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Exploring Green Universities: A Bibliometric Study of Sustainability Research in Higher Education Institutions

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Abstract
This study presents a bibliometric analysis of sustainability research in higher education institutions (HEIs), focusing on key trends, research gaps, and emerging themes. The analysis highlights the growing scholarly attention toward environmental sustainability, green universities, and management control systems (MCS). Over the past decade, sustainability research in HEIs has experienced a consistent upward trend. The findings indicate that dominant contributors to sustainability research include the United States, the United Kingdom, and China, with leading universities and high-impact journals playing a pivotal role in knowledge dissemination. The study identifies core research themes, including sustainability governance, environmental education, and institutional sustainability policies. However, several underexplored areas remain, such as the role of digital technologies (AI, IoT, blockchain) in campus sustainability, financial mechanisms for sustainable initiatives, and the integration of MCS in sustainability frameworks. Additionally, future studies should examine the impact of sustainability policies on student well-being and explore how universities engage with external stakeholders to drive broader sustainability initiatives. Despite limitations, including language restrictions and reliance on the Scopus database, this study provides a structured overview of HEI sustainability research and offers insights for future investigations to enhance institutional sustainability efforts.

Keywords: Bibliometric, Environmental, Green Universities, Higher Education Institutions, Sustainability

1. Introduction

1.1 Introduce the Problem

In recent years, the role of universities in advancing environmental sustainability has gained significant attention in both academic and policy discussions (Sawalkar et al., 2023; Song, 2023). As centers of knowledge production, higher education institutions (HEIs) hold a unique position in shaping environmental consciousness, driving sustainable innovations, and influencing public policy (Madhuranthakam et al., 2023; Sarwar et al., 2023). The increasing recognition of universities as key agents in sustainability transitions has given rise to the concept of "green universities"—institutions that integrate sustainability principles into their teaching, research, campus operations, and community engagement (McCollum & Nicholson, 2023; Nikula et al., 2023). Green universities

aim to reduce their environmental footprint through sustainable infrastructure, renewable energy use, waste reduction programs, and sustainable procurement policies (Kusmulyono et al., 2023). Beyond operational sustainability, these institutions play a crucial role in educating future leaders, policymakers, and professionals who will be responsible for implementing sustainable practices in various sectors (Malone & Young, 2023; Molnar et al., 2023). Given this expanding role, there is a pressing need to systematically examine how universities contribute to environmental sustainability and what mechanisms facilitate or hinder their progress in becoming green institutions.

In response to these challenges, scholars have increasingly turned their attention to studying the sustainability initiatives undertaken by HEIs. Over the past decade, research has explored multiple dimensions of sustainability in universities, including curriculum development, student engagement, faculty research, institutional policies, and governance structures (Asgarova et al., 2023; Bincy & Vasudevan, 2023). A growing body of literature has investigated the impact of sustainability education on student attitudes and behaviors, highlighting the importance of integrating environmental awareness into university curricula. Moreover, empirical studies have examined how HEIs adopt sustainability policies and reporting frameworks, such as the Global Reporting Initiative (GRI) and the Sustainability Tracking, Assessment & Rating System (STARS), to enhance transparency and accountability in their environmental initiatives (Proctor & Rumbley, 2023; Roy, 2023). Despite this progress, gaps remain in understanding the systemic challenges that universities face in implementing sustainability strategies, as well as the role of internal governance and control mechanisms in ensuring long-term sustainability commitment.

One emerging area of interest in this field is the application of Management Control Systems (MCS) to support sustainability initiatives in universities. Traditionally, MCS have been used in corporate settings to monitor financial performance, set strategic goals, and enhance organizational efficiency (Roos & Guenther, 2020). However, in the context of universities, MCS can serve as a framework for integrating sustainability into decision-making processes by establishing performance measurement indicators, incentivizing sustainable behavior, and aligning institutional objectives with broader environmental goals. Universities that incorporate sustainability-oriented MCS can better track their progress in reducing carbon emissions, optimizing resource use, and promoting green research initiatives (Shboul et al., 2023). Moreover, by embedding sustainability metrics into management controls, universities can foster a culture of accountability, encouraging faculty and staff to actively participate in environmental initiatives. Nevertheless, limited research has explored the intersection between MCS and sustainability in higher education, indicating a gap that warrants further investigation.

Given the increasing academic interest in sustainability within HEIs, a bibliometric analysis of this research domain is both timely and necessary. Bibliometric analysis allows for a systematic examination of publication trends, key themes, influential authors, and institutional contributions in a specific research area (Di Vaio et al., 2021). By utilizing data from Scopus, this study aims to map the intellectual landscape of sustainability research in universities, with a particular focus on environmental sustainability, green universities, higher education, and management control systems. This analysis will help identify the dominant research themes, assess the evolution of sustainability discourse in academia, and highlight emerging areas that require further exploration. Additionally, by examining the geographical distribution of research outputs, this study seeks to determine which regions and institutions are leading the discourse on university sustainability and how their contributions shape global discussions on the topic.

Despite the growing body of literature, several research gaps remain. Many studies have focused on sustainability reporting and environmental policies in universities, but fewer have examined how MCS can facilitate or hinder sustainability transitions in HEIs (Ajaps, 2023; Asgarova et al., 2023). Additionally, while the impact of sustainability education on students has been widely documented, there is still limited understanding of how internal governance structures, faculty incentives, and institutional leadership influence sustainability outcomes. This study seeks to bridge these gaps by conducting a comprehensive bibliometric review, providing insights into how sustainability is managed, measured, and controlled within universities. By addressing these gaps, this research will contribute to a deeper understanding of the mechanisms that enable universities to function as drivers of sustainability and offer practical recommendations for enhancing their environmental impact.

To achieve these objectives, this study is guided by several key research questions:
RQ1. What are the main themes and trends in research on environmental sustainability in universities?
RQ2. Which countries and institutions are leading the field in sustainability research?
RQ3. How has the discourse on green universities evolved over the past decade?
RQ4. What are the opportunities for future research in this area?

Through this analysis, we aim to provide a structured overview of existing literature, identify gaps in research, and propose directions for future studies to enhance the role of universities in achieving global sustainability goals.

1.2 Literature Review

1.2.1 Environmental Sustainability

Environmental sustainability refers to the responsible management of natural resources to ensure their availability for future generations while minimizing ecological degradation (Song, 2023). This concept has gained significant importance due to global challenges such as climate change, pollution, and biodiversity loss. Sustainability efforts aim to balance economic growth, social well-being, and environmental protection by promoting efficient resource utilization, reducing carbon emissions, and fostering sustainable consumption patterns (Fakourian & Asefi, 2019; Moqbel et al., 2020).

The role of higher education institutions (HEIs) in advancing environmental sustainability has been widely discussed in recent literature. Universities serve as key drivers of sustainability through research, education, and community engagement (Kukkonen et al., 2021). They are responsible for developing future leaders, policymakers, and professionals who can implement sustainability practices across various industries. Additionally, HEIs have the potential to lead by example by adopting green campus initiatives, implementing waste reduction programs, and promoting renewable energy usage (Lam, 2022).

