the concepts of *environmental disclosure* (which becomes related to the QUALITY theme in the third period) (Figure 9) and *corporate governance* (which becomes related to the FIRM PERFORMANCE theme in the third period) (Figure 13). In fact, these two concepts (*environmental disclosure* and *corporate governance*) are fundamental to explaining the increasing phenomena of greenwashing and the influence of board characteristics in the quality of environmental reporting (Chen and Dagestani 2023).

In parallel, DISCLOSURE also ceases to be a focus of main interest for researchers in the third period as it is integrated into the INTEGRATED REPORTING theme, which becomes

TABLE 6 | Track record of outstanding keywords.

Keyword		Period 1	Period 2	Period 3
corporate social responsibility	T.	CORPORATE SOCIAL RESPONSIBILITY	CORPORATE SOCIAL RESPONSIBILITY	FINANCIAL PERFORMANCE
	Q.	Non motor theme	Motor theme	Motor theme
	T.A.	Greening-Profiting	Greening-Profiting	Profiting
competitive advantage	T.	COMPETITIVE ADVANTAGE	SUSTAINABILITY	FINANCIAL PERFORMANCE
	Q.	Motor theme	Non motor theme	Motor theme
	T.A.	Profiting	Inventing-Profiting	Profiting
environmental performance	T.	FIRM	CORPORATE SOCIAL RESPONSIBILITY	ENVIRONMENTAL PERFORMANCE
	Q.	Motor theme	Motor theme	Motor theme
	T.A.	Greening-Profiting	Greening-Profiting	Greening
green intelectual capital	T.	COMPETITIVE ADVANTAGE	IMPACT	ENVIRONMENTAL PERFORMANCE
	Q.	Motor theme	Non motor theme	Motor theme
	T.A.	Profiting	Greening-Profiting	Greening
intelectual capital	T.	CORPORATE AOCIAL RESPONSIBILITY	DISCLOSURE	INTELLECTUAL CAPITAL
	Q.	Non motor theme	Motor theme	Non motor theme
	T.A.	Greening-Profiting	Inventing-Showing	Inventing-Showing
sustainability	T.	SUSTAINABILITY	SUSTAINABILITY	FINANCIAL PERFORMANCE
	Q.	Non motor theme	Non motor theme	Motor theme
	T.A.	Inventing-Profiting	Inventing-Profiting	Profiting
integrated reporting	T.		INTEGRATED REPORTING	INTEGRATED REPORTING
	Q.		Non motor theme	Motor theme
	T.A.		Showing	Showing

Abbreviations: Q.: quadrant; T.: theme; T.A.: thematic area.
Source: Own elaboration.

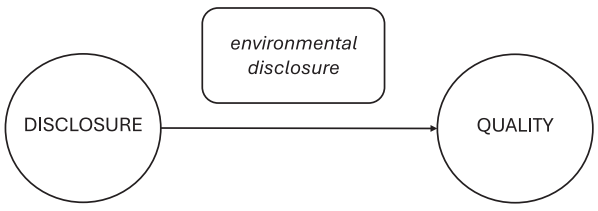

FIGURE 9 | Environmental disclosure transition (P2–P3).

predominant and which encompasses within itself not only the already mentioned term *disclosure* but also, and in a very special way, the term *intellectual capital*.

Indeed, the concept of *intellectual capital* shows a consolidated trajectory linked to the reporting phenomena (Paoloni et al. 2023), which reflects the interest of researchers in highlighting the importance of incorporating non-tangible aspects into traditional reporting by means of disclosure activities (Cuozzo et al. 2017; Curado et al. 2011; Salvi et al. 2020) and integrated reporting initiatives (de Villiers and Sharma 2020).

Finally, it is important to emphasize that the boundaries between the thematic areas analyzed are not fixed and that they offer possibilities of connection and therefore enrich the nature of the relationships proposed. This is the case of themes such as INTELLECTUAL CAPITAL or DISCLOSURE, that play a relevant role not only in relation to the external projection of the IC&ES relationship (Showing thematic area), but also stand out for being strongly related to innovation (Inventing thematic area) as the literature shows us.

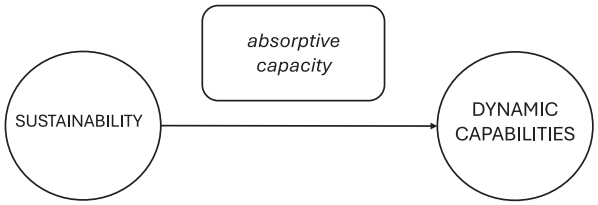

FIGURE 10 | Absorptive capacity transition (P2–P3).

