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Review

Exploring Sustainability Assessment Practices in Higher Education: A Comprehensive Review through Content and Bibliometric Analyses

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Abstract: The drastically increasing significance of sustainability development has motivated higher education institutions (HEIs) to make efforts to achieve sustainability development goals (SDGs). This has led to the inevitable need to track and assess these efforts. This review is centered on the meticulous collection and analysis of pertinent papers within the context of HEIs, subsequently organizing and consolidating them into distinct sustainability domains by utilizing the PRISMA methodology. A collection of 83 pre-existing articles and publications retrieved from the Scopus database is employed for an in-depth exploration of the current research. This study employs both bibliometric and content analyses to explore distribution and citation dynamics and identifies six primary thematic concentrations within the field. The key findings highlight a significant increase in the importance of sustainability, emphasizing the critical need for HEIs to integrate SDGs across all departments. Additionally, the development of cross-institutional evaluation tools tailored to various sustainability aspects is underscored. These tools elucidate key competencies and broaden the application of educational sustainability in both research and curriculum development. The study also identifies a need for future research to explore how effectively these assessment methodologies drive tangible sustainability outcomes within HEIs. It suggests that developing more nuanced and adaptable evaluation tools could better meet the diverse needs of institutions globally. Additionally, the findings support HEIs' and stakeholders' decision making by identifying potential challenges in the implementation and assessment of sustainability.

Keywords: higher education institutions; sustainability development goals; sustainability assessment; content analysis; bibliometric analysis; VOSviewer

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1. Introduction

Sustainability has been widely acknowledged as a collective responsibility, and education plays a crucial role in its achievement. For instance, Brazier [1] and Susan et al. [2] emphasize the importance of education in driving the world toward sustainability. Education is recognized as a key domain that can contribute to meaningful and sustainable development, ensuring a transformed and improved learning experience for future generations [1]. In addition, education, including early childhood education, plays a vital role in developing resilience and capabilities in students, empowering them to become active and informed citizens who can contribute to healthy and sustainable lifestyles both now and in the future [2]. This realization has given rise to the concept of "Education for Sustainability", which emphasizes outdoor, science-based education and places greater emphasis on the interactions between individuals and their environments. Future generations, as future leaders, executives, workers, voters, citizens, and change agents, have an important role to play in building a more sustainable and responsible world [3]. Hence, their actions and

behavior will orientate the sustainability of the earth and the human world in upcoming decades. Moreover, Neha et al. [3] claim that education institutions, as transformative organizations, can firmly contribute to the building of a more resilient, sustainable, and fair world by shaping the ethical, responsible, and sustainable consciousness of future generations, creating public awareness regarding the consequences and repercussions of unsustainable actions and addressing the current sustainability challenge that society is facing. As a result, in recent decades, HEIs have increasingly shown support and dedication in addressing sustainability challenges within their institutions [4]. In addition, HEIs are indispensable environments for the dissemination of sustainability principles. Over the past few years, they have made transformations toward sustainability by refocusing their education, research, social outreach, and community outreach activities [5].

Consequently, there has been a notable increase in the international discourse about incorporating sustainability in higher education, including systematic reviews to examine the research undertaken to date. Hence, many scholars have started reviewing past research on sustainability in education sector, and they have developed frameworks that can help institutions to achieve sustainability and that periodically ensure that the institution is sustainable in various factors as identified from the literature and experts in the field by employing sustainability assessment methods [3,6]. To aid this, identifying the key indicators that affect sustainability in education is crucial. Sustainability indicators are quantitative and/or qualitative measures that aim to inter-relate and assess different areas of social, environmental, economic, institutional, and territorial development. In general, they intend to achieve one or more of the following: evaluate sustainable development conditions and trends across time and space, monitor progress toward goals and targets, inform planning and decision making, compare different places and situations, raise awareness, encourage political and behavior change, promote public participation, and improve communication on sustainability debates [7].

According to Singh et al. [8], numerous research evaluations have been conducted to facilitate the integration of sustainability by examining higher education sustainability assessment tools (SATs). Furthermore, the review of eleven cross-institutional evaluation tools was undertaken to determine their stage of development and proximity to the "ideal tool". Moreover, scholars have employed both statistical and qualitative methods to assess HEI assessment tool issues and methodologies using sixteen SATs. For example, Maragakkis and Dobelsteen [9] conducted an evaluation of assessment tools to identify the key elements and indicators used in ranking sustainability assessment systems and to develop a comprehensive technique for evaluating existing systems and selecting the most suitable one for public use. These evaluations have significantly enhanced our understanding of how HEIs analyze sustainability, although there is still room for improvement in their implementation. Furthermore, SATs identify areas for improvement, make strategies for improving campus sustainability, and foster a sustainability culture to execute sustainability [10,11]. Moreover, SATs should emphasize important issues and be quantitative, comparable, and unambiguous. Such tools, based on indicators and conceptual models that support sustainability choices and enable rapid and wide communication, should aid HEIs in how to react to tough processes and in researching the sustainability transition.

Despite several publications and efforts, there exists an inevitable need for a comprehensive review of past literature that was focused on existing sustainability integration and assessment methods and the various challenges faced by institutions during this sustainability implementation process, apart from the evaluation of SATs for the sustainability assessment. Consequently, the field needs further extensive and comprehensive research and experimentation with more ease and clarity to ensure the existence of sustainable HEIs.

Through a rigorous examination of papers spanning diverse domains, it aims to provide a holistic perspective on the current state of research in this field by comparing the various existing methods and tools and identifying the various challenges and opportunities for future research in the field. Consequently, gaining a profound understanding of key insights and providing synthesized findings will facilitate the identification of research

gaps within specific domains or the broader realm of sustainability. Hence, to aid the sustainability development in HEIs, the scope of this review section delves into a wide range of publications over the past six years concerning sustainability assessment in HEIs, encompassing the tools employed for assessment and the initiatives undertaken by HEIs to integrate sustainability across various dimensions. This comprehensive review is centered on the meticulous collection and analysis of pertinent papers within the context of HEIs, subsequently organizing and consolidating them into distinct sustainability domains by adopting the method of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis), which is a systematic method for reviewing past literature to identify the scope of future research. By consolidating and condensing significant discoveries, methodologies, and suggestions from numerous sources, this investigation offers an asset for scholars, instructors, and policymakers with a keen interest in examining diverse approaches and instruments for instituting and evaluating sustainability within HEIs. Unlike past research, this review is a blend of content analysis, bibliometric analysis, and data analysis of all the publications that falls under sustainability assessment of HEIs.

Consequently, this review paper makes significant contributions to the field in several ways. To begin with, it offers a comprehensive overview of the current state of research on sustainability assessment in HEIs, enabling researchers to pinpoint the predominant themes and research trajectories in this domain. Additionally, it consolidates the discoveries and perspectives from multiple review papers, presenting a holistic view on the efficacy and potential of integrating sustainability within HEIs. Moreover, this review pinpoints research gaps and areas necessitating further exploration, steering future research initiatives. The subsequent sections of this paper will, therefore, outline the methodology utilized for selecting and scrutinizing the research papers, accompanied by a thorough content analysis and amalgamation of the discoveries and perspectives. Essential themes, patterns, and suggestions will be delineated, facilitating readers in acquiring a comprehensive grasp of the existing knowledge foundation. Following that, a thorough bibliometric analysis will be carried out, inspecting notable SATs, frameworks, and models devised by various researchers alongside the escalating importance of sustainability implementation and assessment among policymakers. Furthermore, the ramifications of sustainability implementation, as well as various challenges encountered by institutions in this process, are also pinpointed in this review. Additionally, recommendations for overcoming these challenges and advancing future research are elaborated upon in detail.