However, despite the growing emphasis on environmental sustainability, many institutions struggle with its practical implementation. Financial constraints, lack of policy support, and resistance to change are among the common barriers (Sawalkar et al., 2023). Effective management control systems (MCS) can help universities overcome these challenges by integrating sustainability goals into institutional strategies and decision-making processes. Furthermore, sustainability reporting frameworks such as the Global Reporting Initiative (GRI) and the Sustainability Tracking, Assessment & Rating System (STARS) have been introduced to measure and enhance environmental performance in higher education (Moqbel et al., 2020).

1.2.2 Green University

The concept of a green university has emerged as a response to the need for sustainable development within higher education institutions. A green university integrates environmental sustainability into its core functions, including teaching, research, campus operations, and stakeholder engagement (Kukkonen et al., 2021). This concept aligns with the United Nations Sustainable Development Goals (SDGs), particularly Goal 4 (Quality Education) and Goal 13 (Climate Action), which emphasize the role of education in addressing environmental challenges (Fakourian & Asefi, 2019).

Green universities adopt various strategies to reduce their environmental footprint. These include energy-efficient buildings, waste management systems, water conservation programs, and sustainable transportation initiatives. Some universities have also incorporated sustainability-focused courses and interdisciplinary research programs to educate students about environmental issues (Moqbel et al., 2020). Furthermore, many institutions participate in international sustainability rankings such as the UI Green Metric World University Ranking, which evaluates universities based on their environmental sustainability performance.

Despite these efforts, the transition to a green university model presents several challenges. Institutional resistance, financial limitations, and a lack of standardized sustainability policies often hinder progress. Additionally, while

some universities excel in specific areas of sustainability (e.g., renewable energy use or waste management), others struggle with comprehensive implementation across all institutional levels (Lam, 2022). Effective leadership, stakeholder collaboration, and robust sustainability management frameworks are essential for overcoming these barriers and ensuring the successful transition to a green university model.

1.2.3 Higher Education

Higher education institutions (HEIs) play a critical role in shaping sustainable societies by fostering research, innovation, and awareness of environmental issues. Universities act as knowledge hubs that not only educate students but also influence industry practices and government policies through academic research and public engagement. Many HEIs have started incorporating Education for Sustainable Development (ESD) into their curricula, enabling students to develop the skills and knowledge required to address global sustainability challenges (Popowska & Sady, 2024).

In addition to their educational responsibilities, universities also contribute to sustainability through their campus operations. Implementing eco-friendly policies such as carbon neutrality goals, sustainable procurement, and biodiversity conservation are key aspects of HEIs' sustainability commitments (Sutawaidjaya et al., 2024). Some universities have established sustainability offices to oversee environmental initiatives, track progress, and ensure compliance with sustainability standards (Ficco et al., 2023).

The impact of HEIs on sustainability is not limited to their campuses. Many institutions engage in community outreach programs to promote sustainability beyond academia. Collaborations with local governments, businesses, and non-profit organizations help HEIs extend their influence and contribute to broader sustainability goals (Heinicke & Guenther, 2020). However, while HEIs are well-positioned to lead sustainability efforts, the extent of their impact depends on institutional priorities, governance structures, and resource availability (Baret et al., 2023).

1.2.4 Challenges and Opportunities in Implementing Sustainability in Higher Education Institutions

Despite growing awareness of sustainability in higher education, institutions face numerous challenges in implementing sustainability initiatives effectively. One of the primary obstacles is financial constraints. Many universities, particularly those in developing countries, lack the necessary funding to invest in sustainability infrastructure, such as solar panels, energy-efficient buildings, and water recycling systems (Roos & Guenther, 2020). Budget limitations often force institutions to prioritize short-term operational needs over long-term sustainability projects.

Another major challenge is the lack of policy enforcement and standardization. While many universities have sustainability policies, their implementation varies widely. Some institutions have comprehensive strategies with clear performance indicators, while others adopt fragmented approaches that lack accountability (Khandakar et al., 2022). Additionally, there is no universal framework for assessing sustainability performance in higher education, making it difficult to compare progress across institutions (Ficco et al., 2023).

Cultural resistance and lack of stakeholder engagement also hinder sustainability efforts. Faculty members, administrators, and students may resist changes that require altering traditional academic structures and daily routines (Alexa et al., 2020). Overcoming this resistance requires effective communication, incentives for sustainable behavior, and active participation from all stakeholders (Heinicke & Guenther, 2020).

Despite these challenges, there are significant opportunities for advancing sustainability in higher education. The rise of digital technology and data analytics offers new possibilities for monitoring and optimizing sustainability performance. Smart campus solutions, such as IoT-based energy management systems, can help universities reduce waste and improve efficiency (Popowska & Sady, 2024). Additionally, sustainability research funding and corporate partnerships provide financial support and expertise for HEIs to expand their sustainability initiatives (Baret et al., 2023).

Another promising development is the increasing focus on interdisciplinary research and collaboration. Sustainability is a complex issue that requires expertise from multiple fields, including environmental science, economics, engineering, and social sciences. Many universities are establishing sustainability research centers that bring together experts from different disciplines to address sustainability challenges holistically (Basheer et al., 2024).

Moreover, growing student activism and demand for sustainability-focused education are pushing universities to adopt greener policies. Students are increasingly advocating for climate action, demanding divestment from fossil fuels, and participating in sustainability initiatives on campus (Sutawaidjaya et al., 2024). This shift in student expectations encourages universities to prioritize sustainability in their strategic planning and operational management.

In conclusion, while the path to achieving sustainability in higher education is fraught with challenges, there are numerous opportunities for progress. By leveraging technology, fostering interdisciplinary collaboration, engaging stakeholders, and securing financial support, universities can become key drivers of sustainability at both local and global levels. Future research should focus on identifying best practices, developing standardized sustainability assessment frameworks, and exploring innovative strategies to enhance the effectiveness of sustainability initiatives in HEIs.

2. Method

This study employs a bibliometric method using the PRISMA Protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to ensure a systematic and transparent data screening process. The research data were obtained from the Scopus database using VOSviewer and R-Studio for bibliometric analysis. The first stage involved identification, where a search was conducted using the keywords "universities," "higher education," "green university," and "environmental sustainability." This search yielded 1,608 relevant articles. The collected data were limited to studies published between 2012 and 2024, with a focus on articles written in English and published in reputable journals.

Next, during the screening stage, additional selection criteria were applied to align with the research objectives. The study focuses on the fields of business, management, and accounting; economics and finance; social sciences; and environmental science. Furthermore, only journal articles were included in the analysis. At this stage, 1,130 articles were excluded for not meeting the established criteria, leaving 478 articles eligible for further analysis.

