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The evolution of sustainability in higher education: A conceptual analysis of trends and practices

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Abstract

Purpose: This article examines the conceptual evolution and research trends in sustainability within Higher Education Institutions (HEIs) over the period 2000–2025. Beyond bibliometric description, the study identifies shifts in field priorities, underlying conceptual tensions, and knowledge gaps shaping its development, contributing to an understanding of the transition from operational approaches toward transformative perspectives.

Design/methodology/approach: The study draws on a quantitative bibliometric methodology using the Scopus database, complemented by critical interpretation. Co-authorship, co-citation, and keyword co-occurrence analyses were conducted through scientific visualization tools (VOSviewer) to examine the intellectual structure, thematic evolution, and collaboration networks of the field.

Findings: The results show accelerated growth in scientific output, particularly since the adoption of the 2030 Agenda, alongside thematic diversification and a turn toward governance, impact assessment, and transformative action. Eight interconnected clusters are identified, reflecting the field's maturity — from curricular integration and early environmental management through to systemic approaches encompassing student engagement, community outreach, digitalization, and global frameworks such as the SDGs. Geographic concentration in the Global North persists, though emerging transnational networks are expanding knowledge circulation.

Research limitations/implications: The study is limited to Scopus and a specific search strategy, which may have excluded relevant literature. The bibliometric approach also constrains analysis of institutional and pedagogical processes, pointing to the need for qualitative and comparative research.

Practical implications: The findings identify priority areas for universities, policymakers, and researchers. They underscore the need to strengthen integrated governance models, develop impact-oriented metrics, foster international collaboration, and advance the mainstreaming of sustainability across teaching, research, and community engagement. The strategic role of collaboration networks as mechanisms for knowledge dissemination and legitimation is also highlighted.

Social implications: The study points to the need to move toward more inclusive and transformative models of higher education — integrating Global South perspectives, promoting co-creation with communities, and preparing graduates capable of navigating complex challenges.

Originality/value: This work offers a longitudinal and structural reading of the field by integrating network analysis, thematic trends, and geographic dynamics. It traces the evolution toward systemic,

collaborative, and impact-oriented approaches, and provides a basis for future research agendas and institutional action.

Keywords: Higher education, Sustainability, Literature review, Evolution, Trends

Jel Codes: I23, Q56, M14

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1. Introduction

Over recent decades, sustainability has emerged as a global imperative that is reshaping the role of Higher Education Institutions (HEIs) well beyond their traditional functions (Filho et al., 2024; Xue, 2022). Universities have come to be recognized as key actors in the transition toward more sustainable societies — not merely because of their capacity to generate knowledge, but also because of their influence on the formation of citizens, professionals, and leaders equipped to address complex challenges (Ferguson & Roofe, 2020; Omazic & Zunk, 2021). This shift has driven growing academic and policy interest in how sustainability can be meaningfully integrated into higher education.

The literature documents a significant evolution in how sustainability has been conceptualized within HEIs. Early approaches focused primarily on environmental and operational management at the campus level, encompassing initiatives around energy efficiency, waste reduction, and regulatory compliance (Barth & Rieckmann, 2016; Wiek et al., 2012). Over time, the focus broadened to include pedagogical and curricular dimensions, promoting the development of sustainability competencies and the preparation of graduates capable of approaching complex problems from interdisciplinary perspectives. More recently, sustainability has been framed as a systemic process entailing changes in governance, organizational culture, research, and community engagement (Figueiró & Raufflet, 2015; Lozano et al., 2017).

This trajectory has been shaped by international frameworks such as the United Nations Decade of Education for Sustainable Development (2005–2014) and, above all, the adoption of the 2030 Agenda and the Sustainable Development Goals (SDGs), which have reinforced the responsibility of HEIs as agents of social and territorial transformation (Filho, Salvia et al., 2019; Lozano et al., 2015). As a result, research in this area has grown rapidly and diversified considerably, reflecting the complexity and multidimensionality of the field.

Yet despite this expansion, important theoretical and empirical challenges remain. Several scholars point to a "superficial consensus" in the literature, whereby sustainability is broadly accepted as an institutional goal but tends to be treated as a normative and static concept, with insufficient attention to the structural change processes required to generate real impact (Barth & Rieckmann, 2016; Popowska & Sady, 2024). This results in fragmented knowledge and a limited understanding of how universities can move from declarative commitments to transformative practices — particularly in terms of developing critical competencies, enabling social innovation, and fostering collective action (Holst et al., 2024).

A further challenge concerns geographic bias in knowledge production. Although researchers from the Global South have become more present in recent years, their visibility and centrality within international collaboration networks remain limited (Hallinger & Chatpinyakoop, 2019; Lim et al., 2022). This imbalance risks narrowing the diversity of perspectives, hindering the contextualization of solutions, and reproducing dominant frameworks that do not always speak to the socioeconomic and cultural realities of different regions (Arias-Valle & Marimon, 2025; Fuchs et al., 2023).

Existing bibliometric studies have contributed to mapping the growth and structure of the field, identifying influential authors, journals, and emerging trends (Acosta-Castellanos & Queiruga-Dios, 2021; Hallinger &

Chatpinyakoop, 2019). Much of this work, however, has focused on describing publication patterns, with less attention to the critical interpretation of conceptual change, shifts in research priorities, or what these developments mean for the field's maturity. An integrative analysis that combines trend identification with reflection on its theoretical and practical significance is still needed.

Against this backdrop, this study addresses the following research questions:

RQ1. How has research on sustainability in higher education evolved in terms of growth, structure, and thematic priorities between 2000 and 2025?

RQ2. What international collaboration dynamics characterize the field, and what are their implications for the visibility, circulation, and legitimation of knowledge?

RQ3. How do the thematic clusters identified reflect the transition from reactive, unidimensional approaches toward more systemic and transformative perspectives?

To address these questions, the study conducts a bibliometric and conceptual analysis aimed at moving beyond quantitative description and contributing to a critical understanding of the field's evolution. Three main contributions are offered. First, the study provides a longitudinal view that integrates temporal, geographic, and thematic dynamics, allowing patterns of maturity and emergence to be identified. Second, it analyzes collaboration networks as mechanisms of knowledge diffusion and legitimation, highlighting tensions between hegemony and diversification in academic production. Third, it offers a conceptual interpretation linking thematic evolution to a growing orientation toward implementation, impact assessment, and transformative action.

In doing so, this article not only systematizes the state of the art but also lays groundwork for future research agendas aimed at overcoming fragmented approaches and advancing a higher education system capable of driving meaningful social, climatic, and territorial change.