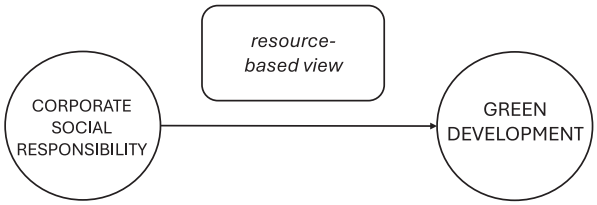

FIGURE 11 | Resource-based dynamic capabilities transition (P2–P3).

4.1.2 | Inventing

The thematic area called Inventing reflects the importance that the IC&ES scholars attach to the intellectual capital-innovation connection. This connection is mainly articulated through the knowledge-based theory of the firm and the related concepts of knowledge management, dynamic capabilities, or absorptive capabilities and is therefore strongly linked to the resource-based view of the firm.

This thematic area is a further result of the fading importance of the DISCLOSURE theme in the discourse on intellectual capital and the natural environment. Indeed, while the term *intellectual capital* plays a prominent role within the DISCLOSURE theme in the second period analyzed, in the third period, the INTELLECTUAL CAPITAL theme acquires its own identity (Figure 8) and appears strongly related to the concepts of *innovation*, *sustainable development*, and *knowledge management*.

Scholars working in this direction emphasize the importance of intellectual capital as a key element in achieving environmental innovations at both process and product levels (Delgado-Verde et al. 2014; Jirakraisiri et al. 2021). From this point of view, intellectual capital comprises a set of environmentally oriented capabilities that are ultimately decisive for innovative solutions both at the firm level and at the regional level (Behnam and Cagliano 2019; Martinidis et al. 2021).

In the same vein, the connection between intellectual capital and knowledge management and innovation can be appreciated in the creation of new sustainable business models where intellectual capital is the driving force for knowledge and sustainable long-term value creation (Alvino et al. 2021).

In addition, the DYNAMIC CAPABILITIES theme stands out for its great versatility within the Inventing thematic area. First, while in the second period it represented one of the many facets of the SUSTAINABILITY theme, in the third period it becomes a theme and appears linked to the concepts of *absorptive capability* and *green product innovation* (Figure 10). This connection reflects the importance of absorptive capacity (understood as a dynamic capacity to channel external influence) in the development of environmental innovations (Rodrigues and Gohr 2022; Singh et al. 2022).

Second, the DYNAMIC CAPABILITIES theme also appears linked to innovative activity in the context of smart cities, as a key factor to meet the challenges of innovation ecosystems (Linde et al. 2021) (Figure 8). Third, the *dynamic capabilities* concept under the resource-based view logic is implicitly present

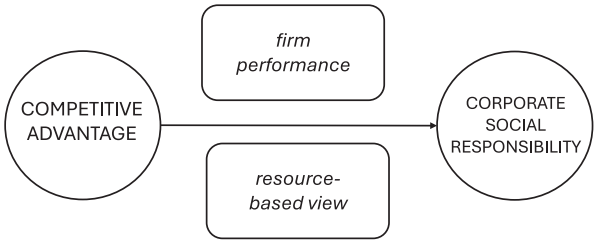

FIGURE 12 | Firm performance and resource-based view transition (P1–P2).

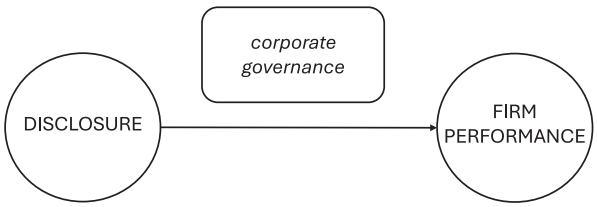

FIGURE 13 | Corporate governance transition (P2–P3).

in the connection between CSR and GREEN DEVELOPMENT themes. Yuan and Cao (2022) corroborate this fact when they claim that dynamic capabilities are the catalyst that connects corporate social responsibility with the environmentally sustainable innovations on which green development is grounded (Figure 11).

Also noteworthy is the versatility shown by some of the themes such as SUSTAINABILITY and DYNAMIC CAPABILITIES. These themes are, according to the scientific literature, strongly related to innovation (Inventing thematic area), but at the same time are valued for the possibilities of economic and financial exploitation (Profiting thematic area) they offer as we will see below.