In the final stage, inclusion, further validation was conducted based on the relevance of keywords, titles, abstracts, and article content, along with an error-checking process. The analysis was carried out to identify research patterns and thematic trends in the literature on environmental sustainability in higher education. VOSviewer was used to visualize keyword networks and researcher collaborations, while R-Studio was utilized for statistical analysis in the bibliometric study (Van Eck & Waltman, 2022). The PRISMA Protocol ensures that the research results are structured and reproducible, adhering to the standards of scientific research based on secondary data (Page et al., 2021). The final search query used was as follows:
(TITLE-ABS-KEY ("universities") OR TITLE-ABS-KEY ("higher education") OR TITLE-ABS-KEY ("green university") AND TITLE-ABS-KEY ("Environmental sustainability")) AND PUBYEAR > 2012 AND PUBYEAR < 2024 AND (LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "ECON") OR LIMIT-TO (SUBJAREA, "ENVI")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (SRCTYPE, "j"))

Table 1: PRISMA Protocol

Stage	Description	Result
Identification	Keywords searched: "universities" or "higher education" or "green university" and "Environmental sustainability"	1.608 articles
Screening	Screening criteria: 1. Year: 2012-2024	Screened and excluded (N = 1.130)

	2. Subject Area: (1) Business, Management, and Accounting; (2) Economics, Econometrics, and Finance; (3) Social Sciences; (4) Environmental Science 3. Language: English 4. Document type: article 5. Source type: journal	1. Year: 600 2. Subject Area: 261 3. Language: 28 4. Document type: 236 5. Source type: 5
Eligibility inclusion	Justification-based keywords used, title, abstract, & error checking Validation process and bibliometric analysis	478 articles were eligible

Source: secondary data (processed, 2025)

3. Results and Discussion

3.1 Document general characteristics

Based on the general characteristics of the documents analyzed, as presented in Table 2, the data cover a timespan from 2013 to 2023, with a total of 478 documents derived from 264 sources, including journals, books, and other publications. The annual growth rate of publications is 12.13%, indicating a consistent increase in research output in this field. The average age of the documents is 5.54 years, suggesting a relatively recent and dynamic body of literature.

The dataset includes 1,620 authors, with 63 documents authored by single authors and 65 single-authored documents in total. The average number of co-authors per document is 3.54, reflecting a collaborative research environment with an international co-authorship rate of 24.69%. Additionally, the documents contain 1,784 keywords plus and 1,695 author's keywords, demonstrating a rich and diverse thematic scope. The 478 documents analyzed are all categorized as journal articles, providing a consistent and focused source of academic insights.

Table 2: Document general characteristics

Description	Results
Main information about data	
Timespan	2013:2023
Sources (Journals, Books, etc)	264
Documents	478
Annual growth rate %	12.13
Document average age	5.54
Average citations per doc	20.83
References	24526
Document contents	
Keywords plus (id)	1784
Author's keywords (de)	1695
Authors	
Authors	1620
Authors of single-authored docs	63
Authors collaboration	
Single-authored docs	65
Co-Authors per Doc	3.54
International co-authorships %	24.69
Document types	
Article	478

Source: secondary data (processed, 2025)

3.2 Evolution in The Number of Publications

Figure 1 illustrates the evolution in the number of articles produced in this field over time. A significant upward trend has been evident in recent years, reflecting the growing attention from both academics and practitioners toward this topic. Several factors contribute to this growth, including the increasing complexity of the business

environment, stricter regulatory requirements, and the development of advanced research methodologies that enable more in-depth and comprehensive analyses.

The rising number of publications can also be attributed to the proliferation of reputable journals that publish research in this domain, coupled with easier access to data through digital technologies. According to Zhang et al. (2022), the literature in economics and finance has experienced accelerated growth since 2015, driven by the increasing demand for data-driven research and the complexities introduced by globalization. This trend underscores the dynamic nature of the field and highlights the necessity for continuous academic engagement to address emerging challenges.

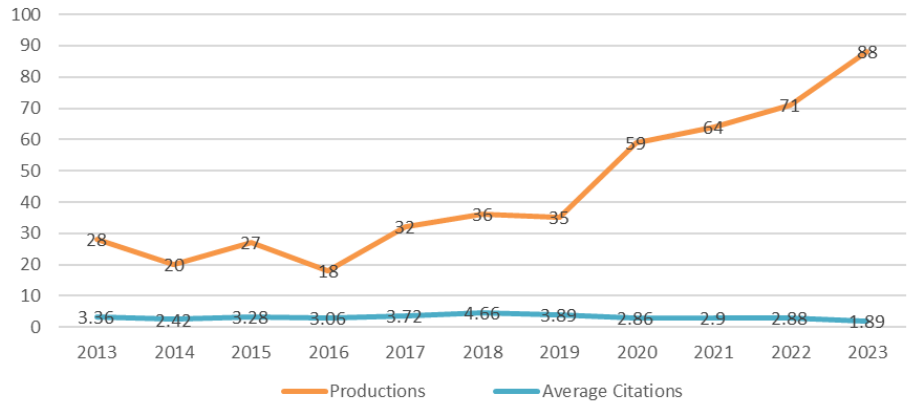

Figure 1: Evolution In the Number of Articles Production and Average Citations

Source: secondary data (processed, 2025)

However, despite the notable increase in the number of publications, Figure 2 reveals a fluctuating pattern in the average number of citations per article. While more papers are being published, not all receive high citation counts. This discrepancy may be attributed to various factors, including the relevance of the research to industry trends, the robustness of the methodological approaches employed, and the extent to which subsequent research cites the articles. Li et al. (2021) found that studies incorporating innovative, data-driven approaches tend to receive more citations compared to descriptive research that reiterates established concepts.

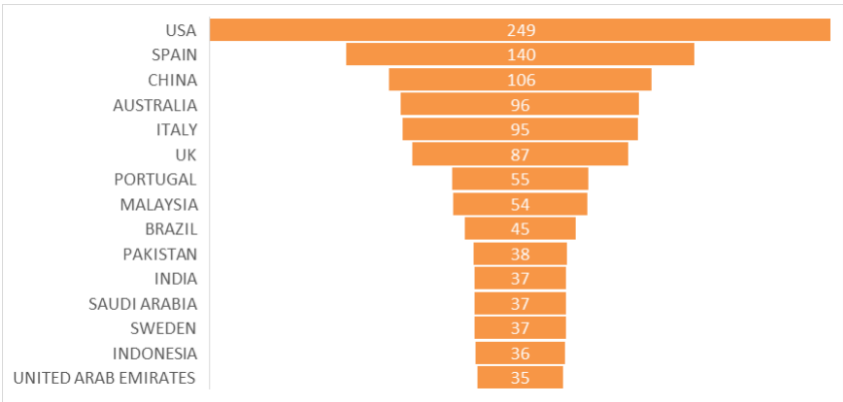

Figure 2: Top 15 Contributing Countries

Source: secondary data (processed, 2025)

This phenomenon implies that the growth in publication quantity should be accompanied by an emphasis on research quality. Ensuring methodological rigor, pursuing novel research questions, and adopting advanced analytical techniques are crucial for enhancing the impact of academic work. By prioritizing quality alongside quantity, researchers can contribute meaningfully to the development of knowledge in this field and ensure the sustained relevance and influence of their work in the broader academic community.

Moreover, the data presented in Figure 2 highlight the significant contributions from various countries to the body of research. The United States leads with the highest number of publications, followed by Spain, China, and Australia. This distribution reflects the global nature of the research landscape and underscores the importance of international collaboration. Cross-border research partnerships can facilitate the exchange of ideas, methodologies, and data, ultimately enriching the literature and promoting more holistic insights into the field's evolving dynamics. In conclusion, the upward trend in publications and the fluctuating citation patterns underscore the dynamic interplay between quantity and quality in academic research. As the field continues to evolve, researchers must remain vigilant in maintaining methodological rigor, engaging with industry trends, and fostering international collaborations to maximize the impact and relevance of their contributions.

