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Research landscape of education and sustainable development in universities: a scopus-based bibliometric analysis

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ABSTRACT

This study aims to map and analyze the development of research on Education for Sustainable Development (ESD) in higher education during the period 2015-2025, representing the first decade following the adoption of the Sustainable Development Goals (SDGs). A bibliometric approach was employed using data retrieved from the Scopus database through the search query TITLE-ABS-KEY ("Education for Sustainable Development" OR "ESD") AND TITLE-ABS-KEY ("Higher Education"). After applying inclusion criteria limited to English-language journal articles published between 2015 and 2025, a total of 382 publications were selected for analysis. The data were examined using VOSviewer to identify publication trends, source productivity, authorship patterns, country contributions, subject areas, and thematic keyword networks. The findings reveal a substantial increase in scholarly output, indicating growing academic interest in sustainability education within higher education. Keyword co-occurrence analysis demonstrates an evolving intellectual structure characterized by a shift from sustainability awareness and environmental education toward sustainability competencies, SDG integration, institutional transformation, and leadership development. Prominent themes include higher education institutions (HEIs), teachers, knowledge development, and SDG implementation. These findings demonstrate that ESD has evolved into a multidisciplinary research field and provide valuable insights for researchers, policymakers, university leaders, and educators in advancing sustainability-oriented strategies and strengthening SDG implementation in higher education worldwide.

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Introduction

The concept of Education and Sustainable Development (ESD) has gained increasing prominence in higher education studies, as it is considered capable of addressing complex global development challenges. Universities play a pivotal role in advancing sustainability agendas by implementing the tridharma of higher education: teaching, research, and community service (Chasokela, 2024; Lazarov & Semenescu, 2022; Lee et al., 2026; Scherak & Rieckmann, 2020). In recent years, the growing number of scholarly publications on integrating sustainability principles into curricula, campus governance, and learning processes reflects heightened academic interest in this topic. To comprehensively understand these developments, bibliometric approaches have been widely employed, as they enable the identification of publication patterns, researcher collaborations,

institutional influence, and emerging research themes. By using Scopus-indexed publication data, this study seeks to systematically and comprehensively map the evolution and characteristics of research on Education and Sustainable Development within the university context (Lim et al., 2022; Mokski et al., 2023; Vaniev & Malt-Cullen, 2025).

Research on education for sustainable development has accelerated significantly following the introduction of the United Nations' Agenda 2030 and the Sustainable Development Goals (SDGs) (Boluk et al., 2019; Hassani et al., 2021; Khizar et al., 2023; Sorooshian, 2024; Weiland et al., 2021). This shift underscores the growing recognition of higher education institutions as key actors in generating solutions to complex social, economic, and environmental challenges. What was once primarily focused on environmental education has now evolved into a multidisciplinary field that incorporates diverse scientific perspectives (Husic, 2024; Määttä & de Gooyert, 2025; Persano Adorno et al., 2025; Sierra & Suárez-Collado, 2021; Skowronek et al., 2022). Numerous studies emphasize the importance of strengthening students' sustainability competencies to enable them to address future challenges responsibly. However, findings remain fragmented regarding the most effective approaches for integrating ESD across disciplines and institutional contexts. Moreover, the rise of cross-national research collaborations reflects a global awareness of the need to share experiences and best practices in implementing ESD. These developments have expanded the scope of research and enriched the academic discourse on sustainability in higher education, although variations in methodological approaches continue to produce inconsistent results across studies. (Amorós Molina et al., 2023; D. Chen et al., 2025).

From a geographical perspective, research on Education and Sustainable Development (ESD) is dominated by countries with strong research capacity and robust policy support for sustainability agendas. Nations such as China, the United States, the United Kingdom, Germany, and Spain are among the leading contributors to publications in international databases. The high level of scientific productivity in these countries is closely linked to substantial investments in research, the presence of sustainability research centers, and universities' commitment to implementing the SDGs. Furthermore, collaboration network analysis reveals that international partnerships are expanding and have become a critical factor in enhancing both the quality and the impact of research. (Muhonen et al., 2024; Tafese & Kopp, 2025). On the other hand, developing countries continue to face various challenges, including limited funding, restricted access to international publications, and weaker integration into global academic networks. (Achraouaou et al., 2025; Fournet et al., 2018). Consequently, strategies are needed to strengthen research capacity to develop further nations' contributions to sustainability studies in higher education.