2. Methodology

2.1. General Methodological Approach

This study adopts a bibliometric methodology with an interpretative orientation, with the aim of analyzing the evolution, structure, and dynamics of the research field on sustainability in HEIs. Bibliometric methodology is particularly well suited to examining knowledge growth, identifying thematic patterns, and mapping collaboration networks, providing a systematic and longitudinal view of the development of a scientific field.

However, in order to move beyond the largely descriptive character of much prior work, this study incorporates a critical interpretation of bibliometric findings. Quantitative analysis is thus complemented by a qualitative reading of the trends identified, making it possible to address not only the evolution of publication volume, but also changes in research priorities, conceptual tensions, and their implications for the maturity of the field.

This approach responds directly to the research questions posed. In particular, the analysis of temporal evolution and thematic clusters allows for examination of the transition from operational approaches toward systemic perspectives (RQ1 and RQ3), while the study of international collaboration networks enables an understanding of the dynamics of knowledge circulation and legitimation (RQ2).

2.2. Data Collection

Bibliographic data were obtained from the Scopus database, selected for its broad multidisciplinary coverage, international recognition, and suitability for bibliometric research. This database captures peer-reviewed publications across a range of disciplines relevant to sustainability in higher education, facilitating an integrative view of the field.

The search strategy was designed using the terms "Sustainability" AND "Higher Education", applied to the title, abstract, and keywords of the documents. No temporal restriction was imposed, with the aim of analyzing the complete evolution of the field up to July 2025. Only documents classified as "articles" were included, excluding reviews, editorials, book chapters, conference proceedings, and other document types, in order to ensure the homogeneity and relevance of the corpus.

The selection process followed criteria informed by systematic review protocols, including deduplication and validation of thematic relevance. The final corpus comprised 2,987 articles. To improve data quality, a thesaurus file was developed in VOSviewer to disambiguate terms and author names, standardizing variations in names, affiliations, and keywords. This step was essential to ensuring the reliability of network analysis and thematic cluster identification.

2.3. Analytical Techniques and Links to the Research Questions

Metadata were exported in a format compatible with VOSviewer (version 1.6.20), a software tool specialized in the analysis of scientific networks. Different bibliometric techniques were applied in order to address the research questions in a structured manner:

Temporal evolution and citation analysis (RQ1). The growth of scientific output was examined alongside the influence of key authors, documents, and journals through citation indicators. This analysis allowed for the identification of phases of field development, as well as turning points that marked shifts in its priorities.

Keyword co-occurrence and thematic cluster analysis (RQ1 and RQ3). Associations between terms were analyzed to identify the main conceptual axes and their evolution. Occurrence thresholds were defined to ensure statistical relevance. The resulting clusters were interpreted qualitatively, drawing on the content of the most influential articles and their temporal evolution, making it possible to characterize the transition from unidimensional toward systemic approaches.

Co-authorship and international collaboration network analysis (RQ2). Relationships between authors, institutions, and countries were explored to understand the structure of the field, central nodes, and collaboration dynamics. This analysis allowed for examination of the relative visibility of different regions, as well as the role of particular actors as facilitators of knowledge circulation.

Geographic analysis of scientific production (RQ2). The territorial distribution of output and its evolution were analyzed, identifying dominant, emerging, and peripheral regions, along with their implications for epistemological diversity and the contextualization of sustainability.

The results of these analyses were represented visually through network maps and temporal overlay visualizations generated by VOSviewer. The interpretation of these maps — and the identification of thematic clusters — was conducted qualitatively in order to understand the meaning and relevance of the relationships detected and to discern the main lines of inquiry within the field.

3. Results

3.1. General Dynamics and The Evolution of Research

Research on sustainability in higher education has grown exponentially, particularly since 2018, with notable peaks in the 2020–2024 period. This trajectory underscores the increasing urgency with which academic institutions are engaging with the sustainable development imperative. *Sustainability* (Switzerland) stands out as the most prolific journal in this area, accounting for over 30% of the articles analyzed (709 documents), followed by the *International Journal of Sustainability in Higher Education* (263 articles) and the *Journal of Cleaner Production* (122 articles). This concentration points to the consolidation of dedicated outlets for the dissemination of this type of research.

Analysis of the average publication years associated with key terms adds nuance to this picture. General terms such as "sustainability" (mean: 2023.26) and "sustainable development" (mean: 2023.05) reflect very recent and ongoing scholarly interest, signaling their continued global relevance. By contrast, terms that explicitly link sustainability to higher education — such as "Higher Education for Sustainable Development" (mean: 2016.73) or "Sustainability in Higher Education" (mean: 2017.67) — show slightly earlier averages. This pattern suggests that the foundational phase of research on sustainability integration in HEIs peaked during the 2010s, whereas more recent work tends to focus on specific sub-themes, innovative methodologies, and — notably — the assessment of implemented initiatives. Figure 1 illustrates this evolution.

The inflection point observed around 2017–2018 can be explained by the convergence of normative, institutional, and social factors at both global and regional scales. First, the adoption of the 2030 Agenda in 2015

began translating into national strategies, institutional plans, and evaluation systems in the following years, generating growing demand for scientific evidence on the contribution of universities to the SDGs. This was particularly visible in Europe, where initiatives such as the European Strategy for Sustainable Development, the strengthening of the European Higher Education Area, and the integration of SDGs into quality assurance and accreditation frameworks stimulated applied sustainability research. Second, the growing relevance of international rankings and evaluation systems — most notably the Times Higher Education Impact Rankings, launched in 2019 — contributed to institutionalizing sustainability as a strategic priority for universities. These instruments created incentives to measure, report, and communicate social and environmental impact, spurring the production of research oriented toward evaluation, governance, and implementation. Third, intensifying public debate around climate change, particularly following the Paris Agreement and the rise of student-led social movements from 2018 onward, reinforced the role of universities as key actors in the ecological transition. This context encouraged a shift away from environmental management toward more transformative perspectives integrating social justice, student participation, and territorial engagement. Finally, the COVID-19 pandemic (2020–2021) acted as an additional catalyst, accelerating digitalization, international cooperation, and reflection on the resilience of educational and social systems — explaining the surge in research on pedagogical innovation, technology, and sustainability, as well as the intersection between global crises and higher education.