2. Materials and Methods

The research employs a systematic methodology for gathering and analyzing literature on the sustainability assessment in HEIs. This approach consists of four primary steps outlined below.

1. Literature Retrieval: This phase involves meticulously selecting relevant search terms and keywords to comprehensively gather publications related to the sustainability assessment in HEIs. Possible synonyms and words related to the topic were identified and combined using the operators ”AND” and ”OR” to obtain a comprehensive set of papers from the Scopus database. The authors conducted a targeted search of the Scopus database using the keywords string “sustainability AND (assessment OR evaluation) AND higher AND education AND (institution OR university) AND (indicator OR framework OR model)”, resulting in the identification of 293 papers spanning the years 2018 through to 2023.
2. Literature Screening: Following the PRISMA statement, a recognized approach for systematic reviews, this study applied a rigorous screening procedure as depicted in Figure 1. Starting with 293 papers, 1 duplicate was removed. After detailed review of each publication, all articles that were deemed irrelevant to the research focus were discarded, narrowing down the list to 83 reviews, conference papers, and articles. All the papers that focused on sustainability development through sustainability assessment in HEIs were shortlisted and, hence, others were removed. The final set

of papers were selected from the years 2018 to 2023 due to the drastically growing emphasis on education for sustainability, the need for curriculum reform, and the growing importance of sustainability metrics in academia within this timeframe.

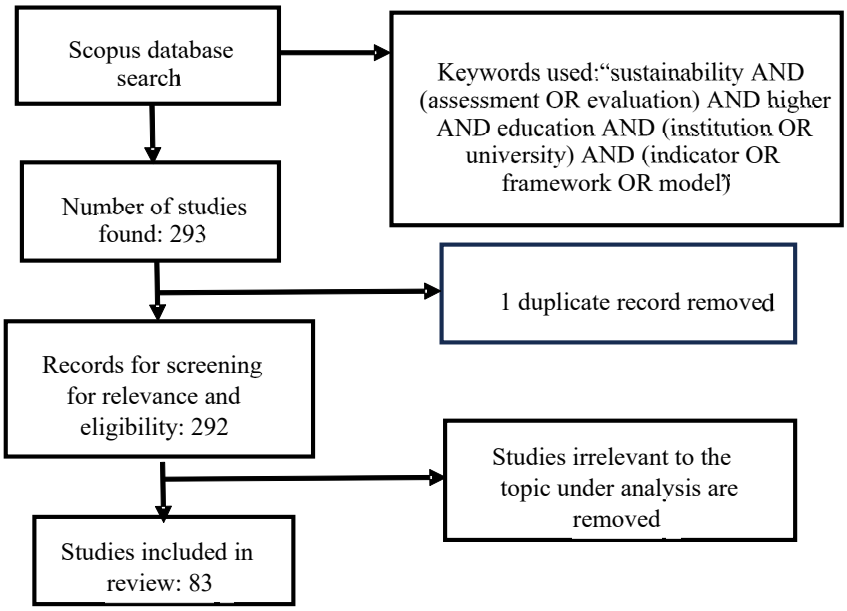


Figure 1. PRISMA literature review search.

Figure 2 illustrates the number of publications related to sustainability assessment practices in higher education from the years 2018 to 2023. The graph reveals a fluctuating trend in research output over these years. However, a significant rise occurred in 2021, suggesting a peak in research interest or possibly an increased focus on sustainability due to global or educational trends during that year. This pattern could be reflective of various factors influencing sustainability research in higher education, such as changes in policy, societal emphasis on sustainability issues, or major global events like the COVID-19 pandemic, which might have impacted research focuses and methodologies. Understanding these trends is crucial for planning future research and educational strategies, as well as for assessing the impact of sustainability initiatives in higher education institutions over time. Additionally, focusing on papers from this timeframe allows for an updated understanding of the methods used to assess universities' sustainability performance, contributing to the ongoing discussion on the need for standardized criteria in sustainability assessment methods. Moreover, it sheds light on the change in research focus before and after the COVID-19 pandemic.

3. Bibliometric Analysis: The research incorporates bibliometric analysis for a systematic evaluation of the academic literature, exploring citations, co-authorships, and keywords to identify key authors, influential works, and emerging themes within the field. This method provides insights into collaborations among researchers and institutions, offering a comprehensive overview of sustainability assessment in HEIs.
4. Content Analysis: This step involves systematically examining a wealth of information and then categorizing and classifying research papers into themes and sub-themes related to sustainability assessment in HEIs. Content analysis delves into the effectiveness of SATs and their integration into different dimensions of sustainability, including the future work possible in the research.

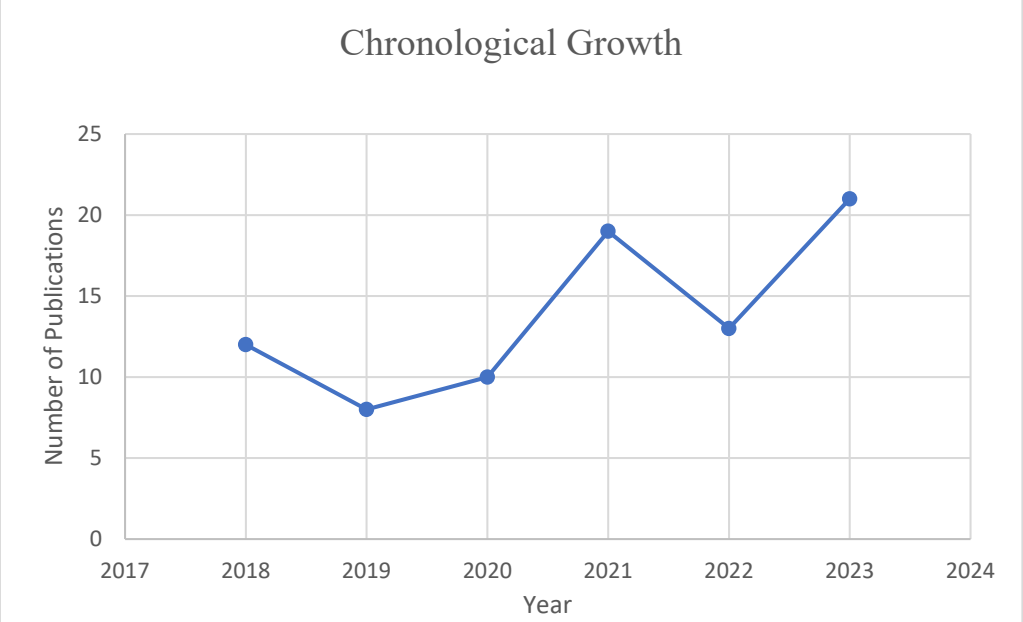


Figure 2. Graph showing variation in research over the years 2018–2023.

3. Bibliometric Analysis

This section engages in an extensive bibliometric analysis of sustainability assessment within HEIs. A compilation of papers sourced from the Scopus database was employed for an in-depth exploration of the current research in this evolving field. The thorough and systematic analysis aimed to uncover emerging trends, participating countries, and key authors in this research domain.