3.3 Distribution Across Global Regions

The distribution of publications based on geographical regions, as shown in Figure 3, indicates that countries with strong research ecosystems, such as the United States, the United Kingdom, and China, continue to dominate the publication landscape in this field. This dominance is primarily driven by significant investments in research and development, which provide these countries with access to high-quality data, advanced research infrastructure, and extensive global collaboration networks. Beyond funding, the presence of prestigious academic institutions and well-established publication practices further bolster their contributions. In contrast, developing countries still face significant challenges in increasing their research contributions in this domain, primarily due to limited access to research funding, technological infrastructure, and academic resources. Additionally, these countries often encounter difficulties in forming international collaborations, which are crucial for enhancing research visibility and impact on a global scale.

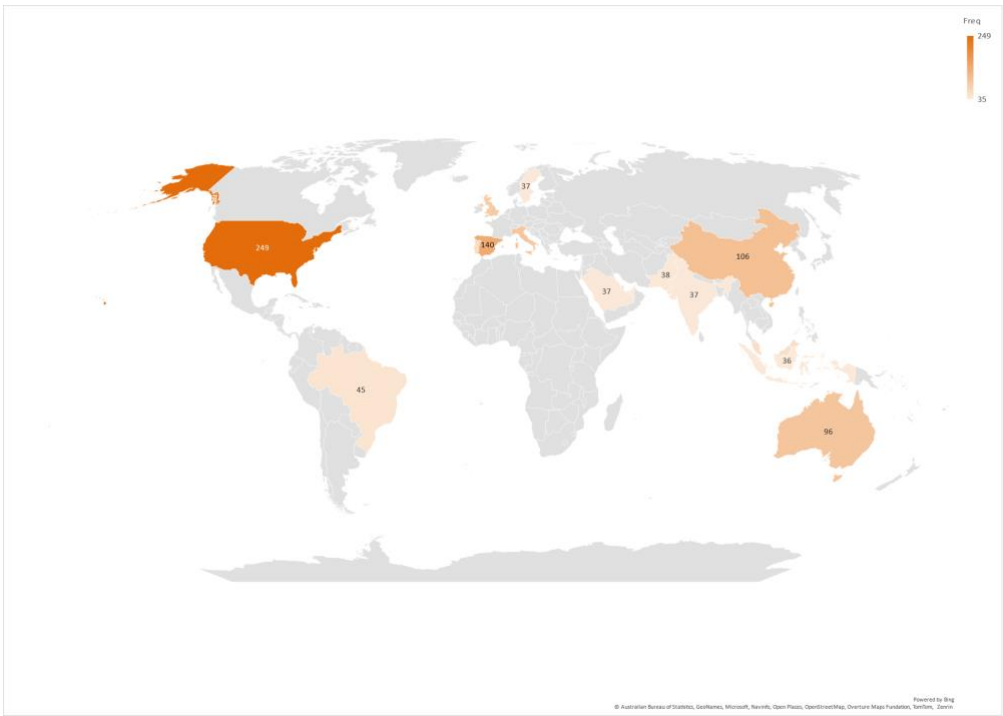

Figure 3: Global Distribution of Publication Density
Source: secondary data (processed, 2025)

Furthermore, Figure 4, which presents the top 10 most-cited countries, demonstrates that countries with high publication volumes do not always correspond to those with the highest academic impact. The United States and the United Kingdom remain the most highly cited countries, indicating that research from these nations is more frequently referenced in subsequent academic work. However, the emergence of new countries in this list signals a potential shift in the centers of academic excellence. This development suggests that academic influence is becoming more geographically diverse, potentially driven by increased global access to advanced research tools and collaborative platforms.

These findings imply the necessity of fostering increased academic collaboration between developed and developing countries to ensure that research in this field becomes more inclusive and provides a broader range of insights. Strengthening academic capacity in developing nations through targeted investments, training programs, and collaborative projects can serve as a strategic approach to enhancing their global research contributions. Such efforts will not only diversify the perspectives within the literature but also promote a more equitable and comprehensive understanding of the field's evolving dynamics. Furthermore, encouraging knowledge transfer and shared research initiatives can help bridge the gap between regions and cultivate a more interconnected academic community worldwide.

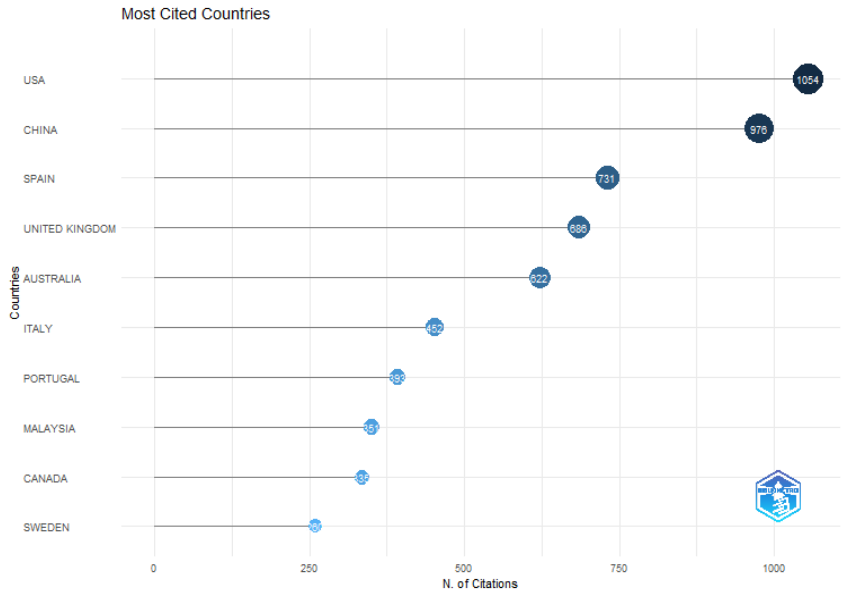

Figure 4: Top 10 Most Cited Countries

Source: secondary data (processed, 2025)

3.4 Journal Analysis

Figure 5 illustrates that publications in this field are predominantly concentrated in several key journals with high-impact factors. The presence of these journals signifies a consistent and reliable platform for researchers to share findings, exchange ideas, and advance the development of knowledge within the discipline. Notably, the journal Sustainability (Switzerland) leads with 73 publications, followed by the International Journal of Sustainability in Higher Education with 39 publications and the Journal of Cleaner Production with 25 publications. This pattern reflects the substantial role of these journals in disseminating research findings and shaping the academic discourse in this field. The dominance of these journals indicates a growing interest in sustainability-related topics, particularly those associated with environmental education, corporate social responsibility, and sustainable development practices.

The prominence of these journals can be attributed to their broad thematic coverage, rigorous peer-review processes, and open-access policies that facilitate greater visibility and accessibility of research findings. According to previous studies, journals with high production volumes often become focal points for academic collaboration and serve as benchmarks for emerging research areas. In addition, the presence of journals like the International Journal of Environmental Research and Public Health and Environmental Science and Pollution Research highlights the interdisciplinary nature of this field, where environmental, social, and economic dimensions intersect to address global sustainability challenges.