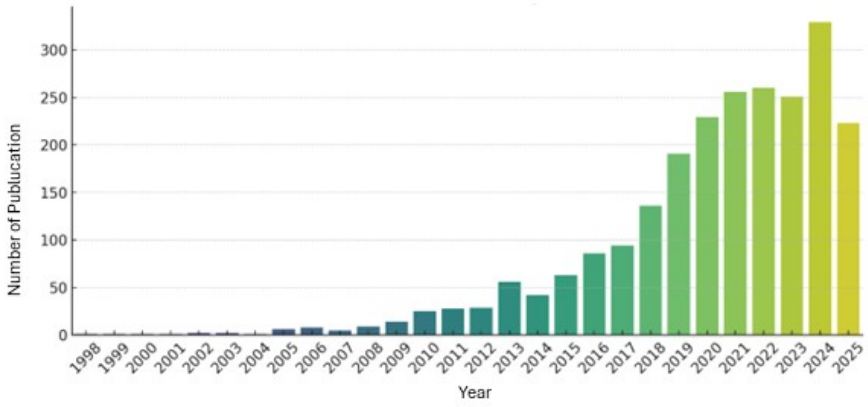

Figure 1. Temporal evolution of scientific output on sustainability

Taken together, these factors suggest that the field's recent growth reflects not simply increased academic output, but a deeper institutionalization and politicization of sustainability in higher education — marking a transition from a phase of awareness-raising and conceptualization toward one of implementation, impact assessment, and systemic transformation.

3.2. Influential Authors and Collaboration Networks

The bibliometric analysis shows that the evolution of sustainability research in higher education is closely linked to the consolidation of epistemic communities and the centrality of particular authors who function as structural nodes in knowledge production and circulation. Among these, Walter Leal Filho stands out as the most influential intellectual figure — not only because of his extensive output (52 documents), but because of his ability to build and sustain international collaboration networks.

Filho is affiliated with the Hamburg University of Applied Sciences, where he has led initiatives in sustainability and education for sustainable development, while also holding an academic appointment at Manchester Metropolitan University. These dual affiliations allow him to operate across two institutional environments with a strong orientation toward applied research and international cooperation. His career includes directing global networks and international projects on sustainability, reinforcing his role as an intermediary across different academic contexts.

His influence extends well beyond traditional indicators of productivity and citation impact. The total link strength in co-authorship analysis — which reflects the intensity of collaborative ties — places him at the center

of the collaboration network, with direct connections to researchers from more than ten countries. This positioning confirms that his leadership rests not only on knowledge generation, but on the construction of relational infrastructures that enable transnational cooperation, the diffusion of conceptual frameworks, and the consolidation of research agendas.

His role as editor-in-chief of the *International Journal of Sustainability in Higher Education* further amplifies his influence. From this position, he contributes to setting thematic priorities, legitimizing emerging approaches, and strengthening academic communities. This dynamic illustrates how intellectual leadership in the field depends not solely on scientific output, but also on occupying strategic institutional and editorial spaces that shape the direction of academic discourse.

Network analysis also reveals the emergence of regional communities, particularly in Latin America. Authors such as Brandli and Munguía show growing output, yet their collaboration networks are less dense and occupy less central positions compared to European nodes. This pattern points to the persistence of structural asymmetries in the internationalization of knowledge, where access to global networks, funding, and publication platforms remains concentrated in the Global North.

At the same time, these dynamics also reflect processes of opening and diversification. Collaborations between European and Latin American researchers — many of them facilitated by networks led by central authors — have contributed to the circulation of contextually grounded perspectives and the gradual incorporation of Global South concerns into the academic agenda. This process reflects a shift from a field initially dominated by Eurocentric frameworks toward a more polycentric configuration, though one still marked by hierarchies of visibility and influence. In this sense, co-authorship networks do not merely reflect patterns of scientific cooperation; they also operate as mechanisms of legitimation and knowledge diffusion. Central authors function as brokers connecting regions, disciplines, and agendas, facilitating field consolidation. The structure observed nonetheless highlights the need for more inclusive and horizontal networks that allow for greater epistemological diversity and a more situated understanding of sustainability in higher education.

Figure 2 illustrates these dynamics, showing the centrality of particular actors, the formation of collaboration clusters, and the transnational connections that shape the current structure of the field. It should be noted that during data cleaning, variants in the coding of Filho's name were detected and unified through the thesaurus to ensure analytical consistency.

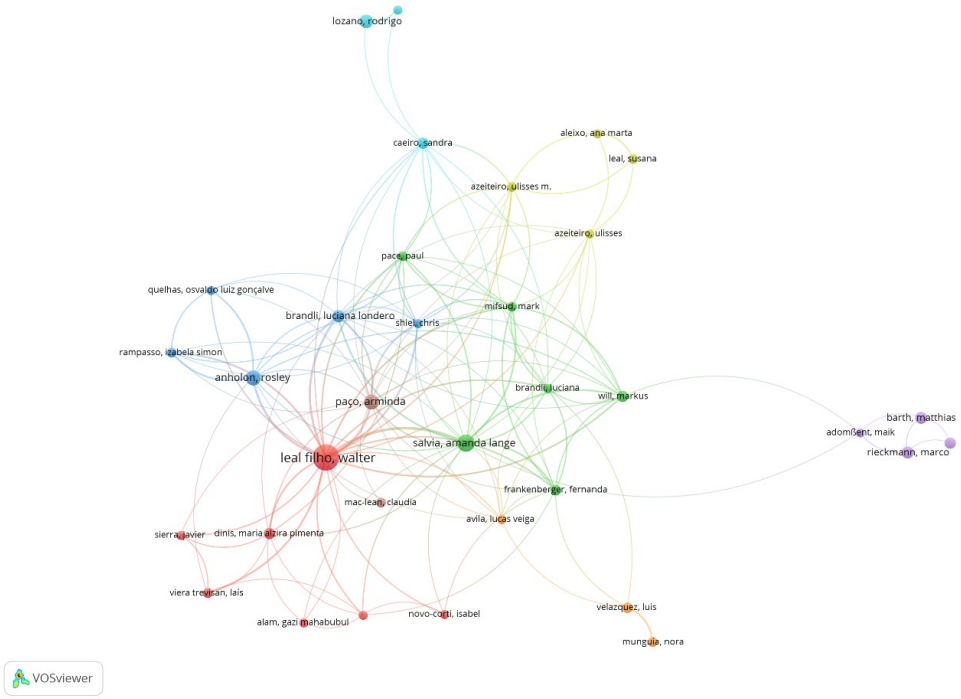

Figure 2. Co-authorship network of influential authors in sustainability in higher education

3.3. Thematic Mapping and Research Axes

This section analyzes keyword co-occurrence to reveal the field's conceptual structure and evolution. Moving beyond description, it examines maturity, thematic shifts, and emerging research agendas. Clusters were generated using VOSviewer with association normalization and a minimum frequency threshold. After cleaning and standardizing terms, eight interrelated clusters were identified. Each cluster was then qualitatively examined through key articles, considering their evolution, contexts, and contributions, allowing the identification of developmental stages rather than a static classification.