4.1.3 | Profiting

The thematic area called Profiting shows the relevant role that the IC&ES scholars have given to the achievement of economic-financial returns. This instrumental perspective is characterized by showing strong connections to both the Inventing and Greening thematic areas because researchers using this approach understand that both innovation and environmental commitment can be exploited for economic gain.

This thematic area stands out for its importance from the very beginning of the study of the IC&ES connection.

Thus, between the first and second periods under consideration, a close connection between the themes of COMPETITIVE ADVANTAGE, SUSTAINABILITY, and CORPORATE SOCIAL RESPONSIBILITY can be clearly appreciated. In this sense, the theme COMPETITIVE ADVANTAGE is strongly associated with the term SUSTAINABILITY in the second period, and in parallel with this, both COMPETITIVE ADVANTAGE and CORPORATE SOCIAL RESPONSIBILITY are related to *firm performance* and the *resource-based view* concept between the first and second periods (Figure 12). In addition, the same pattern continues between the second and third periods in this thematic area. Thus, in the second period, the *market value* concept plays an important role within the theme Legitimacy, and the themes SUSTAINABILITY and CORPORATE SOCIAL RESPONSIBILITY still show a strong connection with the FINANCIAL PERFORMANCE and FIRM PERFORMANCE themes (Figure 8). In turn, the themes DISCLOSURE and FIRM PERFORMANCE are connected through the term *corporate governance* (Figure 13) in the third period.

The above developments within this thematic area show the relevance of the instrumental perspective, where the interest of researchers concerned with the IC&ES relationship is focused on the search for economic–financial return. In this sense, the connections corporate social performance–firm performance (Surroca et al. 2010), sustainability–firm performance (Rodgers et al. 2019) and green intellectual capital–competitive advantage (Dang and Wang 2022) exemplify the orientation of this thematic area very well.

Notwithstanding the above, and as has been pointed out in the previous thematic areas, there is also room for cross-fertilizing between the Profiting thematic area and the Greening thematic area shown below. This is the case with the themes CORPORATE SOCIAL RESPONSIBILITY and ENVIRONMENTAL PROTECTION. In this sense, the CORPORATE SOCIAL RESPONSIBILITY theme shows a very strong profit-oriented component but at the same time also plays an important role in the development of environmental capabilities aimed at achieving tangible environmental results. In turn, the ENVIRONMENTAL PROTECTION theme not only has a sustainable aspect—to the extent that it helps to reduce the environmental impact of business activities, but also constitutes a particular firm's environmental stance, which, unlike prevention, emphasizes the economic aspect of the business–environment relationship. In this sense, from an environmental protection approach, environmental initiatives are generally considered to be the necessary cost to be incurred to respond to regulatory pressures.

4.1.4 | Greening

The thematic area Greening takes this name because it responds to the interest of researchers in bringing the discourse on environmental sustainability into the realm of practice. Researchers in this area are interested in "walking the talk" and going beyond the environmental strategic intent or environmental concern to achieve measurable environmental results.

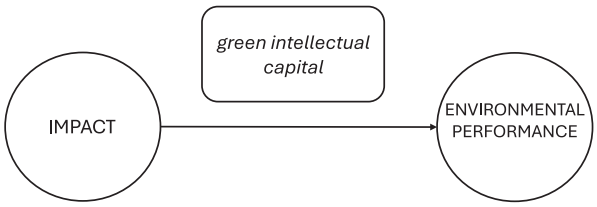

FIGURE 14 | Green intellectual capital transition (P2–P3).

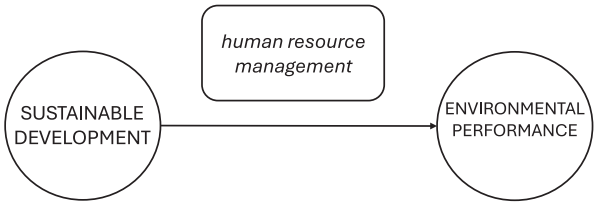

FIGURE 15 | Human resource management transition (P2–P3).

This interest starts to become relevant in the second period under consideration, when the term *environmental performance* appears linked to the more general theme of CORPORATE SOCIAL RESPONSIBILITY. However, in the third period, the ENVIRONMENTAL PERFORMANCE theme takes on its own relevance; it is no longer used in conjunction with the term *corporate social responsibility* but is instead strongly linked to the *green intellectual capital* and *human resource management* terms (Figures 14 and 15).