The analysis of keywords used in Scopus-indexed publications reveals that sustainability has become a central focus in higher education research. Keywords such as "sustainable development," "higher education," "sustainability," "education for sustainable development," and "SDGs" appear frequently across numerous studies, indicating a strong link between the transformation of higher education and the sustainable development agenda. Beyond these core themes, recent research increasingly addresses topics such as learning innovation, the use of digital technologies, the development of sustainability literacy, project-based learning, and the evaluation of universities' contributions to achieving the Sustainable Development Goals. This shift in research direction reflects the need for higher education institutions to adapt to evolving global challenges. Accordingly, identifying keyword trends provides valuable insights into the evolution of research foci and serves as a foundation for shaping future research agendas. (G. Chen et al., 2024; Thawani et al., 2025).

Although bibliometric studies on Education for Sustainable Development (ESD) in higher education have grown substantially, most previous research has primarily focused on descriptive aspects such as publication counts, prolific authors, and citation patterns, while providing limited insights into the evolution of research themes, global collaboration networks, and emerging research directions. Furthermore, many studies have relied on restricted datasets, either limited by time period or geographical scope, thus failing to capture the broader dynamics of ESD scholarship comprehensively. These limitations highlight the need for a more up-to-date and comprehensive bibliometric investigation based on Scopus-indexed publications to identify publication trends, key contributors, collaboration patterns, and future research opportunities in the field of ESD within higher education.

Overall, the bibliometric analysis demonstrates that research on Education and Sustainable Development (ESD) in higher education has experienced consistent growth in both publication volume and thematic diversity. This increase underscores the strategic role of universities as centers of knowledge creation and innovation in supporting the implementation of sustainable development. Various studies have contributed to strengthening sustainability competencies, developing institutional policies, and integrating SDG values into educational processes. Nevertheless, certain aspects still require greater attention, particularly research on the social dimension of sustainability, which remains less explored than the environmental and economic dimensions. Future research should therefore encourage multidisciplinary approaches, expand global collaboration, and

develop ESD implementation models tailored to local contexts. Such efforts are expected to enhance the contribution of higher education to achieving inclusive and long-term sustainable development. Unlike previous reviews that focused on specific aspects or limited datasets, this study provides an integrated mapping of publication trends, influential actors, collaboration networks, and emerging themes. Specifically, this study seeks to address the following research questions: (1) What are the publication growth trends related to ESD in higher education based on Scopus data? (2) Which authors, institutions, countries, and publication sources are most influential in this field? (3) What patterns of research collaboration have emerged? Moreover, (4) Which research themes dominate and hold potential as future directions in the study of ESD within universities?

Method

This study employs a bibliometric approach to map the development of scholarly publications on Education and Sustainable Development (ESD) within the context of higher education. The bibliometric method was chosen because it provides a comprehensive overview of publication trends, author productivity, country contributions, institutional influence, source journals, and the intellectual structure of the field. Research data were obtained from the Scopus database, recognized as one of the largest scientific repositories with extensive coverage of reputable international journals. Data collection was conducted in June 2026 using the keywords "Education for Sustainable Development" OR "ESD" AND "Higher Education" applied to the title, abstract, and keyword fields (TITLE-ABS-KEY). The publication period was limited to the last ten years, from 2015 to 2025, in order to capture the most recent developments in ESD research within higher education institutions.

The data identification stage yielded 382 documents relevant to the research topic, which were subsequently screened based on inclusion and exclusion criteria was taken at 10 July 2026. The inclusion criteria comprised documents published between 2015 and 2025, indexed in Scopus, focused on higher education, and classified as journal articles. Conversely, documents such as conference papers, book chapters, reviews, editorials, notes, and other types of publications were excluded from the analysis to ensure data consistency and quality. Following the screening process, all articles that met the criteria were further examined using metadata, including title, author, affiliation, country, publication source, citation count, and author-provided keywords.



Figure 1. Flowchart of the Bibliometric Research Procedure

Data analysis was conducted using bibliometric software, with VOSviewer employed to tabulate data, examine annual publication trends, and generate descriptive statistics. In addition, VOSviewer was used to visualize networks of author collaboration (co-authorship), country collaboration, citation analysis, and keyword co-occurrence. These analyses aimed to identify the knowledge structure, key research actors, and dominant themes emerging in studies on Education and Sustainable Development within higher education. The

resulting visualizations were then interpreted based on network centrality, cluster formation, citation impact, and thematic density to explain relationship patterns among variables and the trajectory of research development in this field.