Overall, the results show a shift from a fragmented, environmentally focused approach to a more systemic perspective, where pedagogy, governance, social participation, technology, and global frameworks converge in a transformative higher education model. Table 1 summarizes these clusters and their contributions.

Cluster	Conceptual focus	Associated knowledge domains	Temporal evolution	Most cited articles	Dominant countries / networks	Contribution to systemic change	Emerging agenda
1. Curricular Integration and Teacher Education	Integration of sustainability into curricula, competency development, and teacher education oriented toward transformative pedagogies and experiential learning	Education, Social Sciences, Business and Economics, with growing interdisciplinarity toward Engineering and Environmental Sciences	2005–2015: development of sustainability competency frameworks 2015–2020: curriculum mainstreaming and SDG alignment 2020–2025: challenge-based learning, digitalization, and assessment of educational impact	Filho et al. (2019, +500), Brundiers (2021, +400), Shephard (2008, +400) Lozano (2019, +100)	Germany, UK, USA, New Zealand, and Nordic countries, with internationally led networks from Europe and North America	Constitutes the pedagogical core of the field, shifting focus from environmental management toward training change agents and institutional transformation	Competency impact assessment, AI and learning analytics integration, transdisciplinary approaches, and greater emphasis on social justice and transformative action
2. University Governance and Institutional Commitment	Policies, leadership, and organizational structures for institutionalizing sustainability, including strategies, accountability, and ESG and SDG alignment	Social Sciences, Business and Economics, Public Management, and Education Policy	2000–2010: institutional environmental management and "green" policies 2010–2020: barriers, enablers, and organizational change 2020–2025: multilevel governance, co-creation, and ranking pressures	Velazquez et al. (2006, +500), Aleixo (2018, +300), Purcell (2019, +200)	USA, Portugal, Mexico, and Western Europe, with growing internationalization	Introduces sustainability as an institutional logic, connecting strategy, governance, and organizational legitimacy	Transformative governance models, ESG integration, impact metrics, and cross-sectoral leadership
3. Student Engagement and Transformative Action	Student agency, curricular co-creation, climate activism, and action-oriented learning	Education, Social Sciences, and citizenship studies	2005–2015: extracurricular initiatives 2015–2020: collaborative projects and service-learning 2020–2025: co-governance and transformative action	Severino-González (2021, 19), Muñoz-García (2021, 11)	Spain, Chile, and emerging global networks	Reconfigures the role of students as agents of change and catalysts for institutional innovation	Digital activism, climate justice, knowledge co-creation, and participation in governance
4. Community Engagement and University Outreach	Territorial engagement, service-learning, community co-creation, and the third mission of the university	Education, Territorial Development, Social Sciences	2000–2010: local initiatives 2010–2020: institutionalization of service-learning 2020–2025: SDG-oriented strategic alliances	Zilahy (2009, 59), Ramachandra (2014, 21), Avelar et al. (2022, 18)	Europe (Hungary), Latin America (Brazil), and Asia (Malaysia)	Extends sustainability beyond the campus, strengthening social and territorial impact	Citizen science, climate justice, territorial living labs, and regenerative economies
5. Sustainability Assessment and Reporting	Indicators, benchmarking, rankings, reporting, and accountability systems	Business, Economics, Education, and Environmental Sciences	2005–2015: development of evaluation frameworks 2015–2020: alignment with global rankings 2020–2025: impact metrics and external audits	Filho (2015, +200), Abad-Segura (2021, +100), Findler (2019, +100)	Europe, particularly Germany, Spain, and Austria	Professionalizes university sustainability and strengthens institutional accountability	SDG impact, advanced analytics, open data, and qualitative assessment of change

Cluster	Conceptual focus	Associated knowledge domains	Temporal evolution	Most cited articles	Dominant countries / networks	Contribution to systemic change	Emerging agenda
6. Global Frameworks (SDGs)	Implementation of the SDGs in teaching, research, governance, and community engagement	Education, Social Sciences, Public Policy	2015–2018: awareness-raising and mapping 2019–2024: institutional operationalization	Filho (2021, +100), Ruiz-Mallén (2020, +100), García-Feijoo (2020, +100)	Germany, Spain	Provides a common framework and guides the international research agenda	Measurable impact, SDG budgeting, and analysis of synergies and trade-offs
7. Environmental Dimension	Ecological management, climate change, energy, circular economy, and sustainable campuses	Engineering, Environmental Sciences, and Education	2000–2010: eco-campus 2010–2015: environmental indicators 2015–2025: decarbonization and living labs	Filho (2018, +300), Žalėnienė (2021, +300), Biasutti (2017, +200)	Germany, Lithuania, Italy	Operational foundation of the field, integrating environmental management with learning and governance	Net-zero, climate resilience, circularity, and IoT technologies
8. Digitalization and Sustainability Technologies	Use of ICT, artificial intelligence, and data analytics in sustainable education and management	Engineering, Education, Business	2010–2015: e-learning 2015–2020: blended learning 2020–2025: AI and smart campuses	Gherheş (2021, +200), Mian (2020, +100), Sá (2020, +100)	Europe, Asia, Middle East	Integrates technological innovation with sustainability, accelerating institutional transformation	Generative AI, digital twins, sustainability analytics, and data ethics

Table 1. Summary of thematic clusters in sustainability research in higher education

Cluster 1 — Curricular integration and teacher education is the most extensive, comprising 898 documents published between 1996 and 2025, confirming its foundational role in the consolidation of the field. From its earliest stages, this line of research focused on embedding sustainability competencies in curricula and preparing faculty for mainstreaming the topic, shaping the orientation of subsequent approaches. Prominent authors include Filho, Brundiers, Shephard, and Lozano, all widely cited and centrally positioned in collaboration networks. Leading countries include Germany, the United States, New Zealand, and Sweden, with institutions such as Hamburg University, Arizona State University, the University of Otago, and the University of Gävle. This cluster reflects the shift of sustainability from a peripheral concern to a core element of the educational mission of universities (Barth & Rieckmann, 2016). Its main contributions center on the development of competency frameworks, transformative pedagogies, and curricular alignment with the SDGs. In recent years, research has evolved toward challenge-based approaches, experiential learning, and the assessment of educational impact, consolidating education for sustainability as a strategic axis.