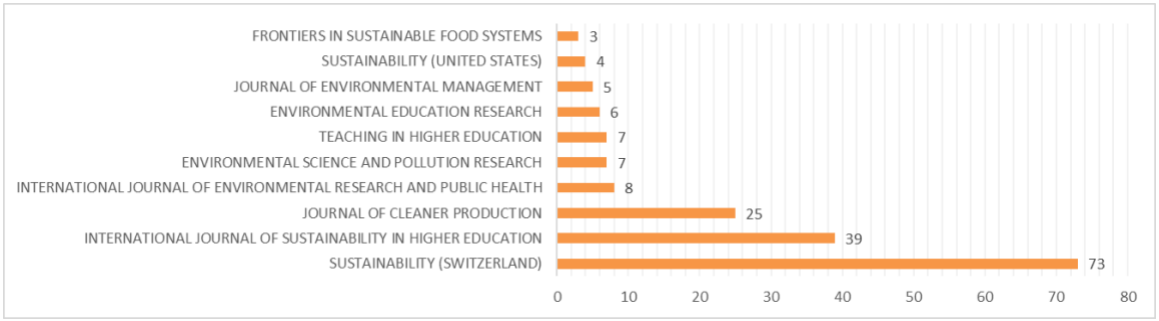

Figure 5: Top 10 Journals by Production

Source: secondary data (processed, 2025)

Furthermore, Figure 6 presents the top 10 sources based on their local impact, measured by the H-index. The Journal of Cleaner Production and Sustainability (Switzerland) stand out as the most influential source, with H-index values of 22 and 21, respectively. These journals' high citation rates suggest that their published works serve as essential references for subsequent research, indicating their central role in shaping the academic dialogue surrounding sustainability issues. The high impact of these sources also demonstrates their ability to attract high-quality research contributions, particularly in areas that integrate environmental management practices with educational strategies.

The distribution of journals based on their impact underscores a discernible pattern: journals with a broad, interdisciplinary focus tend to have higher citation rates, reflecting the increasing recognition of the interconnectedness of sustainability issues across various sectors. Additionally, the appearance of journals such as Teaching in Higher Education and Environmental Education Research in the top 10 list emphasizes the growing importance of educational approaches in promoting sustainability practices. The varying impact levels across journals also suggest a potential for future research to explore the relationship between publication volume, citation frequency, and the practical application of sustainability principles across different regions and industries.

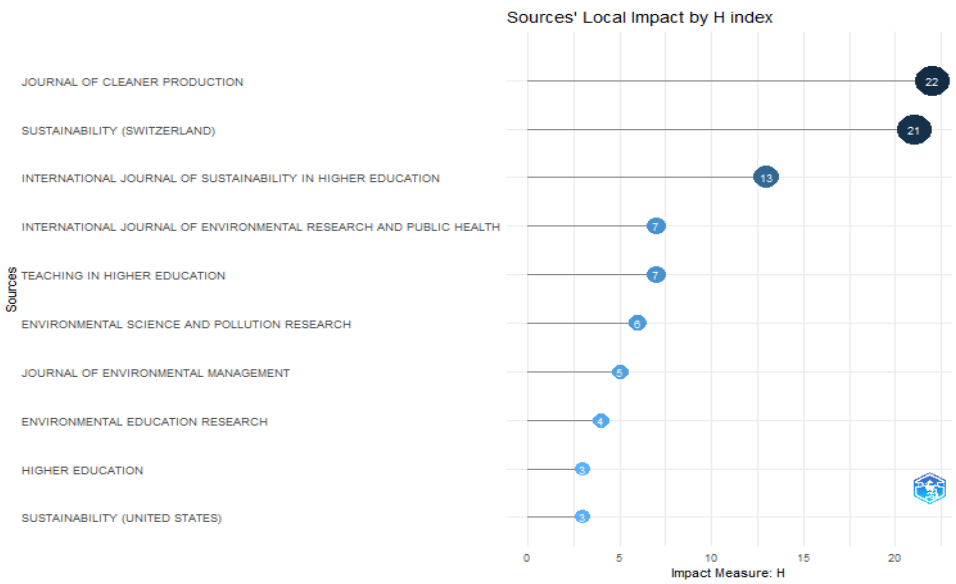

Figure 6: Top 10 Sources' Local Impact

Source: secondary data (processed, 2025)

These findings imply that researchers should carefully consider both the production volume and impact factor of journals when selecting publication outlets. High-impact journals not only provide greater visibility for research but also contribute to broader academic discussions that influence policy and practice. By strategically targeting journals with high relevance and visibility, researchers can maximize the reach and influence of their work while contributing to the ongoing efforts to address complex sustainability challenges on a global scale.

3.5 Network Analysis of Conceptual Structure

Figure 7 presents a comprehensive co-word network analysis that visually maps the intricate relationships among various keywords used in published research. The interconnectedness of terms like sustainability, environmental sustainability, and higher education highlights the central themes that dominate the academic discourse. The prominence of these keywords suggests a growing research focus on integrating sustainable practices within educational institutions, with a particular emphasis on the role of universities in promoting environmental awareness, knowledge dissemination, and actionable strategies. The dense clusters of related keywords underscore the interdisciplinary nature of this research, bridging environmental science, education, social studies, and institutional practices.

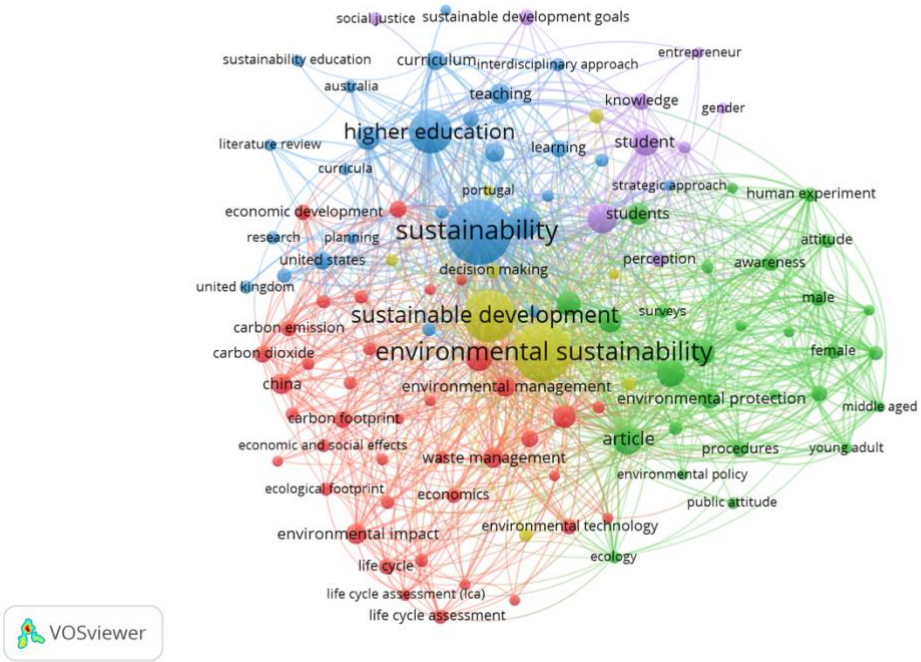

Figure 7: Graphical Representation of The Co-Word Network

Source: secondary data (processed, 2025)

Table 3 provides quantitative insights into these keywords, listing variables like sustainability with the highest connection strength (811) and occurrence (189), followed by environmental sustainability (759 connections, 154 occurrences) and sustainable development (688 connections, 122 occurrences). The average publication years for these terms, ranging from 2018 to 2020, indicate a sustained and growing interest in these topics, likely driven by global initiatives such as the UN Sustainable Development Goals (SDGs). Notably, the variable higher education has the highest average publication year (2020.06), suggesting its growing importance in recent years.