This study employs a bibliometric procedure comprising data identification, document screening, metadata extraction, bibliometric analysis, network visualization, and interpretation of results. The analysis focuses on annual publication growth, source impact, citation performance, collaboration intensity, leading authors, institutions and countries, and thematic evolution based on keyword co-occurrence and clustering. Through these stages, the study aims to provide a comprehensive overview of the research landscape on Education and Sustainable Development in higher education, while identifying research opportunities from underexplored themes, weakly connected clusters, and emerging keywords that indicate potential future research agendas.

Results and Discussions

The bibliometric mapping results indicate that several international journals play a crucial role in disseminating knowledge on Education and Sustainable Development (ESD). Publications appearing in reputable journals serve as primary references for academics in advancing research in this field. Citation analysis reveals several influential authors and research groups who have contributed significantly to shaping the conceptual foundations and the developmental trajectory of sustainability studies in higher education. Key topics receiving considerable attention include the development of sustainability competencies, the implementation of SDGs within higher education systems, sustainable campus management, and curriculum innovations oriented toward sustainability. The high degree of interconnectedness within the citation network demonstrates that this area of study has established a strong and continuously evolving intellectual structure, underscoring ESD research's position as a vital domain within contemporary higher education literature (Hallinger & Chatpinyakoop, 2019; Prieto-Jiménez et al., 2021).

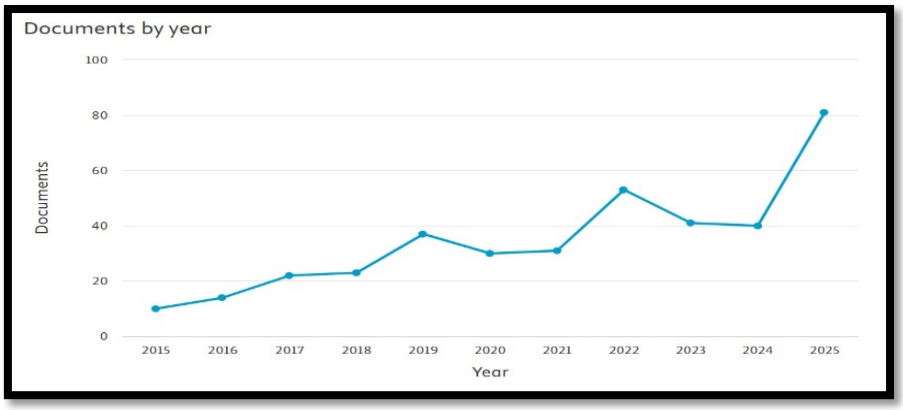


Figure 2. Trend Publication-based author

The figure shows that research publications on Education and Sustainable Development (ESD) in higher education have generally increased during 2015–2025. At the beginning of the period, the number of publications was relatively low, with 10 documents in 2015, gradually increasing to 14 in 2016 and 22 in 2017. The growth continued, reaching 37 documents in 2019. Although there was a slight decline in 2020 to 30 documents, publication output rose again in 2021 and surged in 2022, totaling 53 documents. These findings indicate the growing attention of academics worldwide to sustainability issues in higher education.

The development of publications during the 2023–2025 period demonstrates a dynamic trajectory while reaffirming the growing relevance of ESD themes in higher education research. Following a moderate decline from 53 documents in 2022 to 41 in 2023 and 40 in 2024, the number of publications rose sharply in 2025, reaching 81—the highest figure recorded during the observation period. This surge highlights the growing prominence of sustainable development issues in university research agendas, particularly amid heightened attention to implementing the Sustainable Development Goals (SDGs). Overall, this trend reflects strong growth in ESD scholarship and signals promising prospects for the future advancement of sustainability studies in higher education.