Cluster 2 — University governance and institutional commitment encompasses 539 documents from 2000 onward and reflects the growing interest in understanding how universities institutionalize sustainability through policies, structures, and strategies. This field has evolved from environmental management studies and institutional "green" plans toward comprehensive approaches centered on leadership, accountability, climate risk management, and SDG alignment. The strong participation of European and North American institutions — particularly those with formal sustainability structures — has contributed to the development of organizational change models, institutional strategies, and performance indicator systems. Current trends point toward mission-oriented governance, the integration of ESG criteria, and linkages with international rankings. The relevance of this cluster demonstrates that sustainability has transcended the academic sphere to become integrated into the organizational structure of HEIs (Arias-Valle & Marimon, 2024; Filho, Doni et al., 2019), in parallel with its global transition from a voluntary commitment toward a strategic imperative driven by the 2030 Agenda (Lozano et al., 2015). However, the analysis of collaboration networks and the most productive countries (such as the United States, the United Kingdom, and Spain) shows that the governance models and management policies dominating the literature originate predominantly from the Global North (Arias-Valle et al., 2021a, 2021b; Roos et al., 2023), which reinforces the structural biases identified by Hallinger and Chatpinyakoop (2019) and Lim et al. (2022).This concentration raises questions about the transferability of these approaches to diverse institutional and socioeconomic contexts (Shava et al., 2023).

Cluster 3 — Student engagement and transformative action is the most recent and smallest cluster, with just 8 documents between 2018 and 2024, reflecting its emergent character. Research in this area focuses on the role

of students as agents of change, addressing curricular co-creation, participation in decision-making bodies, service-learning, and climate and social activism. Geographic diversity is notable, with contributions from Europe and the Americas, and growing involvement from student affairs units and teaching centers. Findings suggest that active student participation can accelerate curricular change, drive impact-oriented projects, and strengthen key competencies. The cluster's evolution traces a shift from extracurricular initiatives toward models of co-governance and student leadership, evidencing a move from theory to practice in education for sustainability (Agustina et al., 2023; Alm et al., 2022). Research confirms that universities are increasingly conceived not only as spaces of learning, but as platforms for social action and institutional transformation (Chusniyah et al., 2024; Gómez et al., 2024). Current debate nonetheless underscores the need to examine the quality and impact of this participation, beyond its mere formal presence.

Cluster 4 — Community engagement and university outreach (18 documents, from 2009 onward) addresses territorial engagement, social innovation, and local impact as central dimensions of university sustainability. This cluster groups research on community co-creation, service-learning, and regional development, with a relevant presence across Europe, Latin America, and Oceania. Key contributions include the development of collaboration frameworks, methodologies for assessing social impact, and SDG-oriented strategies. The cluster's evolution reflects a transition from isolated projects toward long-term strategic partnerships, with emerging approaches such as climate justice, citizen science, and regenerative economies. It underscores the extension of sustainability beyond the campus, consolidating the role of HEIs as key actors in territorial transformation and the co-creation of solutions to local challenges (Álvarez-Vanegas et al., 2024; Aramburuzabala & Cerrillo, 2023). The growing integration of the SDGs has reinforced this orientation, fostering cross-sectoral collaboration and social impact initiatives (El-Jardali et al., 2018; Filho, Dibbern et al., 2023). Network analysis, however, shows a concentration in the Global North — particularly the United Kingdom and Spain — suggesting that dominant frameworks for community engagement may not fully reflect the realities of the Global South (Arias-Valle et al., 2024; Hallinger & Chatpinyakoop, 2019).

Cluster 5 — Sustainability assessment and reporting comprises 210 documents, from 2002 onward, and responds to the growing need to measure, benchmark, and legitimize institutional progress on sustainability. This area integrates indicators, benchmarking practices, and reporting systems aligned with global frameworks such as the SDGs, ESG criteria, the Global Reporting Initiative (GRI), and the Sustainability Tracking, Assessment & Rating System (STARS). European and North American institutions with formal planning and data management structures have dominated this area, contributing to the development of comparable metrics, monitoring systems, and impact evaluation frameworks. The cluster's evolution traces a transition from campus-focused environmental auditing toward comprehensive models oriented toward transparency, accountability, and institutional legitimation. This reflects the progressive professionalization and formalization of sustainability within HEIs (Filho et al., 2022), driven by growing demands for accountability and the need to demonstrate the impact of university initiatives (Amiano et al., 2022; Holst et al., 2024; Omazic & Zunk, 2021). The proliferation of indicators and reports has, however, generated debate about their quality, comparability, and utility for promoting structural change — pointing to limitations associated with the lack of standardization and the predominance of quantitative metrics.

Cluster 6 — Global frameworks and SDGs (55 publications, from 2017 onward) reflects the growing centrality of the SDGs as a shared reference point for sustainability research in HEIs. This area addresses curricular mapping, the alignment of research and institutional governance with the 2030 Agenda, and strong engagement from international networks and university alliances. Its evolution shows a transition from early awareness-raising toward institutional operationalization, with increasing emphasis on impact measurement, SDG-aligned budgeting, and transnational cooperation. The cluster's growth confirms the influence of the 2030 Agenda as a guiding framework for academic and strategic priorities (Filho et al., 2025), and demonstrates the field's capacity to respond to the global call for action (Ferguson & Roofe, 2020). Network analysis — featuring authors such as Rodrigo Lozano and teams from European and Latin American universities — also points to the consolidation of transnational communities focused on SDG implementation.

Cluster 7 — Environmental dimension comprises 511 publications, from 1998 onward, constituting one of the earliest axes of the field and reflecting its roots in campus environmental management. Initially focused on

energy efficiency, waste management, and carbon footprints, this area has evolved toward climate change, the circular economy, and institutional resilience (Bagheri-Majd, 2022). Its applied and technical character — with strong representation from engineering disciplines and multicontinental case studies — has contributed to the development of environmental impact reduction methodologies, climate strategies, and sustainable campus models. The persistence of this line in the literature, particularly in journals such as the *Journal of Cleaner Production*, confirms its continued relevance as the operational foundation of sustainability in higher education. The cluster's evolution reflects a shift from an exclusively environmental focus toward a more holistic vision, in line with broader conceptual changes in the field (Figueiró & Raufflet, 2015). Current trends point toward decarbonization, net-zero approaches, and the integration of sustainability into institutional planning.

Cluster 8 — Digitalization and sustainability technologies (215 publications, 2009–2025) reflects the growing impact of digital technologies, e-learning, learning analytics, and artificial intelligence on university sustainability. This cluster shows a strong presence across Asia, Europe, and North America, particularly in institutions with technological profiles and in disciplines such as engineering, education, and management. Contributions focus on pedagogical innovation, improvements in institutional efficiency, educational inclusion, and the use of data for strategic sustainability decision-making. The cluster's evolution traces a transition from early approaches centered on online and blended learning toward the development of integrated digital ecosystems, collaborative platforms, and intelligent campus management systems — a change closely tied to the expansion of digital education and, more recently, accelerated by the post-pandemic shift toward technological transformation.