The distribution of variables across different clusters illustrates the thematic diversity within this research domain. Cluster 3, which includes terms like sustainability, higher education, and environmental education, signifies the intersection of educational practices with environmental objectives. Cluster 4 focuses on environmental sustainability and sustainable development, reflecting a broader, policy-oriented research direction. Clusters 1, 2, and 5 encompass more specialized topics such as climate change, human factors, and the university sector, indicating the nuanced exploration of social, institutional, and ecological aspects.

Table 3: Variable used in green university research

Variables	Cluster	Total connection strength	Occurrences	Avg. Pub. Year
sustainability	3	811	189	2019.48
environmental sustainability	4	759	154	2019.44

sustainable development	4	688	122	2019.37
higher education	3	357	86	2020.06
university sector	3	322	46	2019.33
education	5	251	38	2019.61
human	2	411	35	2019.43
student	5	236	33	2019.67
climate change	1	162	33	2018.97
environmental education	3	119	27	2018.96
humans	2	345	27	2019.74
university sector	3	322	46	2019.33
environment	1	165	23	2018.61
environmental management	1	143	19	2017.74
innovation	3	17	96	2019.82

Source: secondary data (processed, 2025)

Figure 8, which presents the thematic map by keywords, categorizes research topics based on their development and relevance. Core themes like environmental sustainability and climate change appear in the upper-right quadrant, indicating their established presence and central importance in the literature. The size of the bubbles corresponds to the relative frequency of each keyword, with larger bubbles like environmental sustainability and sustainable development signifying their pervasive influence. In contrast, emerging or niche themes, such as solid waste and landscape, are positioned in the lower-left quadrant, suggesting potential areas for future exploration. The presence of terms like campus sustainability and attitude near the center indicates their bridging role between established and emerging research directions. The circles along the central axis represent themes transitioning between niche and core categories, suggesting their potential to become future research priorities if their relevance and development degree continues to grow.

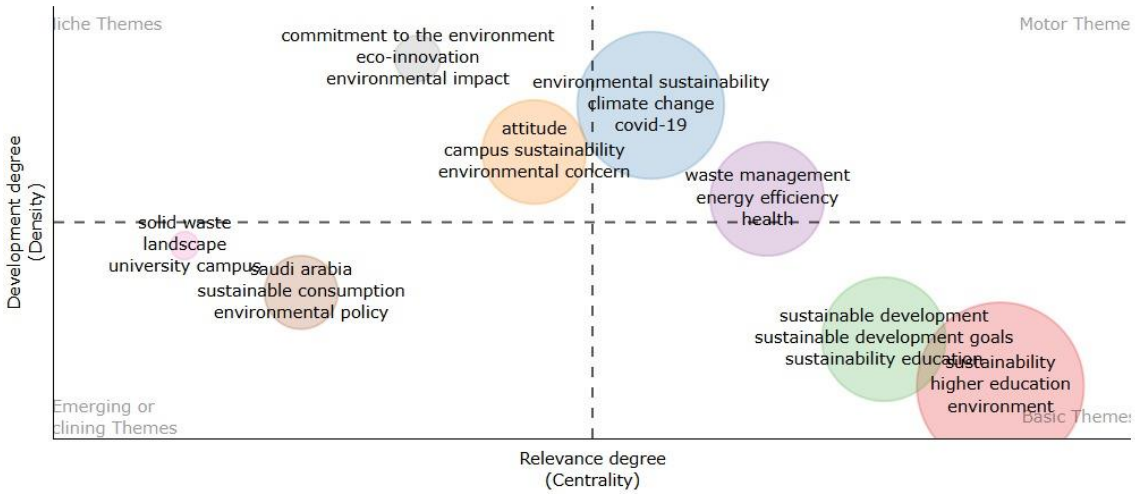

Figure 8: Thematic Map by Keywords

Source: secondary data (processed, 2025)

Figure 9 illustrates the thematic evolution of keywords over different periods, revealing shifts in research priorities. From 2013 to 2015, research predominantly focused on climate change, sustainability, and sustainable development. Over time, the introduction of terms like environmental education and circular economy between 2016 and 2019 reflects an expanded research agenda. More recent developments in 2020–2022, such as the emergence of green libraries and Pakistan, point to the growing diversification of research themes and the increasing participation of developing countries in sustainability-related studies. The evolution lines in Figure 9 illustrate how keywords related to education and institutional practices have consistently grown, underscoring the enduring relevance of educational strategies in promoting sustainability. The bubbles along the central axis of the thematic map indicate transitional themes that may gain prominence in the future if research interest continues to grow. The consistent growth of terms like environmental sustainability and waste management suggests an

increasing focus on practical implementation strategies in institutional contexts. Looking ahead, research trends may likely focus on the intersection of digital tools and sustainability, with potential growth in areas like smart campuses and sustainable technology adoption to address evolving environmental and educational challenges.

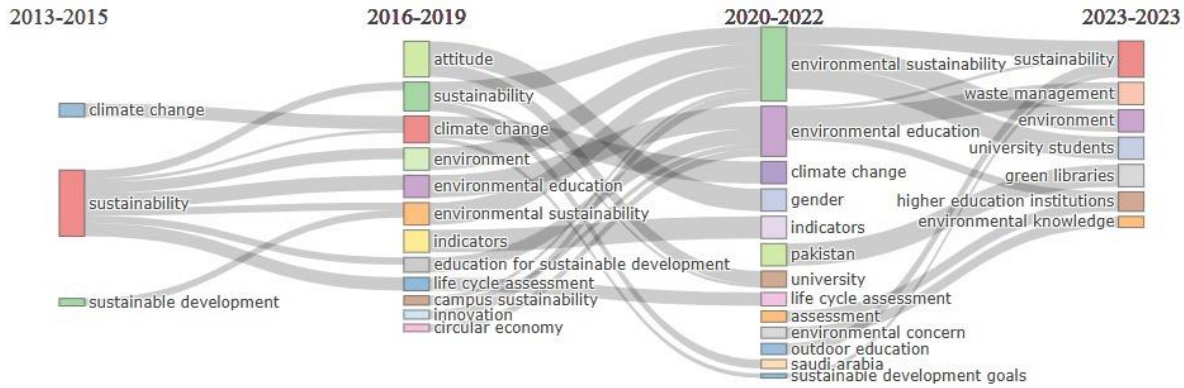

Figure 9: Thematic Evolution by Keywords

Source: secondary data (processed, 2025)

The analysis of publication trends, keyword relationships, and thematic evolution reveals a dynamic and evolving field. The prominence of sustainability-related terms underscores the field's relevance in addressing contemporary environmental challenges, while the thematic shifts indicate a continual adaptation to emerging issues and regional contexts. Future research could further investigate the practical applications of these insights, particularly in supporting policy development and institutional practices aimed at promoting sustainability. Additionally, exploring the role of less prominent themes might provide valuable insights into the evolving landscape of green university research. The ongoing development of themes along the central axis of the thematic map suggests potential growth in research on digital sustainability, smart campuses, and innovative environmental management practices.