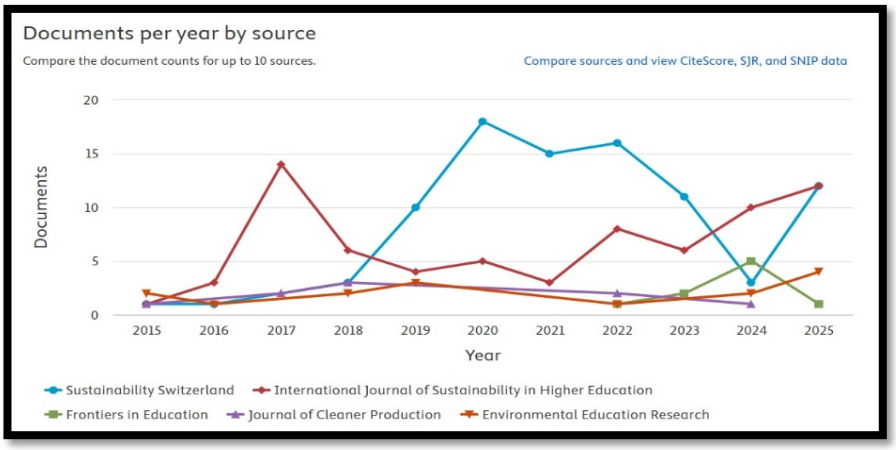


Figure 3. Publication Trends based on the source article

The figure illustrates the distribution of publications by the most productive journal sources in Education and Sustainable Development (ESD) research within higher education during 2015–2025. In terms of document count, Sustainability ranks first with 90 publications, followed by the International Journal of Sustainability in Higher Education with 72 publications. The dominance of these two journals demonstrates their role as primary outlets for the development and dissemination of sustainability-related research in universities. Annual trends show that Sustainability experienced very strong growth beginning in 2019, peaking between 2020 and 2022, before a temporary decline in 2024 and a rebound in 2025. Meanwhile, the International Journal of Sustainability in Higher Education exhibited a more stable growth pattern, consistently contributing publications throughout the observation period.

The dominance of Sustainability and the International Journal of Sustainability in Higher Education reflects not only their high publication productivity but also their substantial influence on shaping the direction of ESD research. As leading publication outlets, these journals contribute to establishing methodological standards, broadening scholarly discussions on SDG implementation, and guiding research toward sustainability competencies, curriculum transformation, and sustainable higher education policies.

Other journals, such as Environmental Education Research, Frontiers in Education, and the Journal of Cleaner Production, make relatively smaller contributions but play an important role in enriching the diversity of ESD research themes. Environmental Education Research has demonstrated a notable increase in publications in the later years of observation, while Frontiers in Education began to show growth after 2022. In contrast, the Journal of Cleaner Production has tended to maintain a stable number of publications without significant surges. Overall, this pattern indicates that ESD research is becoming increasingly concentrated in journals specifically focused on sustainability and higher education. This condition reflects the field's growing maturity and the rising demand for publication forums aligned with the global sustainable development agenda.

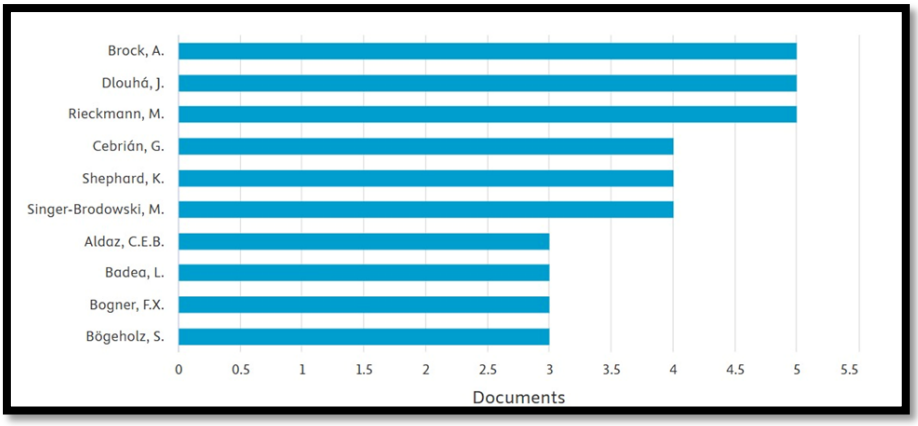


Figure 4. Publication trend based on the author.

Based on the Documents by Author graph, publication productivity in the analyzed field is dominated by several leading authors. Brock, A., Dlouhá, J., and Rieckmann, M. occupy the highest positions, each contributing five documents. They are followed by Cebrián, G., Shephard, K., and Singer-Brodowski, M., each with four documents. Meanwhile, Aldaz, C.E.B., Badea, L., Bogner, F.X., and Bögeholz, S. each produced three documents. This pattern indicates that the field's development is still largely influenced by specific research groups that consistently contribute to scholarly output. The dominance of these authors highlights their central role in shaping concepts, theories, and research practices within the domain. Brock, A. authors also lead citation and co-authorship networks worldwide.

This finding is consistent with the bibliometric principle that scientific fields often evolve around a core group of highly productive scholars who drive knowledge production and influence research directions. The concentration of publications among leading authors such as Brock, Dlouhá, and Rieckmann suggests the existence of well-established research clusters that continuously contribute to theoretical advancement and methodological innovation. Their sustained productivity not only enhances the visibility of the field but also facilitates the dissemination of key concepts through collaborative networks, international partnerships, and highly cited publications. As a result, these scholars serve as intellectual leaders whose work provides an essential foundation for subsequent studies and helps shape the future research agenda within the domain (Hiemstra & Brockett, 2012; Ragadhita et al., 2026; Scherak & Rieckmann, 2020).