For the visualization of the research, VOSviewer 1.6.20 was employed. This software generates visualization maps, allowing the examination of correlations between different terms. In this study, we crafted five types of maps using this tool, where each node represented related terms like keywords and authors. The significance of these terms in the field is discerned by variations in the node sizes. These nodes are interconnected by arcs, depicting their degree of association, which diminishes with an increase in distance [12].

3.1. Co-Occurrence Map Based on Text Data

Data analysis of the text was utilized to determine the presence of pertinent and frequently occurring terms in the titles and abstracts of the chosen publications, resulting in the construction of a visualization map of the network [12]. Among the 87 publications, a total of 2425 terms were generated, and 182 terms met the minimum occurrence requirement of 5. The thesaurus file that was produced aided in eliminating duplicate terms [13]. Furthermore, VOSviewer computed a relevant score for each of these 182 terms, and based on this, the top 60% most relevant terms were chosen. This resulted in a total of 181 terms, as depicted in Figure 3. Therefore, by examining the terms with high relevant scores, one can identify the specific topic covered by the text data, while those with low relevant scores are more general in nature [12].

Figure 3 illustrates a network comprising connections among various terms and their application in the realm of research and development within this domain. Multiple terms, such as student, sustainable development, assessment tool, sustainability development goals, and campus, are linked, suggesting the wide-ranging utilization of these terms within the field of study. Additionally, Figure 4 exhibits direct connections between the terms and "sustainability assessment".

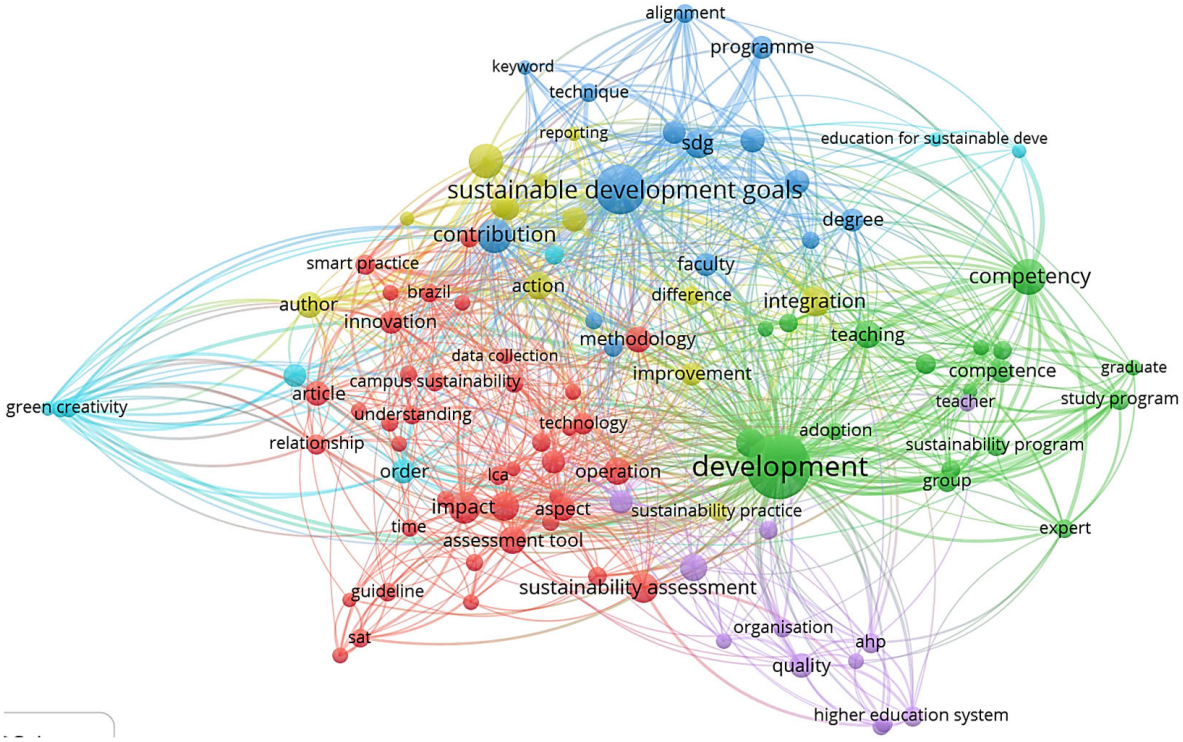


Figure 3. Co-occurrence map of the text data.

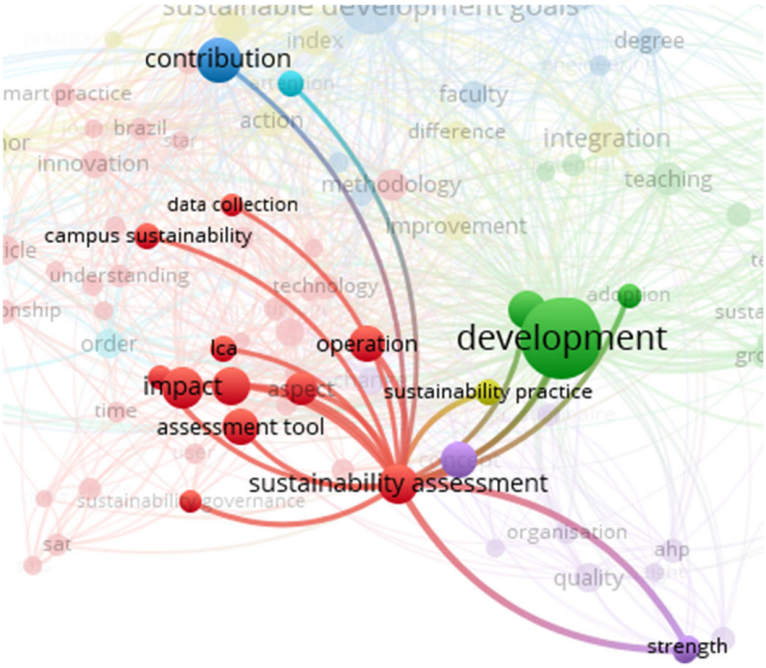


Figure 4. Direct connection of terms with "sustainability assessment".

The network depicted in Figure 4 illustrates the direct connections between the terms and "sustainability assessment". This clearly demonstrates the growth of sustainability research in the realm of education, particularly in the field of higher education, which is supported by the presence of the term "campus sustainability". A significant portion of the research studies on sustainability focus on sustainability development, as evident from efforts by institutions to abide by the SDGs. Furthermore, the methods employed for these studies are indicated by terms like data collection, assessment tool, impact, contribution,

life cycle analysis, and so forth. This clearly states that most of the research is constituted of analytical studies as this is a developing field and further research is needed to ensure that the HEIs achieve the SDGs.