Taken together, the results allow for the identification of an evolutionary structure of the field organized into three levels. First, the mature clusters (curricular integration, governance, and the environmental dimension) have consolidated the conceptual and institutional foundations of sustainability in higher education. Second, the transitional clusters (assessment, community engagement, and global frameworks) reflect a shift toward implementation, impact measurement, and territorial transformation. Finally, the emerging clusters (student participation and digitalization) signal a new phase characterized by social and technological innovation, the rising prominence of new actors, and the development of more critical and inclusive approaches.

This evolution confirms that the field is transitioning from a phase centered on management and institutionalization toward a stage oriented toward systemic transformation and the generation of social impact. Nonetheless, significant gaps persist — particularly the need for longitudinal studies, greater inclusion of Global South institutions, and comparative analyses that move beyond localized perspectives. These aspects are key to strengthening the field and guiding future research agendas.

3.4. Geographic Dynamics, Institutional Factors, and Determinants of Impact

The integrated analysis of geographic distribution, collaboration networks, and institutional environments reveals that research on sustainability in higher education is shaped not solely by publication volume, but by structural factors such as scientific policy frameworks, evaluation systems, linguistic affinities, and the existence of specialized organizational infrastructures. These elements condition both international visibility and the capacity to influence the global academic agenda.

First, the results show a strong geographic concentration in Europe and North America, in line with prior studies that identify persistent asymmetries in the production and circulation of knowledge. Within this context, Spain stands out for its high publication volume, which can be explained by the combination of incentives linked to national evaluation systems and an applied orientation centered on institutional case studies and public policy. However, this productivity coexists with challenges of international visibility, particularly due to the weight of publications in Spanish and more limited insertion into dominant Anglophone citation networks.

Second, co-authorship analysis reveals the consolidation of an Atlantic research ecosystem, structured primarily around Europe and Latin America. This network is organized around key nodes in Germany, the United Kingdom, and Portugal, with strategic bridges toward Brazil and other Latin American countries. The leadership

of researchers such as Filho, affiliated with the Hamburg University of Applied Sciences and Manchester Metropolitan University, has been fundamental in consolidating global networks for research and knowledge transfer. His recurring collaboration with scholars such as C. Shiel (Bournemouth University) and Á. Paço (Universidade da Beira Interior) has shaped a Eurocentric cooperation triangle that has facilitated the internationalization of the field.

Portugal plays a particularly relevant role as a bridging country, connecting the European and Lusophone spaces — most notably Brazil. Universities such as the Universidade da Beira Interior and the Universidade de Coimbra have developed a significant presence within these networks, combining scientific output, international cooperation, and project leadership. This pattern reflects the extent to which collaboration networks are shaped by geopolitical strategies, cultural affinities, and shared funding frameworks, beyond mere geographic proximity.

Alongside this transnational model, the results also identify an alternative pattern based on more concentrated nodes of influence. The case of the Universidad de Sonora in Mexico illustrates how a solid conceptual contribution can generate global impact without relying on extensive networks. The foundational work on the "sustainable university" (Velazquez et al., 2006) has positioned this team as an international reference point, demonstrating that scientific centrality can derive both from connectivity and from the capacity to generate influential theoretical frameworks.

Third, the analysis highlights the decisive role of institutional environments in shaping the field. Universities that have developed formal sustainability structures — such as dedicated offices, research centers, or strategic programs — tend to show greater productivity, impact, and collaborative capacity. Notable examples include the Hamburg University of Applied Sciences and Manchester Metropolitan University, which have consolidated global networks through academic leadership and institutional support. Similarly, institutional initiatives such as the Sustainability Institute of the Universitat Politècnica de Catalunya and the Hong Kong Sustainable Campus Consortium demonstrate how inter-university cooperation and strategic alignment with the SDGs strengthen applied research and social impact generation.

The field's expansion has also favored the progressive incorporation of Global South perspectives, particularly from Brazil and South Africa, which introduce critical approaches centered on social justice, inclusion, and institutional transformation. These contributions broaden epistemological diversity and challenge dominant technocratic frameworks, though their visibility within high-impact networks remains limited. The case of South Africa is particularly noteworthy. The research of Lesley Le Grange from Stellenbosch University, for instance, introduces a critical and philosophical perspective that questions the reduction of sustainability discourse to the economic imperatives of the neoliberal model (Le-Grange, 2011). This study proposes reimagining education for sustainability beyond these "shackles" and suggests that students are key actors in this process of reconceptualization. This critical perspective, in contrast to the more pragmatic, policy implementation-oriented approaches that prevail in the Global North, exemplifies how researchers from the Global South are enriching the field by introducing deeper debates about the social role of the university, neoliberalism, and environmental justice.

Taken together, these results show that international collaboration simultaneously functions as a mechanism of knowledge diffusion and legitimation while also reproducing structural hierarchies in scientific production. The evidence suggests that academic influence can manifest both through dense global networks and through foundational conceptual contributions developed in local contexts. In this regard, a future agenda should promote more inclusive alliances, comparative research, and horizontal collaboration models that integrate diverse contexts and strengthen the capacity of higher education institutions to drive sustainable transformations.

Figure 3 presents a synthesis of these dynamics, illustrating the geographic structure of collaboration networks, key institutional nodes, and knowledge exchange flows.

Table 2 below synthesizes regional research priorities, institutional approaches, and impact drivers, offering a comparative map of how these factors materialize across different geographic contexts.

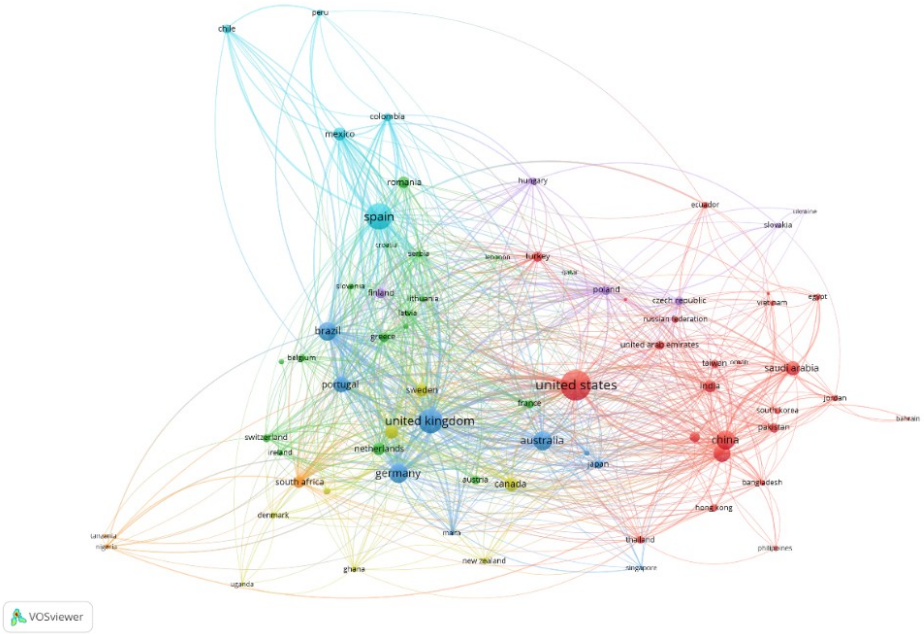

Figure 3. Geospatial mapping of international research collaborations and knowledge exchange networks