The trend in author productivity also reflects the presence of a strong academic network in the development of related research themes. Authors with the highest number of publications tend to serve as key references due to their sustained contributions in enriching the literature. The relatively small differences in document counts among authors suggest that this field is evolving collaboratively rather than relying on a single dominant figure. This condition serves as a positive indicator, as it demonstrates a more balanced distribution of knowledge among researchers. With an increasing number of authors actively contributing, the prospects for emerging new perspectives, methodological innovations, and strengthening research quality in the future are expected to grow and remain sustainable.

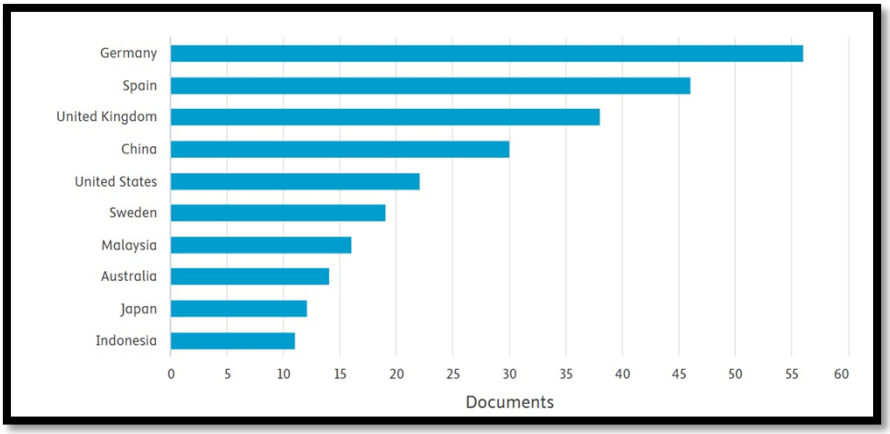


Figure 5. Trend based on country

Based on the Documents by Country or Territory graph, research publication contributions are predominantly dominated by European countries. Germany ranks highest with 56 documents, followed by Spain with 46 and the United Kingdom with 38. The dominance of these three countries highlights Europe's strong commitment to advancing research in this field. In addition, China ranks fourth with 30 documents, reflecting the growing role of Asian nations in scholarly output. The United States also makes a significant contribution with 22 documents, while Sweden, Malaysia, Australia, Japan, and Indonesia complete the list of countries actively contributing to international publications in this area. This distribution indicates that research productivity remains concentrated in developed countries with stronger funding systems, research infrastructure, and international collaboration networks, whereas many developing countries continue to face limitations in research capacity and publication access, thereby widening global research disparities.

The trend indicates that the centers of research development remain concentrated in countries with strong research capacity, funding, and international collaboration networks. The high number of publications from Germany, Spain, and the United Kingdom reflects their success in building research ecosystems that support academic productivity. Meanwhile, the presence of China, Malaysia, Japan, and Indonesia demonstrates that Asia is becoming increasingly active in expanding its contribution to the global literature. Although Indonesia's publication output is still relatively low compared to other countries, its participation signals positive potential

for future growth. Strengthening international collaboration, enhancing research policy support, and building academic capacity are expected to further increase the contributions of developing countries in the years ahead.