Table 1 provides a compilation of the top 10 terms that appear most frequently. These terms are accompanied by their respective scores, which are calculated by VOSviewer. VOSviewer determines the relevance of each term by analyzing the distribution of second-order co-occurrences among all terms and comparing it to the overall distribution of co-occurrences. The degree of dissimilarity between these two distributions, as quantified by the Kullback–Leibler distance, determines the level of relevance for each term [14]. The presence of the terms "development" and "sustainable development goals" clearly indicates that widespread research and efforts in developing and achieving SDGs are being carried out by scholars focused on HEIs. The term "student" symbolizes the fact that students are in the epicenter of most of the research as their contribution to social, environmental and education indicators of sustainability is inevitable. Next, the term "competency" highlights the research being conducted on how to instill competencies like problem-solving skills, communication skills, etc., to aid efforts and awareness in the field. "Contribution" and "impact" indicate the set of research studies analyzing the contribution and impact of implementation of different methods/frameworks/tools in sustainability. "Ranking" and "sustainability assessment" emphasize the importance of sustainability assessment in HEIs and how researchers embrace the topic to explore more tools and techniques to assess sustainability. The term "integration" represents the set of studies that assesses and analyzes the extent of integration of SDGs into every dimension of sustainability in HEIs. Finally, the term "campus" indicates that the campus is still considered more by researchers rather than the institution. The analysis sheds light onto the dominant areas of research in the field and the gaps that must be addressed.

Table 1. Top 10 terms by occurrences in the text data.

Term	Occurrences	Relevance Score
Development	95	0.2018
Sustainable Development Goals	60	0.6384
Student	41	0.4311
Competency	30	1.0767
Contribution	29	0.342
Ranking	27	0.7027
Impact	23	0.6873
Integration	21	0.7242
Sustainability Assessment	21	1.0307
Campus	20	0.7896

3.2. Co-Occurrence Map Based on Keywords

The analysis of bibliographic data of 83 papers was conducted to determine the keywords that appear repeatedly. A total of 543 keywords were examined, and 48 were selected based on a threshold value of occurrence of three, as depicted in Figure 5. Thesaurus files were generated and uploaded to VOSviewer to prevent duplications. All types of keywords, including author keywords and index keywords, were scrutinized. Table 2 presents the top ten list of commonly occurring keywords, along with their occurrence and total link strength. The total link strength represents the overall strength of the co-occurrence links between a specific keyword and other keywords.

Table 2 also provides a comprehensive analysis of the most frequently appearing keywords in the field of GAI in education, offering valuable insights into the prominent themes and research areas. The top ten keywords serve as an indication of the central focus and key aspects of integrating GAI into educational contexts.

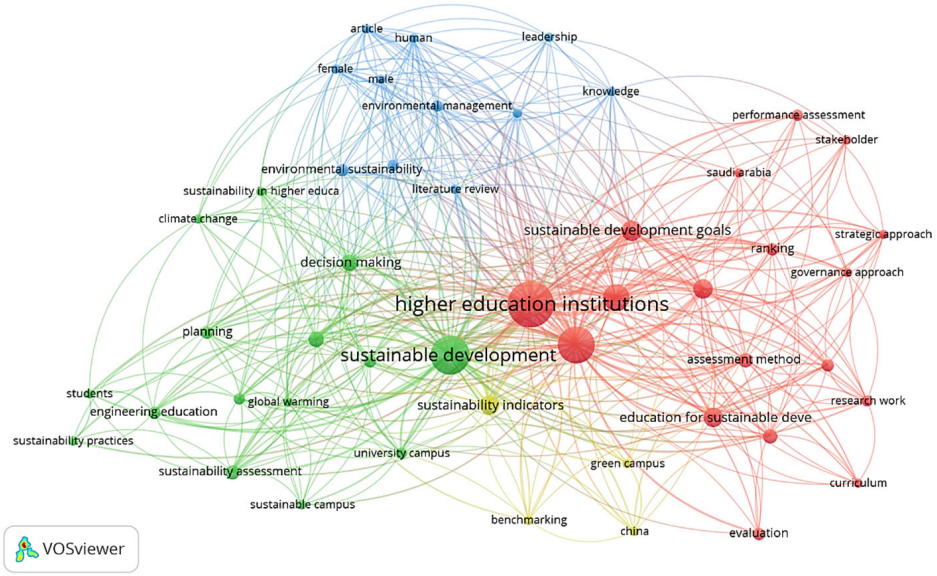


Figure 5. Co-occurrence map of all keywords.

Table 2. Top 10 keywords by occurrences.

Keywords	Occurrences	Total Link Strength
Higher Education Institutions	62	254
Sustainable Development	44	201
Sustainability	40	191
University	21	108
Institutional Framework	12	71
Sustainable Development Goals	13	66
Sustainability Indicators	12	55
Decision Making	8	50
Environmental Impact	7	47
Assessment Method	6	35

For instance, "higher education institutions" topped the list with 62 occurrences, showing that much research is focused on higher education institutions. "Sustainability development" and "sustainability" have almost the same number of occurrences, showing that HEIs are linked to sustainable development and sustainability. Setting aside the first four terms in the set of keywords for the Scopus CSV file, "institutional framework" comes next, showing that research is being conducted by scholars to create and analyze institutional frameworks and the continuing corrective process that is being undertaken to reach the sustainability development goals. "Sustainability indicators" is the next term that shows its presence in almost every research study in the field of sustainability assessment that helps with "decision making", which is the following term. The term "environmental impact" in the table reinforces the fact that the majority of studies on the sustainability assessment of HEIs are focused on their environmental impact, this trend is changing as researchers are now focusing on social economic and educational factors too. Finally, the assessment method indicates the importance of shortlisting an effective assessment method to assess sustainability.

As mentioned above, two additional keyword maps were generated based on the most common author keywords and most common index keywords. Keeping three as

the minimum limit for the occurrences, a map of 37 keywords was designed for the index keywords (Figure 6). Likewise, network visualization of the index keywords was generated by keeping an occurrence threshold of three, which yielded 16 author keywords, as shown in the map in Figure 7.

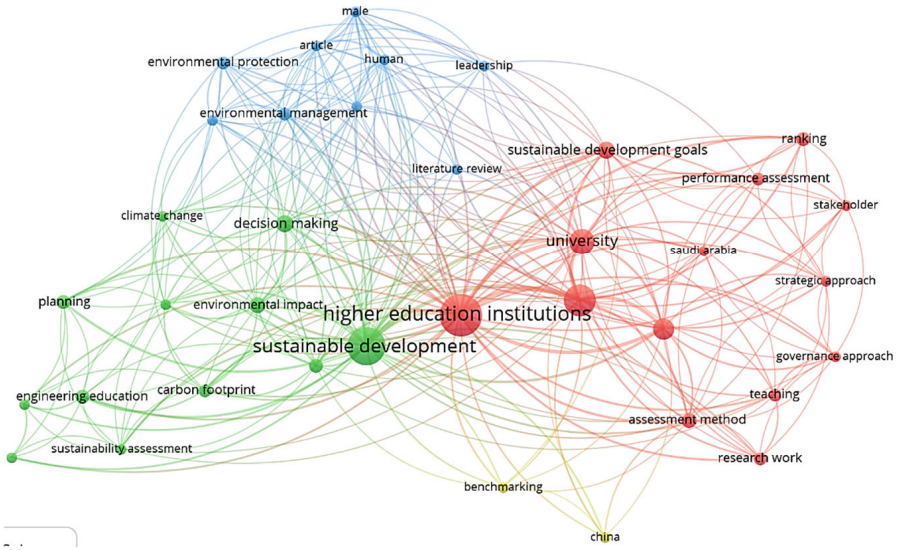


Figure 6. Co-occurrence of index keywords.