3.6 Network analysis of social structure

Table 4 provides additional context by detailing the characteristics of these collaborative authors, including their cluster affiliation, total connection strength, number of documents, and average publication year. Ahmad Manzoor, for instance, is positioned in Cluster 12 with the highest total connection strength of 19 and an average publication year of 2021.5, indicating his significant role in recent research contributions. The presence of other authors, such as Huisingh Donald from Cluster 10 with 21 connections, suggests diverse collaborative interactions across institutions and countries, emphasizing the global nature of this research community. The variation in average publication years, ranging from 2015 to 2021, indicates the continuous evolution of research contributions and the ongoing development of new perspectives in this field. This diversity in clusters and publication years demonstrates the dynamic nature of research in sustainability, driven by both experienced researchers and new contributors.

Table 4: Collaborative Author

Authors	**Cluster**	**Total connection strength**	**Document**	**Avg. Pub. Year**
Ahmad, manzoor	12	9	4	2021.5
Abu qdais, hani	3	12	1	2019
Huisingh, donald	10	21	2	2015
Buitrago, jorge oswaldo sanche	11	11	1	2021
Skanavis, constantina	9	30	2	2017.5
Bacelar-nicolau, paula	1	19	2	2021
Filho, walter leal	8	25	2	2017
Azeiteiro, uiisses miranda	5	40	2	2018.5
Birkey, rachel	5	4	1	2017
Aldaz, cecilia elizabeth bayas	6	8	1	2019

Dagiliute, renata	4	13	1	2015
Alahmari, muteeb	4	6	1	2019
Clarke, amelia	4	8	1	2017
Alba-hidalgo, david	6	16	1	2018
Trendafilova, sylvia	7	6	2	2020.5
Boylan, sinead	2	6	1	2021

Source: secondary data (processed, 2025)

Figure 10 illustrates the social network among authors in this research field, reflecting the patterns of academic collaboration among key researchers. The network visualization reveals several clusters of authors who frequently collaborate, indicating the collective nature of research efforts in this domain. The presence of nodes with thicker connecting lines represents stronger collaborative relationships, while isolated nodes suggest potential areas for future collaborative efforts. The interconnectedness observed across clusters underscores the multidisciplinary nature of this research area, as scholars from different fields come together to address complex sustainability issues.

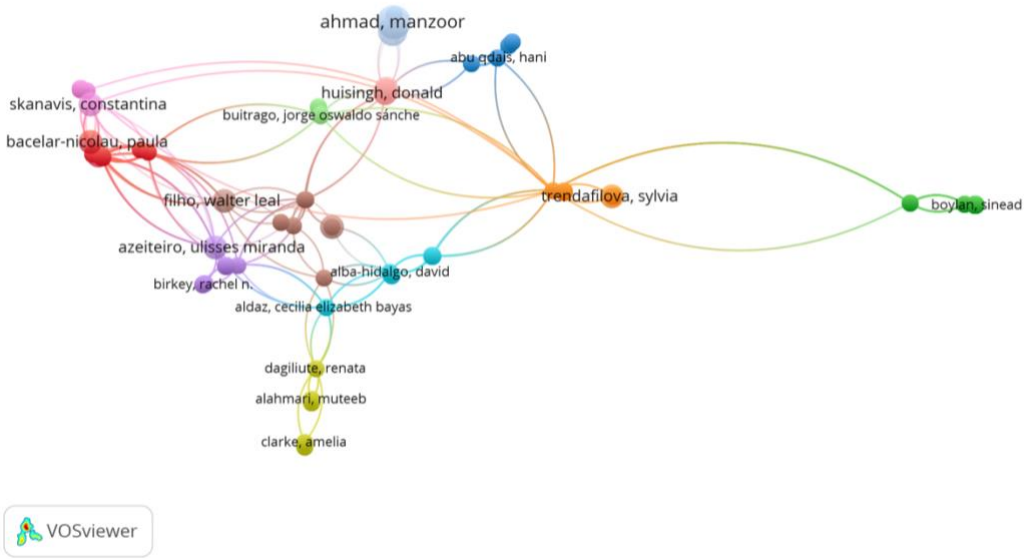

Figure 10: Graphical Representation of The Author's Network

Source: secondary data (processed, 2025)

Furthermore, Figure 11 presents the top 10 authors with the highest local impact, measured using the H-index. Ahmad M stands out with an impact measure of 5, positioning him as a thought leader whose research has significantly influenced subsequent studies. Authors like Adenle YA and Khattak SI, each with an impact measure of 3, also contribute notably to the field. The chart indicates a concentration of impactful research among a limited group of authors, suggesting that these individuals may serve as key opinion leaders who shape the research agenda and methodological advancements. The relatively lower impact measures for other authors hint at the potential for emerging scholars to contribute more prominently to future research endeavors.

The collaborative nature of these authors is further highlighted by the distribution across various clusters, as seen in Table 4. Authors such as Trendafilova Sylvia (Cluster 7) and Azeteiro Ulysses Miranda (Cluster 5) demonstrate the interdisciplinary connections that characterize this field. The average publication years, which range from 2015 to 2021, reflect a continuous interest in the topic and the introduction of new perspectives over time. This temporal distribution suggests that the field remains active and dynamic, with ongoing contributions from both long-standing researchers and new entrants.

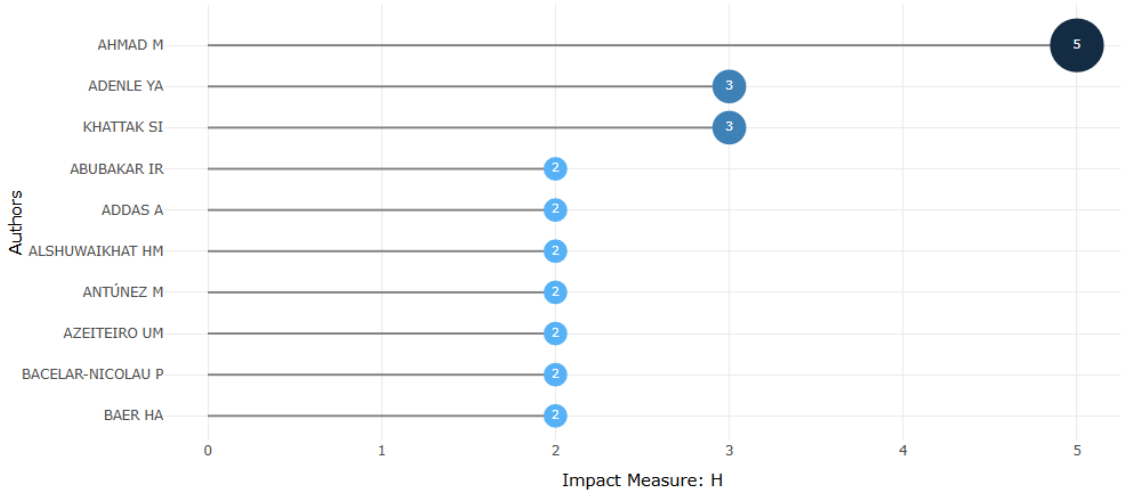

Figure 11: Top 10 Authors' Local Impact

Source: secondary data (processed, 2025)

The network structure, with its various interconnected nodes and clusters, implies potential opportunities for future collaborations, particularly among authors with limited connections to the broader network. This evolving structure suggests that upcoming research trends may focus on expanding these collaborative efforts to address emerging challenges in sustainability, particularly through international and cross-disciplinary partnerships. The increasing prominence of environmental, social, and governance (ESG) considerations in global research agendas may further stimulate these collaborative efforts, driving future investigations into more effective sustainability practices.