Region	Key universities and initiatives	Strategic orientation	Mechanisms of scientific influence	Implications for field development
Europe (Germany, United Kingdom)	Hamburg University of Applied Sciences, Manchester Metropolitan University	Education for sustainable development, SDGs, institutional governance	Leadership of highly connected authors, global networks, international projects	Consolidation of conceptual frameworks and global expansion of the field
Europe (Portugal)	Universidade da Beira Interior, Universidade de Coimbra	Curricular integration, lusophone networks, international cooperation	Role of bridging country, Europe–Brazil collaboration, knowledge transfer	Internationalization of the field and circulation of ideas North–South
Spain	Universitat Politècnica de Catalunya, Universitat Oberta de Catalunya, Universidad de Jaén	Meta-research, pedagogical innovation, professional competencies, transformative learning and co-creation, transdisciplinary research	High productivity, case studies, alignment with public policy	Generation of practical evidence and strengthening of the implementation approach
Latin America (Mexico)	Universidad de Sonora, Universidad Autónoma de Guerrero	Conceptualization of the sustainable university, institutional sustainability	Concentrated research nucleus, high conceptual impact	Production of foundational frameworks and global dissemination from local contexts
Latin America (Brazil)	University networks and European collaborations	SDG implementation, territorial development	International cooperation, interinstitutional projects	Expansion of the field in the Global South
Asia	Universiti Sains Malaysia, Hong Kong Sustainable Campus Consortium	Institutional innovation, campus sustainability	Inter-university collaboration, validation of "servant leadership" as a driver of sustainability	Development of systemic models for sustainable management
Africa (South Africa)	Stellenbosch University	Social justice, transformative sustainability	Critical perspectives, questioning of technocratic approaches	Epistemological diversification and new research agendas

Table 2. Synthesis of regional research priorities, institutional approaches, and impact drivers

4. Discussion

4.1. Interpretation and Implications

The results of this study suggest that sustainability in higher education has ceased to be an emerging field and has become a consolidated one, although it remains marked by conceptual and operational tensions. More than a thematic expansion, the evolution observed reflects a reconfiguration of the role of universities in relation to global challenges. Sustainability has moved from being a set of peripheral initiatives to constituting an organizing framework for institutional mission, driving new forms of governance, evaluation, and collaboration. However, this institutionalization has also generated the risk that sustainability may translate into a process of normative formalization and compliance, rather than a driver of deep transformation.

In this regard, one of the main challenges identified is the gap between discourse and implementation. The widespread adoption of frameworks such as the SDGs has contributed to aligning agendas and generating a common language (Filho, Simaens et al., 2023; Holst, 2023), but has not necessarily produced structural changes in educational, organizational, or community engagement models. The proliferation of strategies, indicators, and reporting systems has strengthened accountability (Amiano et al., 2022; Andrades et al., 2024), but has also favored technocratic approaches oriented toward measurement, with less attention to the processes of learning, conflict, and experimentation that characterize sustainable transitions. From a pragmatic perspective, this raises the need to shift the focus from evidence production toward the generation of institutional capacities for change (Avelar & Farina, 2022; Filho, Salvia et al., 2019).

Another relevant finding is that university sustainability is taking shape as a field of organizational innovation rather than as an exclusively academic domain. The emergence of approaches such as living labs, co-creation with social actors, and student participation indicates that transformation depends on the articulation between teaching, research, and management. These approaches, however, remain fragmented and, in many cases, dependent on individual initiatives or temporary projects (Holst et al., 2024; Lozano et al., 2015). The institutionalization of these models requires changes in academic incentive structures, funding arrangements, and performance evaluation systems, which continue to prioritize scientific productivity over social impact.

The geopolitical dimension of knowledge constitutes another critical aspect. Despite the growing participation of Global South researchers, the dominant agendas, evaluation frameworks, and conceptual reference points remain strongly influenced by the Global North (Arias-Valle et al., 2024; Martí-Noguera et al., 2018). This situation limits epistemological diversity and may generate solutions poorly adapted to diverse institutional and territorial contexts. At the same time, the expansion of transnational networks and the emergence of critical perspectives are contributing to challenging this balance, promoting more situated, participatory, and social justice-oriented approaches (Kester & Misiaszek, 2025; Lo-Presti et al., 2023). From a pragmatic standpoint, this implies that the internationalization of research should advance toward models of horizontal collaboration and knowledge co-production.

The results also suggest that the future of the field will be conditioned by the capacity of universities to integrate sustainability into their core functions in a coherent manner. This entails overcoming the fragmentation between curriculum, campus management, research, and territorial engagement, and advancing toward mission-oriented governance models. In this context, digitalization and AI emerge as potential facilitators (Borsatto et al., 2024; Filho et al., 2026), but also raise new dilemmas related to equity, data ethics, and the environmental impact of technological infrastructures. The convergence of sustainability and digital transformation will require interdisciplinary approaches and evaluation frameworks that account for systemic effects.

From a practical standpoint, the findings underscore the need to strengthen cross-sectoral and territorial alliances. Universities are increasingly called upon to act as intermediaries between knowledge, public policy, and social action (Filho et al., 2024; Saad et al., 2026). This demands the development of mediation capacities, adaptive leadership, and organizational learning, as well as the promotion of experimentation and learning from practice. The evidence indicates that the most influential institutions are not necessarily the most productive, but those capable of articulating networks, mobilizing actors, and generating reference frameworks.

The future research agenda should focus less on the description of initiatives and more on understanding the mechanisms of change. This includes the longitudinal analysis of institutional transformations, the evaluation of

the real impact of sustainability education, the integration of Global South perspectives, and the development of methodologies capable of capturing complex and contextual processes. Taken together, these challenges point to the need for a shift in focus: from sustainability as an object of study toward sustainability as an organizational, social, and political practice.