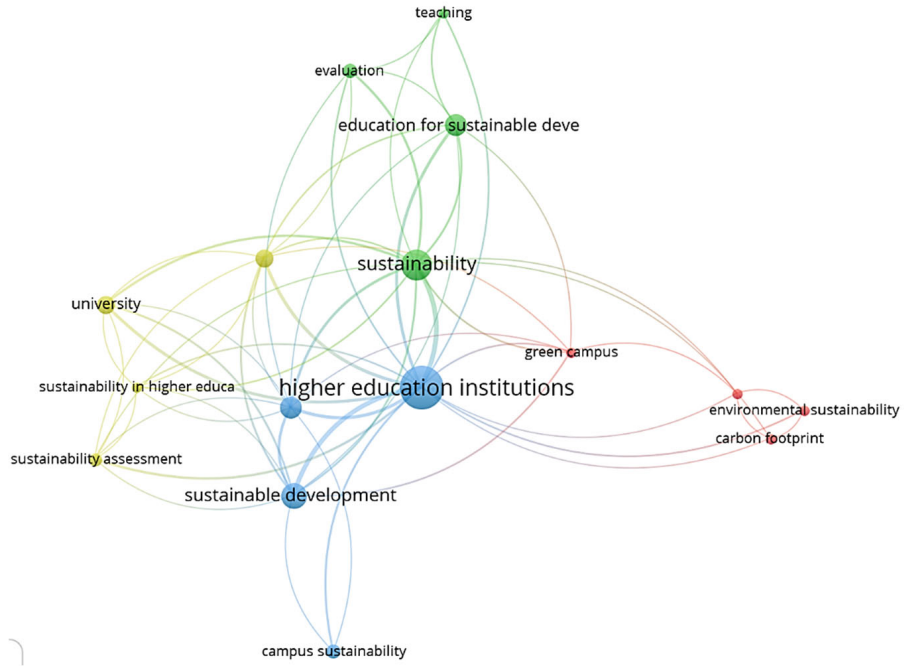


Figure 7. Co-occurrence map of author keywords.

3.3. Co-Occurrence Map Based on Country of Authorship

The analysis based on country of co-authorship was performed for 83 documents by setting an occurrence threshold of three. Out of 50 countries, 19 met the threshold, as illustrated in Figure 8.

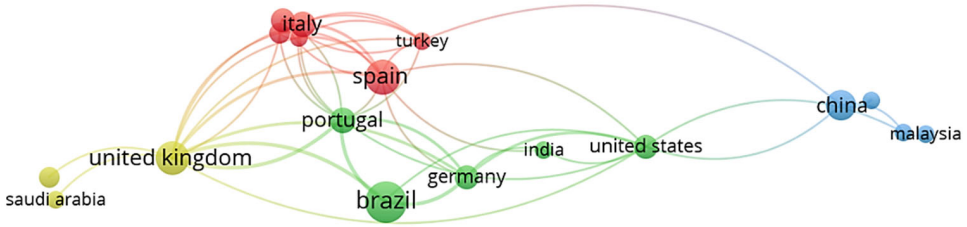


Figure 8. Co-occurrence map of country of authorship.

Most of the documents appeared from Brazil, followed by Spain and the United Kingdom. The ten countries with the highest link strength are depicted in Table 3.

Table 3. Top 10 countries by link strength.

Country	Documents	Citations	Total Link Strength
United Kingdom	10	122	29
Portugal	6	101	25
Spain	11	397	22
Serbia	2	39	19
Colombia	2	22	18
Germany	5	270	17
Sweden	3	143	15
Turkey	3	23	15
Brazil	14	132	14
Italy	6	99	14

From Table 3, the United Kingdom emerges as the country with the highest number of contributions and connections, demonstrating the crucial role of sustainability in HEIs in this region. Portugal, Spain, and Serbia come under the set with the strongest links. The number of documents from Brazil, the United Kingdom, and Spain also demonstrate their valuable contributions and explorations in the field. Spain, Germany, India, the United States, and Canada take the top positions in terms of the highest number of citations, marking their contribution to the relevant and most sought-after areas in the field. Thus, the analysis shows elevated scores for the European countries, followed by South American and Asian countries, reflecting the fact that research in the field is being embraced by scholars in most parts of the world.

3.4. Co-Occurrence Map Based on Authorship

The visualization maps provide an overall view of the relationship between authors and publications in the study of sustainability assessment in higher education. The web presents an idea of the collaboration and knowledge sharing by people from different backgrounds regarding the concept. This would shed light onto trends in the current as well as future research in the field. The result of this analysis provides the number of citations, documents, links, etc., along with the authors' names as depicted in Figure 9. Thus, the top ten list of authors according to their citations are mentioned in Table 4. Three authors have produced three documents, while all the others in the table have worked on two documents together.

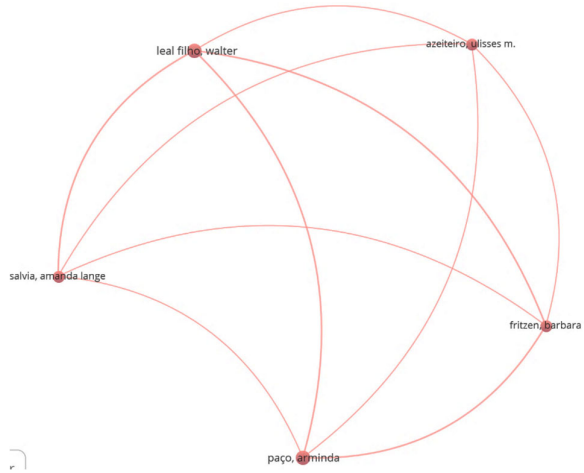


Figure 9. Co-occurrence map of authors.

Table 4. Top 10 authors by citations.

Author	Documents	Citations	Total Link Strength
Rieckmann, Marco	2	225	0
Lozano, Rodrigo	2	115	0
Kioupi, Vasiliki	2	52	2
Voulvoulis, Nikolaos	2	52	2
Leal Filho, Walter	3	45	7
Paço, Armisnda	3	37	6
Salvia, Amanda Lange	2	37	5
Azeiteiro, Ulisses M.	2	35	4
Fritzen, Barbara	2	33	6
Du, Yawei	2	19	0

Marco Rieckmann has 225 citations, being the higher number of the group. Research concentrating on sustainability in higher education, especially on fostering competencies that should be developed to enhance the process of sustainability implementation in HEIs, was the highlight of Marco Reichmann's research. These belong to the valuable contributions and works in this area. Rodrigo Lozano is also a well sought-after author, with 115 citations, as he has contributed to developing many SATs and review papers that guide emerging research. The other authors following them have a good number of citations. Overall, the interest of researchers in the area is clearly visible.

3.5. Data Analysis of Article Sources

A compilation of sources was derived from the entire collection of 83 publications and organized in a descending fashion based on the frequency of publications. Upon analysis, it was evident that the journal titled "Sustainability (Switzerland)" occupied the foremost position, with the highest number of publications, amounting to 23. The "International Journal of Sustainability in Higher Education" followed suit with 10 publications. "Journal of Cleaner Production" and "AIP conference proceedings" contributed five and three publications respectively, while the remaining sources possessed two or fewer publications. Figure 10 visually depicts the top ten sources and their corresponding number of publications.