3.7 Opportunities for Future Research

Based on the bibliometric analysis, several research trends remain underexplored yet hold significant potential for future development. The thematic evolution presented in Figure 9 illustrates how academic research on university sustainability has continuously evolved. One area that has received limited attention is the application of digital technology in supporting campus sustainability. While the concept of smart campuses has emerged, studies on how technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data can be leveraged to optimize energy consumption, waste management, and resource efficiency remain scarce. These digital approaches could serve as effective solutions for creating greener and more efficient academic environments. Future research could focus on how universities can integrate technology-driven systems into their sustainability policies and how data-driven decision-making can enhance the effectiveness and scalability of sustainability initiatives.

Beyond technological aspects, research on the relationship between university sustainability policies and student well-being remains underexplored. Most studies emphasize environmental impacts and institutional governance, while the social and psychological dimensions of sustainability receive less attention. A university's commitment to green policies not only contributes to carbon footprint reduction but also fosters healthier and more conducive learning environments. For instance, increased green spaces can help reduce student stress levels, while sustainable transportation policies can improve mobility and promote healthier lifestyles. Therefore, further research could examine the correlation between campus sustainability initiatives and student well-being, as well as how student engagement in sustainability programs enhances their environmental awareness and participation in sustainability-related activities.

Another underexamined trend is the financial sustainability of universities in implementing green initiatives. Many higher education institutions, particularly in developing countries, face financial constraints that limit their ability to adopt sustainability policies. Consequently, research on innovative funding mechanisms such as green bonds, crowdfunding for sustainability projects, and private-sector partnerships could offer valuable insights. Current research primarily focuses on implementing sustainability policies, whereas studies on securing long-term funding sources for sustainability initiatives remain limited. Future studies could investigate the effectiveness of various

green financing models and how universities can design sustainable investment strategies that align with their academic and operational priorities.

Furthermore, the integration of management control systems (MCS) into university sustainability frameworks remains a relatively unexplored research area. While many universities have adopted sustainability reporting frameworks such as the Global Reporting Initiative (GRI) and the Sustainability Tracking, Assessment & Rating System (STARS), limited studies have examined how internal control systems influence the effectiveness of sustainability policies. Universities require concrete performance measurement tools to assess the success of their sustainability strategies, and MCS-based key performance indicators (KPIs) could serve as effective mechanisms for monitoring progress. Future research could explore how MCS can be leveraged to enhance accountability, transparency, and stakeholder engagement in university sustainability efforts. A well-structured management control system would ensure the consistent and measurable implementation of sustainability policies, thereby reinforcing institutional commitments to long-term environmental responsibility.

Beyond internal university frameworks, the role of universities in promoting sustainability within external communities remains an underdeveloped research avenue. Most existing studies focus on on-campus sustainability policies, while relatively few examine how universities can collaborate with local governments, industries, and communities to drive sustainable practices. Universities have the potential to serve as change agents by fostering partnerships with local stakeholders through initiatives such as environmental education programs, community-based waste management projects, and renewable energy solutions in surrounding areas. Given these research gaps, future studies should explore how universities can strengthen their collaboration with external stakeholders to enhance the impact of sustainability initiatives on a broader scale. By addressing these emerging research themes—including digitalization in campus sustainability, the impact of sustainability policies on student well-being, innovative financing models, management control systems, and community engagement—academia can contribute to the development of more resilient, innovative, and sustainable higher education institutions.

4. Conclusions

This research provides a comprehensive bibliometric analysis of sustainability research in higher education institutions (HEIs), identifying key trends, research gaps, and emerging themes. The study explores how research on university sustainability has evolved, highlighting dominant topics such as environmental sustainability, and green university initiatives. Over the past decade, there has been a consistent increase in the number of publications in this field, with occasional declines in output due to external factors such as economic downturns or global crises. The peak of sustainability research in HEIs occurred in 2019, followed by steady interest in subsequent years. The development of sustainability research has been influenced by contributions from various countries and academic journals that serve as publication hubs. The United States, the United Kingdom, and China are the dominant contributors. Journals such as Sustainability (Switzerland) and the Journal of Cleaner Production have been the most prominent platforms for publishing sustainability-related research. The analysis of collaborative authorship further indicates that international partnerships have strengthened research development, contributing to increased citation impact and academic influence.

The primary trends in sustainability research include campus sustainability policies, environmental education, and the integration of sustainability into university governance and management. Existing literature emphasizes the importance of HEIs in promoting sustainable development through research, education, and institutional policies. Universities are not only expected to implement sustainability practices but also to act as role models for society by fostering innovation and environmental awareness. However, previous studies highlight that the success of sustainability initiatives in HEIs depends on institutional commitment, financial resources, and effective governance structures. Additionally, interdisciplinary collaboration and stakeholder engagement are critical for driving sustainability initiatives forward. University leaders, faculty members, and policymakers must ensure that sustainability policies are aligned with long-term institutional goals and supported by adequate resources. The literature also points out that integrating sustainability into teaching and research enhances students' environmental consciousness and prepares them for sustainability-related challenges in their future careers.

Developing themes with potential for further research include the role of digital technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and blockchain in enhancing campus sustainability. Other underexplored topics include financial sustainability mechanisms, such as green bonds and sustainability-focused investment strategies, which can help universities secure funding for long-term sustainability projects. Additionally, future studies could investigate the impact of sustainability policies on student well-being and academic performance, as well as the role of management control systems (MCS) in tracking and optimizing sustainability efforts within universities. Further research could also explore how universities engage with external stakeholders, including local governments, industries, and communities, to promote sustainable development beyond campus boundaries. The relationship between sustainability governance and institutional performance remains an emerging area of interest, particularly in understanding how universities can leverage sustainability strategies to enhance their global reputation and competitive standing.

This research identifies several limitations, the first being that it primarily focuses on English-language publications, excluding studies published in other languages such as Spanish, Chinese, French, and German. Future research could address this limitation by incorporating a multilingual approach to gain a more diverse perspective. Secondly, this study relies exclusively on the scopus database due to its extensive coverage and high-quality content. However, future research could expand the dataset by integrating other databases, such as Web of science or Google Scholar, to provide a more comprehensive bibliometric review. Thirdly, this research employs bibliometric analysis based on metadata such as keywords, titles, abstracts, citations, and affiliations. Further studies could utilize additional analytical techniques, such as network analysis and content mapping, to explore the causal relationships and theoretical developments in sustainability research within HEIs. Despite these limitations, this study successfully addresses its research objectives and contributes to the understanding of sustainability in HEIs by consolidating previously fragmented research and identifying key areas for future exploration.

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