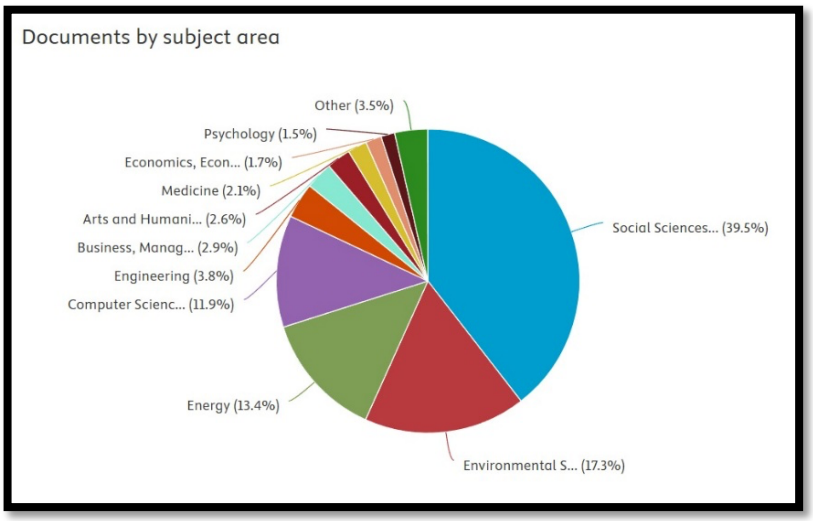


Figure 6. Trends by Subject

Based on the Documents by Subject Area graph, the field of Social Sciences dominates research publications with 325 documents, accounting for approximately 39.5% of the total output. This dominance highlights the strong connection of the studied themes with social issues, education, community behavior, and sustainable development. Environmental Science ranks second with 142 documents (17.3%), followed by Energy with 110 documents (13.4%) and Computer Science with 98 documents (11.9%). Meanwhile, other fields such as Engineering, Business, Arts and Humanities, Medicine, and Economics contribute smaller shares but demonstrate the multidisciplinary engagement that enriches both the academic and practical development of this area of study. The predominance of Social Sciences further underscores its pivotal role in advancing Education for Sustainable Development (ESD) concepts by integrating educational, behavioral, cultural, and policy dimensions that foster sustainability awareness and transformative social change, exceeding the contributions of other disciplines that tend to focus on more specific technical or sectoral aspects.

This trend indicates that research is evolving across disciplines with a primary focus on social and environmental aspects. The strong contributions from Social Sciences and Environmental Science highlight that sustainability issues, education, and changes in societal behavior are the main concerns of researchers. Meanwhile, the involvement of fields such as Energy and Computer Science reflects the growing need for technological innovation and data-driven solutions to support sustainable development. The diversity of disciplines engaged demonstrates the complexity of the issues under study and the necessity of multidisciplinary approaches. This condition is a positive indicator, as it broadens research perspectives, enriches analytical methods, and fosters more innovative and sustainable academic collaborations in the future.

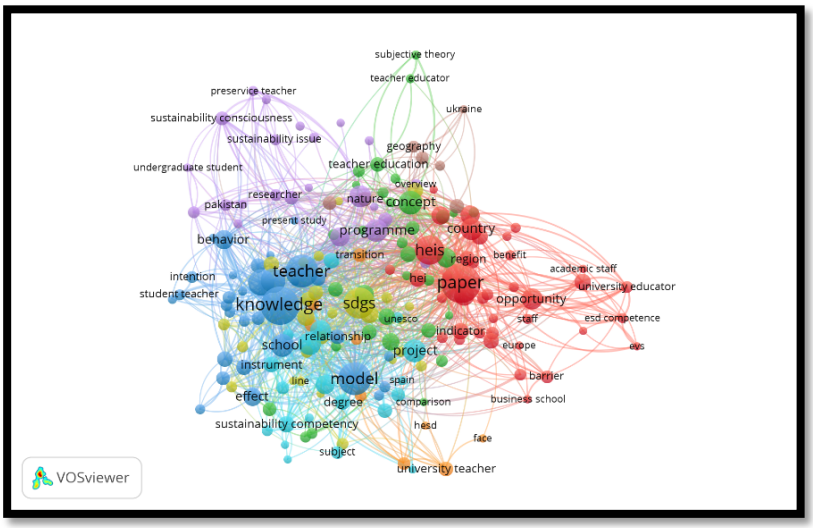


Figure 7. Trend on Network Visualization

Based on the keyword network visualization generated in VOSviewer, the research is dominated by several highly interconnected themes: teacher, knowledge, model, paper, SDGs, program, and HEIs (Higher Education Institutions). Larger node sizes indicate a higher frequency of occurrence in publications, while numerous connecting lines reflect strong relationships among topics. The blue cluster centers on the concepts of teacher, knowledge, and model, highlighting a focus on competence development, knowledge building, and educators' role in implementing Education for Sustainable Development (ESD). Meanwhile, the green and red clusters emphasize the interlinkages among SDGs, educational programs, higher education institutions, and opportunities for implementing sustainability within a broader academic context.