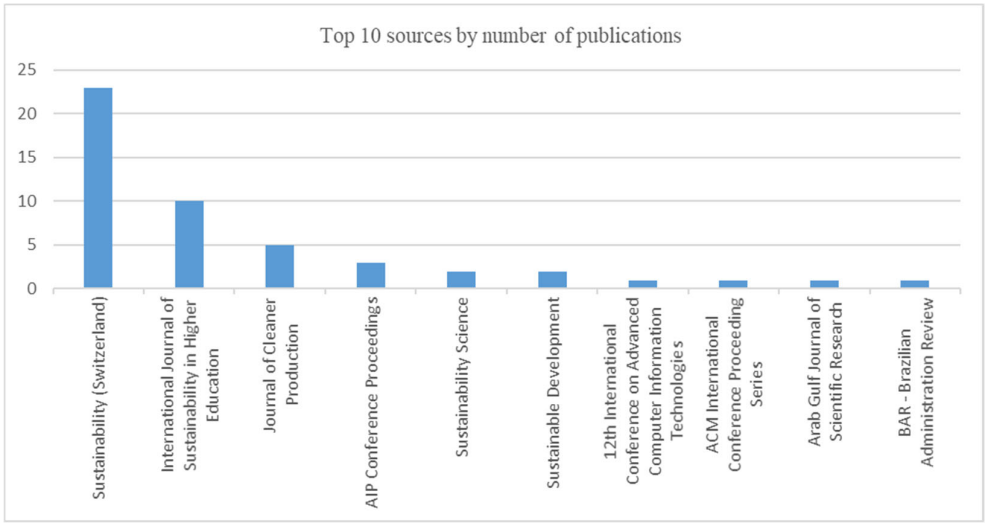


Figure 10. Bar graph of the top 10 sources by number of publications.

The data analysis above showing the impressive number of documents by the sources displays their remarkable position in the world of research. The number of publications from sustainability journals highlights the paramount importance of sustainability studies in the current era.

3.6. Data Analysis of Document Types and Research Types

An examination of the 83 papers was conducted to determine the priority in each classification, considering their document types, fields of study, tools utilized, and research types. The analysis based on different document types is depicted in Figure 11. The classification is divided into three categories, namely articles, conference papers, and reviews, as these were the only types considered in the study. Most of the 83 papers fell under the "article" category, while the "conference paper" and "review" categories had comparatively fewer documents. The prevalence of scholarly articles in the dataset is consistent with academic databases like Scopus, underscoring their crucial role as dependable sources of scientific information.

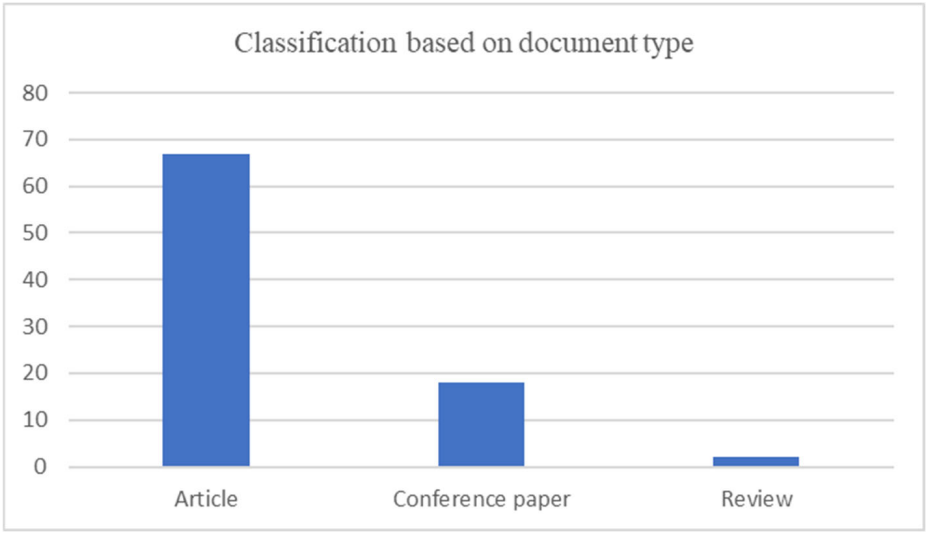


Figure 11. Occurrences of types of documents.

Moreover, an extensive examination was conducted to identify and categorize the specific types of research conducted in each document. The data presented in the chart reveals that most of the research falls under the classification of analysis and the development and

application of tools, models, or frameworks. The analysis category encompasses studies that explore the integration of sustainability dimensions into higher education systems and the step-by-step implementation process in educational institutions. The graph in Figure 12 clearly illustrates a significant amount of research focused on creating various tools, models, conceptual frameworks, and techniques to assess sustainability in HEIs. This emphasizes the growing importance of monitoring the sustainability efforts undertaken by stakeholders and policymakers in these institutions. Subsequently, a significant portion of research has been dedicated to assessing sustainability in different aspects of institutions, with a particular focus on environmental sustainability, such as the carbon footprint and the competencies of students, staff, and administrators. As this field of research continues to emerge and gain prominence, numerous reviews have been conducted to analyze past research and to identify effective tools and techniques for integrating sustainability into institutions and ensuring progress toward achieving SDGs. Additionally, some studies have employed bibliometric analysis and systematic content analysis to delve into the content of each document. Furthermore, a few studies have also focused on examining the impact of embracing sustainability in institutions across various domains.

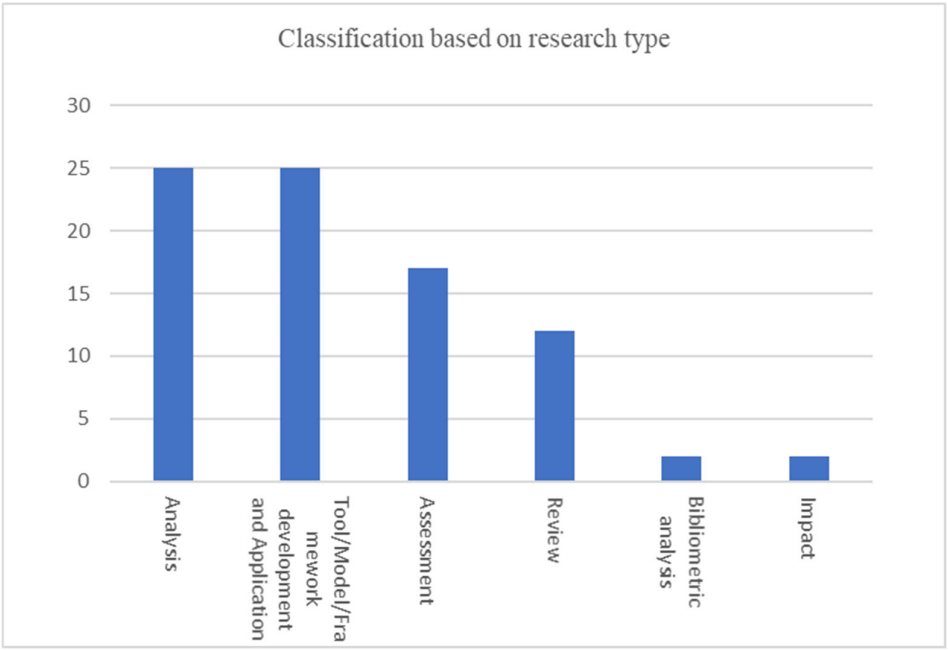


Figure 12. Occurrences of types of research.