4.2. From Institutionalization to Transformation in University Sustainability

Building on this basis, the present study proposes advancing from a descriptive reading of the field toward an interpretive framework centered on processes of change in university sustainability. More than a simple thematic diversification, the results suggest the coexistence of distinct institutional logics that reflect heterogeneous degrees of maturity, organizational capacities, and impact orientation. In this sense, the observed evolution can be understood as a progressive transition from operational approaches centered on environmental management and impact reduction, toward processes of institutionalization oriented toward the integration of sustainability into governance, curriculum, and evaluation systems, and, more recently, toward perspectives that prioritize systemic transformation, co-creation, and social innovation.

This model distinguishes three interrelated phases. The first, operational in character, is based on the adoption of technical environmental management practices and institutional efficiency measures, which allow for the generation of initial capacities and internal legitimacy. The second, institutionalization, involves the formalization of sustainability within organizational structures, strategies, and accountability systems, supported by global frameworks such as the 2030 Agenda and by pressure from public policies, rankings, and accreditation processes. The third, still emerging, is oriented toward transformation, in which universities seek to act as agents of change through the integration of their core functions, experimentation in real-world contexts, and the development of territorial alliances and transnational networks.

This transition, however, is neither linear nor uniform. Institutions advance at different rates and face tensions between legitimation, implementation, and impact. While some remain centered on compliance and formalization, others adopt experimental models that integrate learning, governance, and social action. This heterogeneity makes clear that university sustainability must be understood as an adaptive process, conditioned by institutional contexts, resources, leadership, and regulatory frameworks. In this sense, the movement between phases depends not solely on the adoption of new agendas, but on the capacity to overcome organizational barriers and activate enabling conditions. Among these, the following stand out: the development of mission-oriented governance, the alignment of incentives and structures, the articulation of teaching, research, management, and territorial engagement, and the construction of cross-sectoral alliances that enable knowledge co-production. The transition also requires evaluation systems oriented toward impact and organizational learning, along with more inclusive international networks that integrate Global South perspectives and foster epistemological diversity.

In this context, Table 3 synthesizes this transition model, identifying the main barriers, enabling conditions, and mechanisms that facilitate the advancement toward more transformative approaches. Rather than a normative framework, this proposal offers an analytical and practical tool for interpreting institutional trajectories, guiding university strategies, and structuring future research agendas.

5. Conclusion

This study aimed to analyze the conceptual, thematic, and structural evolution of research on sustainability in higher education between 2000 and 2025, with the purpose of identifying trends, collaboration dynamics, and emerging priorities that reflect the transition toward more systemic and transformative approaches. Through a bibliometric analysis with critical interpretation, the work sought to go beyond quantitative description and contribute to an integrated understanding of the field's maturity and tensions.

With regard to the first research question, the results show that the field has experienced accelerated growth, particularly since the adoption of the 2030 Agenda, accompanied by thematic diversification and a progressive orientation toward implementation, impact assessment, and institutional transformation. This process evidences a transition from approaches centered on environmental management toward perspectives that integrate curriculum, governance, social innovation, and digitalization. Regarding the second question, the analysis reveals

that international collaboration networks play a key role in the diffusion and legitimation of knowledge, although they continue to reproduce structural asymmetries that favor the centrality of the Global North. Finally, in relation to the third question, the thematic clusters identified reflect a field in evolution, in which mature approaches, areas in transition, and emerging agendas oriented toward systemic transformation coexist.

Phase	Predominant focus	Critical barriers	Enabling conditions	Transition mechanisms	Risks and tensions
Operationalization	Environmental management, efficiency, and regulatory compliance	Institutional fragmentation; sustainability as a technical function; weak connection to teaching and strategy	Initial leadership; creation of sustainability offices; development of technical capacities	Progressive integration into strategic plans; linkages with curriculum and professional development	Reduction of sustainability to operational practices; low internal legitimacy
Institutionalization	Governance, curriculum, metrics, 2030 Agenda	Formalization without transformation; bureaucratization; technocratic approach centered on indicators	Mission-oriented governance; institutional incentives; evaluation systems; external pressure (rankings, public policy)	Articulation of university functions; organizational learning; interdisciplinary experimentation	Symbolic compliance; dependency on global frameworks; disconnection from local contexts
Transformation (emerging)	Social innovation, co-creation, territorial impact, digitalization	Limited scalability; project dependency; organizational resistance; resource gaps	Cross-sectoral alliances; student participation; inclusive international networks; impact-oriented funding	Knowledge co-production; territorial integration; institutionalization of living labs; critical digitalization	Institutional capture; North–South inequalities; ethical and technological risks

Table 3. Transition model toward transformative universities: phases, barriers, and enabling conditions

As with any study, this work presents limitations that open opportunities for future research. First, the exclusive use of the Scopus database and a specific search strategy may have excluded relevant literature, particularly in languages other than English or from regional sources. Future research could broaden the scope through the use of multiple databases, multilingual approaches, and more inclusive search strategies, which would allow for a better capture of the epistemological diversity of the field. Second, the bibliometric character of the analysis limits the understanding of the institutional, pedagogical, and cultural processes that underpin the transformation toward sustainability. Qualitative, longitudinal, and comparative studies are necessary to analyze how universities develop capacities for change, face resistance, and generate impact in specific contexts. Third, the conceptual interpretation proposed, although grounded in empirical evidence, requires validation through case studies, organizational analyses, and public policy evaluations that allow for the refinement of the transition model put forward. In this regard, future research should focus on understanding the mechanisms of change rather than describing isolated initiatives. This includes the analysis of institutional trajectories, the evaluation of the real impact of sustainability education on professional and social practice, the integration of Global South perspectives, and the development of methodological frameworks capable of capturing complex, adaptive, and contextual processes. It is also a priority to explore how digitalization, artificial intelligence, and cross-sectoral cooperation can act as facilitators of sustainable transformations, while at the same time avoiding the reproduction of inequalities and technocratic approaches.

Taken together, this study contributes to the literature by offering a longitudinal and structural view of the field, integrating the analysis of networks, trends, and geographic dynamics, and by proposing a conceptual model that allows for an understanding of the transition toward more transformative universities. Beyond its academic contributions, the work seeks to guide institutional strategies, public policies, and research agendas, reinforcing the role of higher education as a key actor in the transition toward more sustainable, inclusive, and just societies.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Authors' contributions

María Belén Arias-Valle: conceptualization, methodology, data collection, formal analysis, writing - original draft.

Jasmina Berbegal-Mirabent: formal analysis, writing - review and editing, supervision.

Data availability

Data available upon request.

Use of Artificial Intelligence

No generative AI tools were used in the writing or data generation of this article.

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