The keyword network visualization reveals that research on Education for Sustainable Development (ESD) is strongly concentrated around interconnected themes such as teachers, knowledge, learning models, SDGs, programs, and higher education institutions (HEIs). This finding suggests that educators play a pivotal role in developing sustainability competencies and translating knowledge into transformative actions. Furthermore, HEIs are increasingly recognized as key agents in advancing the SDGs through teaching, research, community engagement, and institutional governance. These relationships highlight the growing importance of integrating sustainability principles into educational practices and policies to foster long-term societal transformation (Elihami & Pajarianto, 2025; Filho et al., 2025; Llanos-Ruiz et al., 2025; Serafini et al., 2022)

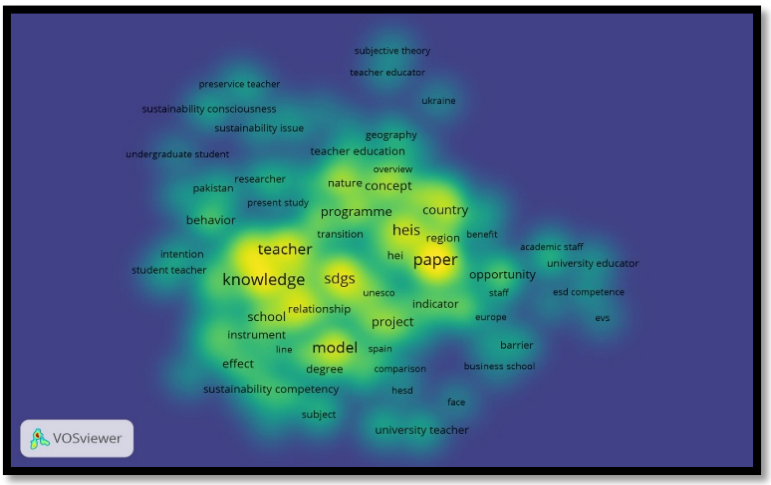


Figure 8. highlighting dominant themes

In addition to highlighting dominant themes, the keyword network map reveals the multidisciplinary character of ESD research, connecting aspects of education, sustainability, policy, and competence development. The presence of keywords such as sustainability consciousness, teacher education, university educator, ESD competence, behavior, and sustainability competency indicates that the research is not only focused on knowledge transfer but also on shaping attitudes, behaviors, and sustainability competencies (Cebrián et al., 2020; Cyfert et al., 2025; Esteban Ibáñez et al., 2026; Hanisch & Eirdosh, 2023; Novita et al., 2025). The close interconnections among clusters demonstrate strong conceptual collaboration across different areas of study. These findings suggest that future research directions will increasingly emphasize the integration of SDGs into higher education, the strengthening of educator capacity, and the development of learning models capable of supporting transformation toward a sustainable society.

The findings of this study are consistent with previous bibliometric investigations that reported a substantial increase in publications related to Education for Sustainable Development (ESD) and higher education sustainability research. Research on Higher Education for Sustainable Development (HESD) has experienced significant growth and has become an increasingly important interdisciplinary field (Gorski et al., 2023; Husamah et al., 2022; Kusumaningrum et al., 2023; Ragadhita et al., 2026; Rodríguez-Zurita et al., 2025; Trevisan et al., 2024). Similarly, Tafese and Kopp (2025) found that ESD publications increased sharply after 2018, driven by the growing influence of the Sustainable Development Goals (SDGs) on higher education research agendas. However, compared with these previous studies, the present findings indicate a continued acceleration in publication output through 2025, suggesting that ESD has evolved beyond an emerging research topic into a well-established field of inquiry. Furthermore, while earlier studies frequently emphasized environmental sustainability issues, recent publications increasingly integrate social, educational, and competency-development perspectives, reflecting a more holistic approach to sustainability in higher education (Barnett-Itzhaki et al., 2025; Costa & Cipolla, 2025; Kolenc Kolnik, 2007; Xiao et al., 2025)

The analysis of publication sources shows that Sustainability and the International Journal of Sustainability in Higher Education are the most dominant journals publishing research related to ESD. The high number of articles published in these journals indicates that ESD has developed into a research area with strong publication platforms and a continuously expanding academic community. This finding is consistent with Prieto-Jiménez et al. (2021), who emphasized that sustainability-focused journals serve as central hubs for knowledge dissemination in sustainable education studies. The dominance of these two journals also demonstrates that sustainability issues have become an integral part of the global higher education agenda, encompassing policy, curriculum development, and institutional practices. Accordingly, the presence of such specialized journals has substantially accelerated the growth and dissemination of ESD research across countries. (Prieto-Jiménez et al., 2021).

In terms of author productivity, Brock, Dlouhá, and Rieckmann are recorded as the most prolific researchers in this field. Nevertheless, the differences in publication counts among authors are relatively small, indicating that the development of ESD research is not concentrated on a single individual. Instead, the field has advanced through the collaborative involvement of numerous scholars from diverse disciplines. This characteristic reflects the inherently multidisciplinary nature of ESD, which integrates perspectives from education, environmental studies, public policy, and sustainability competence development. As Rieckmann (2018) emphasized, addressing sustainability challenges requires approaches that engage multiple disciplines and stakeholders. Therefore, the relatively balanced distribution of productivity can be regarded as a positive indicator, as it creates opportunities for theoretical and methodological innovations that advance this research domain. (UNESCO, 2018).