3.7. Data Analysis on the Location of Research

The analysis of the 83 papers revealed diverse geographical focuses of sustainability research within HEIs. As shown in Figure 13, a significant number (30 papers) did not specify the location, indicating that the geographical context may not be central to these studies. However, 16 papers specifically addressed Europe, suggesting a strong regional focus, likely due to stringent sustainability policies, well-established institutional support, and ample funding opportunities that also promote international research collaborations. Asia and South America are also prominent areas of study, reflecting their growing research outputs in sustainability. The analysis underscores that while Europe leads in this area, research on sustainability spans across all dimensions—social, economic, and environmental—globally, highlighting the universal relevance of sustainability issues in higher education.

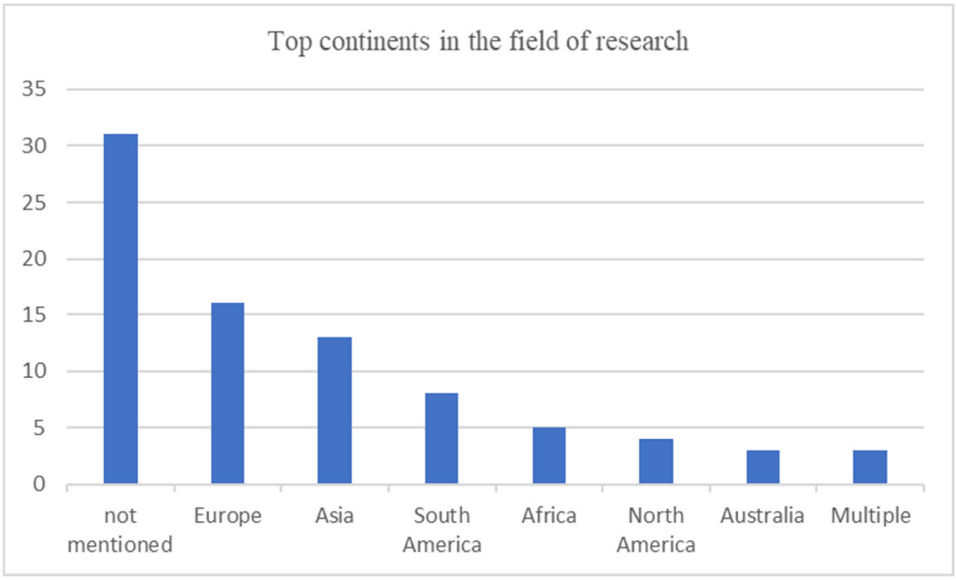


Figure 13. Top continents in the field of research.

4. Content Analysis

For authors in the field of higher education, the significance of sustainability has taken center stage as institutions increasingly recognize their essential role in shaping a responsible and environmentally conscious future. Scholars and institutions are delving into innovative practices that integrate sustainable principles, aiming to equip students with the knowledge and skills necessary for addressing global challenges. Hence, this section is aimed at an extensive content analysis centered on the topic of sustainability assessment in HEIs. As part of this study, a thematic analysis was conducted on the selected set of 83 papers. Each paper was meticulously reviewed and categorized into six distinct themes, based on the aims and objectives described in the abstracts and paper content. The themes and the papers categorized under each are detailed in the following sections.

4.1. Analysis of Sustainability Implementation in Higher Education Institutions

This section explores a set of research papers focusing on how progressively sustainability has gained importance in HEIs over the years, analyzing the efforts put in by institutions to embrace SDGs and their implications on the institutes. These publications reflect how the education community has embraced the concept of sustainability and ensured that they closely monitor their effect on the institution. As depicted in Table 5, several papers propose methods for deploying indicators, integrating sustainability, and assessing sustainability performance in HEIs. For instance, Griebeler et al. [15] and Zahid et al. [16] discuss frameworks for deploying indicators and integration and implementation outlooks of sustainability in HEIs, respectively, while others provide overviews and assessments of the status and implementation of sustainability practices in specific regions or countries. For example, Bautista-Puig and Sanz-Casado [17] focus on sustainability practices in Spanish HEIs, while Alsharif et al. [18] examine campus sustainability in Saudi Arabian universities. In contrast, many focused on review methods and the challenges in assessing sustainability performance in HEIs. Gutiérrez-Mijares et al. [19] review methods for assessing sustainability performance, while Caeiro and Azeiteiro [20] discuss sustainability assessment in HEIs.

Table 5. Analysis of sustainability implementation in HEIs.

Themes	Year	Authors	Focus
Analyzing the integration of sustainability in HEIs	2022	Griebeler et al. [15]	Analyzes the incorporation of SDGs at HEIs and proposes testing a set of indicators that is related to SDG descriptions and targets to assess HEIs' contribution to the SDGs.
	2021	Zahid et al. [16]	Seeks to create a framework for integrating sustainability into HEIs and suggests a measure called the Sustainability Integration and Implementation Index.
	2021	Bautista-Puig and Sanz-Casado [17]	Examines the integration of sustainability practices in both Spanish public and private universities (SUE) by analyzing the correlation between these practices within their institutions.
Reviewing the past literature related to sustainability in HEIs	2023	Gutiérrez-Mijares et al. [19]	Reviews past literature of various methods employed to assess sustainability in universities.
	2022	Simina [21]	Assesses the past literature and identifies the main topics that are focused on the research of university sustainability.
	2020	Caeiro and Azeiteiro [20]	Presents research from diverse locations and institutions encompassing various subjects, with the overarching goal of assessing the effectiveness and influence of different implementation dimensions of sustainability assessment.
Identifying the possible consequences of sustainability implementation in HEIs	2022	Veidemane [22]	Investigates the opportunities and challenges in developing internationally acceptable indicators by studying existing ranking systems.
	2020	Alsharif, Peters and Dixon [18]	Investigates the current initiatives related to sustainability planning and actions on university campuses in Saudi Arabia. Additionally, it explores the possibilities and obstacles associated with promoting and facilitating advancements in this regard.
	2018	Zainordin Nabd Ismail [23]	Explores the merits and drawbacks of current sustainability assessments in HEIs by evaluating the previous declarations concerning sustainability at these institutions.

The publications underscore the growing significance of sustainability in the present era, emphasizing the imperative for HEIs to adopt SDGs across all departments. The researchers stress the vital role of tracking progress to ensure effectiveness. Proposed evaluation methods include constructing frameworks, establishing implementation indices, and exploring correlations between sustainability indicators. The success of integration hinges on judiciously selecting relevant sustainability indicators in each dimension. Notably, the studies reveal a stronger focus on the environmental and educational dimensions of sustainability in universities, with comparatively milder contributions to the social and economic dimensions. Consequently, there is a compelling need for institutional leaders to intensify their efforts and enhance awareness among stakeholders. For instance, the research on Spanish public and private universities identified the importance of a sustainability plan and green offices apart from the realization that sustainability is not embedded in the whole HEI system's strategies and policies [19]. Moreover, the identified opportunities for development include the potential for developing internationally comparable indicators for sustainability in HEIs [22]. Additionally, Simina [21] highlights the importance of

sustainability for enhancing university competitiveness, suggesting an opportunity for HEIs to leverage sustainability initiatives for strategic advantages. The case studies conducted across university experts identified barriers like institutional constraints, the lack of resources, cultural factors, the lack of supportive leadership, the lack of sustainability knowledge and awareness among senior management, and an absence of sustainability-related legislation policy or strategic direction in the HEIs, which, in turn, reinforced the need for effective sustainability indicators and more generalized assessment tools to form a functional ranking system.