Several contributions within this thematic area analyze the connections green intellectual capital-environmental performance (Asiaei et al. 2023; Asiaei, Jusoh, et al. 2022), green intellectual capital-green human resource management-environmental performance (Mansoor et al. 2021) and exemplify at firm level the need to bring environmental concerns down to earth, not only to achieve tangible environmental results, but also to involve all company employees in the task (Nisar et al. 2021).

In addition, and together with the ENVIRONMENTAL PERFORMANCE theme, the GREEN STRUCTURAL CAPITAL theme also becomes highly visible in the last period within the Greening thematic area (Amores-Salvadó et al. 2021). Indeed, the IMPACT theme of the three types of green intellectual capital (green human capital, green structural capital, and green relational capital) (Chen 2008) as drivers and catalysts for environmental results has received increasing attention in the literature (Ali et al. 2021; Asiaei et al. 2023; Ullah et al. 2022).

4.2 | Final Remarks

In summary, what the existence of these four thematic areas reflects is the versatility of the IC&ES connection. In this sense, the literature analyzed attributes to this connection different opportunities to be exploited by IC&ES scholars. Thus, in line with the above-mentioned Showing thematic area, the IC&ES connection represents an opportunity to give visibility to the intangibles that underpin companies' environmental efforts.

Nurturing such intangibles can also foster the creativity of companies—thus developing the thematic area Inventing—in the fulfillment of their environmental purposes or, following the Profiting approach, be indispensable elements for taking advantage of interesting economic opportunities for companies. And finally, the IC&ES connection can sustain the necessary reconfiguration of resources and capabilities that every company needs to carry out to achieve measurable environmental results and develop its Greening orientation.

Ultimately, our results not only highlight the existence of cross-fertilization areas within the IC&ES field but also, in the same line, complement early findings on the versatility of intellectual capital (Subramaniam and Youndt 2005) and extend its scope to the realm of organizations and the natural environment by offering interesting possibilities for advancing the concept of versatility within this field.

5 | Conclusions

This bibliometric analysis provides an overview of the IC&ES literature from a holistic perspective that allows us to assess the growing attention that scholars pay to this research topic. In addition, through in-depth analysis, it provides the specific themes identified by IC&ES scholars, their evolution dynamics, and the relationships and the cross-fertilizing areas between them.

This study makes four main contributions to literature. First, the performance analysis captures the productivity index through the total number of publications and their importance through the total citations (as per year as by period). In this sense, the journals with the greatest number of published articles have been identified, in which the most citations of works on IC&ES are received, and the WoS categories that characterize the IC&ES realm. It can be observed that there is an increasing scientific production in recent years that addresses research in IC&ES. Therefore, given the relatively short history of this topic since its inception in 2002, there is great room for improvement, further advance, and development.

Second, our analysis provides IC&ES scholars with a science map that helps to understand the conceptual evolution of the IC&ES nexus and how the underlying cognitive structure and the conceptual building blocks of this research field are formed. Through the co-word analysis, we identify the main themes around which the different topics within IC&ES research are organized over time and assess their relative importance not only in terms of their internal consistency but also of their external ties to other themes. In this sense, two aspects are particularly relevant and can be highlighted: (a) the declining relevance of the DISCLOSURE theme in favor of the concept of the INTEGRATED REPORTING theme that is considered nowadays as the new trend in corporate reporting (Vitolla et al. 2019, 2020) the blurring character of the CORPORATE SOCIAL RESPONSIBILITY theme, which seems to be losing momentum and ends up being broken down into the more specific themes of FINANCIAL PERFORMANCE and ENVIRONMENTAL PERFORMANCE, the latter taking stock of the relevance that the theme SUSTAINABLE DEVELOPMENT had in previous periods. In short, as can be appreciated throughout the years, IC&ES literature undergoes a movement from the general to the specific in its main themes. This not only allows for the assessment of the evolution of literature and key themes over time, as previously noted, but also shows, through the identification of thematic areas, how these key themes have been utilized in specialized literature to date. These thematic areas emphasize the external projection of the IC&ES relationship (Showing), the innovative character of this relationship (Inventing), the economic results derived from it (Profiting) or the practical application of the environmental approach (Greening).