The country-level analysis reveals that Germany, Spain, and the United Kingdom are the leading contributors to ESD research publications. The high productivity of these countries can be attributed to strong national policy support for sustainable education development and the substantial research capacity of their higher education institutions. Beyond Europe, China also demonstrates a significant contribution, reflecting its growing attention to sustainability issues and investment in research. Meanwhile, developing countries such as Indonesia and Malaysia are beginning to show increased participation in international publications. These findings suggest that ESD research is no longer dominated solely by developed nations but is expanding more broadly across regions worldwide. This supports the argument of Lozano et al. (2015), who emphasized that research productivity in sustainability is strongly influenced by policy support, research funding, and the intensity of international collaboration within a country. (Lozano et al., 2015).

Nevertheless, the dominance of several developed countries in ESD research production may also contribute to an imbalance in the global development of knowledge. Research agendas, theoretical perspectives, and policy recommendations are often shaped by the socio-economic contexts of these leading nations, which may not fully reflect the educational realities and sustainability challenges faced by developing countries. Consequently, limited representation from the Global South could hinder the diversification of ESD approaches and reduce opportunities for locally relevant innovations, emphasizing the need for more inclusive international collaboration and equitable research capacity development across regions.

Further analysis of subject areas and keyword mapping reveals the dominance of Social Sciences and Environmental Science as the fields contributing most to ESD research. This dominance indicates that sustainability issues are primarily examined through perspectives of education, behavioral change, environmental awareness, and social transformation. In addition, the keyword network visualization shows strong interconnections among terms such as teacher, knowledge, SDGs, HEIs, teacher education, and sustainability competency. These linkages suggest that current research focuses not only on the transmission of sustainability knowledge but also on the development of competencies, attitudes, and behaviors that support the achievement of sustainable development goals. This finding aligns with Kolnic's sustainability competence framework, which emphasizes the importance of systems thinking, critical reflection, collaboration, and responsible decision-making in sustainability education. (Kolenc Kolnik, 2007). Therefore, future research is expected to increasingly emphasize the integration of the SDGs into curricula, the enhancement of educator capacity, and the development of innovative learning models capable of driving sustainability transformation within higher education.

Furthermore, the keyword mapping suggests several emerging research directions that warrant greater scholarly attention. Although terms such as teacher, knowledge, HEIs, and sustainability competency occupy central positions within the network, topics related to digital transformation, artificial intelligence for sustainability education, interdisciplinary curriculum design, assessment of sustainability competencies, and the long-term impact of ESD implementation remain comparatively underexplored. The relatively lower occurrence of these themes indicates potential research gaps that could enrich the field. Future studies should therefore focus on evaluating the effectiveness of innovative pedagogical approaches, integrating emerging technologies into

ESD practices, and examining how sustainability competencies translate into behavioral change and societal impact across diverse educational and cultural contexts. Such research would contribute to strengthening the practical relevance and global applicability of ESD within higher education.

Conclusions

The bibliometric analysis reveals that research on Education for Sustainable Development (ESD) in higher education experienced significant growth between 2015 and 2025, reflecting the increasing global recognition of universities' roles in achieving the Sustainable Development Goals (SDGs). The findings indicate that Sustainability and the International Journal of Sustainability in Higher Education serve as the leading publication outlets, while the distribution of productive authors suggests a collaborative and multidisciplinary research structure rather than domination by a small group of scholars. At the country level, Germany, Spain, and the United Kingdom emerge as the most influential contributors, although the increasing participation of China, Indonesia, and Malaysia demonstrates the gradual expansion of ESD research beyond traditionally dominant regions. Nevertheless, disparities in research productivity remain evident, highlighting the need for more equitable global research collaboration and capacity development. Furthermore, the dominance of Social Sciences and Environmental Science confirms that ESD is primarily discussed through educational, environmental, and social transformation perspectives. Keyword mapping reveals strong connections among concepts such as sustainability competencies, teacher education, knowledge, SDGs, and higher education institutions, indicating a shift from knowledge transmission toward competency-based and transformative approaches. Future studies should focus on underexplored areas, including artificial intelligence in ESD, digital learning innovation, sustainability competency assessment, interdisciplinary curriculum development, and comparative studies involving developing countries to strengthen the global relevance and inclusiveness of ESD research.

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