Third, drawing on the versatility of the intellectual capital concept, we identify the linkages between the different thematic areas, which reveal the existence of blended conceptual approaches and cross-fertilizing areas that can enhance the scientific literature in the field. In this sense, scholars in the field harmonize the external projection of the IC&ES relationship with its innovative character through the Showing-Inventing connection, the innovation-focused character of the IC&ES literature with the economic and business case approach through the Inventing-Profiting connection, and the importance of the pro-economic orientation of the IC&ES relationship with the pro-environmental approach through the Profiting-Greening connection. The identification of these cross-fertilizing subdomains paves the way for new contributions and new research avenues.

Fourth, we show an up-to-date vision of the IC&ES literature. In this sense, and despite the identification of areas of cross-fertilization among thematic areas with promising research possibilities, we highlight that the IC&ES field is evolving towards a certain specialization of the key themes (INTEGRATED REPORTING, FINANCIAL PERFORMANCE and ENVIRONMENTAL PERFORMANCE) without connection between thematic areas and mostly focused on the connection of IC&ES to firm performance. Indeed, after an initial emerging stage (2002–2014) with few impactful IC&ES topics, and a subsequent stage of effervescence (2015–2019) characterized by the proliferation of IC&ES topics across all thematic areas, the field has evolved towards a certain specialization in the most recent period under analysis (2020–2022). As shown in Figure 8, during the last period, each of the motor themes (INTEGRATED REPORTING, FINANCIAL PERFORMANCE, and ENVIRONMENTAL PERFORMANCE) has been developed by concentrating in a single specific thematic area without any overlapping with other areas, that is, independently from the rest.

This recent thematic specialization of the IC&ES literature shows very prominently the existence of two opposing visions of the IC&ES relationship that seek on the one hand, economic benefit and, on the other hand, environmental performance. The theoretical implications of the separate development of both visions are important, as they suggest that there is an "exhaustion" of the "it pays to be green" argument, which seems, according to our results, to be insufficient to address the complexity derived from the economic and environmental challenges of the IC&ES connection. Determining whether this specialization is a step forward or a missed opportunity for collaboration between the different orientations within the IC&ES literature is a task that remains for future research on the subject.

This work is not without limitations. Our analysis is restricted to WoS articles and reviews published in English. The extension of the analyses to other databases would help to give more consistency to the results obtained. In addition, methodological and selection biases-keywords and parameters selection-may occur in the application of the SciMAT technique. Finally, an in-depth analysis of the theoretical frameworks underpinning each of the thematic areas identified is beyond the scope of this paper. Nevertheless, these limitations provide future research possibilities. Other databases and analytical tools could be used to apply bibliometric analyses on IC&ES, such as Scopus or VOSviewer, respectively. Additionally, as the field continues to evolve, future research can deepen the understanding of the theoretical frameworks used in the different thematic areas identified, explore the possibilities of theoretical cross-fertilizing within nearby thematic areas, or identify new areas of development not identified so far, among other issues.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are openly available in WOS. Search criteria included for replication in the paper at https://www.webofscience.com/wos/alldb/basic-search.

Endnotes

[1] In the overlapping map, circles represent the periods, and the number inside the circle shows the keywords used in each period. Numbers on the horizontal arrow between periods represent shared keywords by two periods and, in parentheses, the Similarity Index between both (close to 1, higher stability across periods). Upper-incoming arrow represents the number of new keywords for the period, and upper-outgoing arrow represents the number of keywords that are not collected in the next period.

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Appendix A

Growth-Managed Index (GMI)'s Details

$$\left(GMI = \frac{(h-index)^2}{docsCount} \right)$$

The GMI index aims to reflect the quality and impact of a cluster, considering both the number of highly cited documents (captured by the *h*-index) and the total number of documents. The highest possible GMI value is equal to the *h*-index when the *h*-index and the total number of documents in the cluster are similar. If a cluster has significantly more documents than its *h*-index, the GMI value decreases. This is because the additional documents beyond the *h*-index have fewer citations (and thus don't contribute to the *h*-index), suggesting potentially lower average quality. This could indicate a high volume of publications without a corresponding increase in impactful work.

The GMI index rewards clusters with a high *h*-index, acknowledging their strong core of impactful publications. However, it still penalizes clusters with an excessive number of documents relative to their *h*-index, highlighting potential inefficiencies in output. The GMI is particularly useful for comparing clusters with the same *h*-index. In such cases, the cluster with fewer total documents will have a higher GMI. This is because its documents, on average, have a higher impact, indicating better overall quality. Similarly, when comparing two clusters with the same total number of documents, the cluster with the higher *h*-index will receive a better GMI score, reflecting its greater number of highly cited publications.