These publications project the need for further research into and the development of effective frameworks, methods, and indicators for assessing and integrating sustainability in HEIs. This involves addressing identified challenges and leveraging opportunities to enhance sustainability practices. There is also a call for more comprehensive sustainability assessments in HEIs, with a focus on strengths and weaknesses to guide future improvements as realized through case studies in Saudi Arabian HEIs [23]. Moreover, exploring the relationship between sustainability and competitiveness in HEIs and identifying strategies to enhance both aspects could be a promising avenue for future research [21]. Overall, the papers provide valuable insights into the current state, challenges, and opportunities regarding sustainability in HEIs, as well as directions for future research and action.

4.2. Comprehensive Sustainability Assessments

In the journey toward achieving sustainability, HEIs play a crucial role, requiring thorough and extensive evaluations of their sustainability strategies. This section initiates an investigation into scholarly inquiries dedicated to thorough sustainability appraisals within HEIs, encompassing social, environmental, and economic aspects. These aspects collectively offer a comprehensive perspective on an institution's sustainability endeavors. Our examination classifies these research endeavors into categories based on the focus and approach, with the goal of shedding light on the array of methods used in evaluating sustainability comprehensively. As illustrated in Table 6, the research and associated case studies conducted in Brazilian universities [24–26] have made efforts to identify several institutional and educational indicators. This aims to ensure that the tools developed are holistic and applicable to any university, regardless of geographic location. These studies highlight indicators that can enable HEIs to integrate sustainability into every stratum of development, including strategies and policies. In contrast, case studies from Egyptian universities and the Abdullah Gul University in Turkey have focused on how these indicators can effectively create frameworks, models, and tools to assess sustainability in HEIs. Methods such as life-cycle analysis, multi-criteria analysis, principal component analysis, the entropy weighting method, the qualitative scoring method, and the analytical hierarchy process (AHP) were employed in most of the papers [27,28]. R programming language was used in research to categorize the indicators for assessment [29].

Table 6. Comprehensive sustainability assessments.

Themes	Year	Authors	Focus
Sustainability indicators for comprehensive sustainability assessment in HEIs	2023	Paz et al. [24]	Investigates the institutional sustainability indicators to equip Brazilian institutions to support municipalities to eliminate their deficits and contribute to social responsibility through critical document analysis.
	2019	Da Silva, De Azevedo, and Almeida [25]	Proposes comprehensive set of indicators that can be used as a holistic tool to measure sustainability using literature review and expert validation to find all the indicators that can be employed to assess the sustainability of HEIs in Brazil.
	2018	Da Silva, Junior et al. [26]	Explores a series of sustainability indicators implemented in Brazilian HEIs to function as a means of evaluating and revealing sustainability practices and initiatives.

Table 6. *Cont.*

Themes	Year	Authors	Focus
	2018	Brito, Rodríguez, and Aparicio [30]	Contributes to the development of indicators suitable for assessing the effectiveness of sustainability efforts by evaluating the satisfaction of teachers and students.
Frameworks/models and tools for sustainability assessment in HEIs	2023	Du et al. [27]	Proposes a sustainable campus framework and two hierarchy tools for China HEIs: quick and in-depth analysis tools that can be employed for general and targeted analysis, respectively.
	2023	Gulcimen et al. [28]	Assesses the Abdullah Gul University Sumer Campus sustainability by integrating environmental life-cycle assessment (E-LCA), life-cycle costing (LCC), and social life-cycle assessment through life-cycle sustainability assessment approaches focusing on social and environmental dimensions.
	2023	Cao et al. [31]	Develops a model to evaluate the quality and sustainability of HEIs by employing principal component analysis (PCA) and the entropy weighting method (EWM).
	2022	Yurchyshena, Shaulska, and Naumova [29]	Categorizes HEIs based on the potential sustainability indicators using R programming language.
	2021	Yan and Wang [32]	Addresses this need by creating models to evaluate the health and sustainability of higher education systems to assess the well-being and sustainability of HEIs.
	2021	Venezia and Pizzutilo [33]	Develops a self-evaluation tool for educators and HEIs to assess their commitment to education for sustainable development by proposing a composite index that allows for the isolation of individual components that contribute to sustainability and that provides an overall measure of all considered elements.
	2021	Horan and O'Regan [34]	Proposes a framework of sustainability indicators to help policymakers in the international ranking process by referring to the UI GreenMetric and STARS ranking systems and comparing it to the available national sustainability data.
	2020	Du et al. [35]	Creates recommendations that can be used as input for the development of a sustainable assessment tool (SAT) tailored to the current sustainability development stage of Chinese HEIs.
	2020	Adenle et al. [36]	Introduces the modifiable campus-wide appraisal model (MOCAM), offering a comprehensive spatial-based information and assessment framework for stakeholders by addressing the underutilization of social media and spatial-based indicators.
	2019	Blasco, Brusca, and Labrador [37]	Adds to the sustainability assessment literature and extends the discussion by investigating its impact on university performance and examining the connections among the three dimensions of sustainability in universities.
	2018	Li, Gu, and Liu [38]	Puts forward a novel strategy employing a qualitative scoring method (QSM) and an analytical hierarchical process (AHP) to identify and rank the primary sustainability indicators for university campuses at the local level in Australia.
	2018	Shariman and Mahmud [39]	Evaluates the efficiency of the university's sustainability programs using the context, input, process, and product (CIPP) evaluation model.
	2018	Ulkhaq et al. [40]	Analyzes the disparity between the university's efforts in promoting sustainability and the students' perceptions of these initiatives.

Table 6. *Cont.*

Themes	Year	Authors	Focus
Sustainability tools—review, comparison, and application	2023	Konbr, Elsayed, and Elboshy [41]	Utilizes two global sustainability assessment systems for campuses—the UI GreenMetric and STARS—and examines past studies to develop a proposed framework suitable for the Egyptian context.
	2022	Doocy et al. [42]	Evaluates the effectiveness and credibility of STARS in sustainability tracking of HEIs.
	2022	Galleli et al. [43]	Evaluates the UI GreenMetric and the Times Higher Education Ranking according to the Berlin Principles' framework by analyzing their evaluation criteria.
	2021	De La Poza et al. [44]	Investigates the sustainability achievements and reporting levels according to the Times Higher Education Ranking criteria by modeling and quantifying the impact of the sustainability of HEIs.
	2021	Kutty, Shalabi, and Ibrahim [45]	Conducts a bibliometric analysis of existing tools and techniques for sustainability assessment in HEIs.
	2019	Drahein, De Lima, and Da Costa [46]	Evaluates a method for appraising the implementation of sustainability at seven HEIs in the southern region of Brazil, utilizing the sustainability assessment for higher technological education (SAHTE) model.
	2019	Findler et al. [47]	Examines the extent to which sustainable assessment tools (SATs) can gauge the influence of HEIs on sustainable development (SD).
	2019	Parvez and Agrawal [48]	Determines the sustainability performance of HEIs in India by referring to STARS and UI GreenMetric world ranking systems.

Similarly, research attempts have been made to provide a guide to developing a composite index for self-evaluating sustainability initiatives by employing scoring and weighting methods. These studies revealed that the social category of indicators and curriculum strengthening require more focus by stakeholders of the HEIs. In addition, research found that weighting methods, social media, and spatial based indicators are underutilized in the field of sustainability assessment. Major research at universities such as the Tanta University campus in Egypt and a Brazilian university [41,48] aligns with existing SATs, particularly STARS, the UI Green Metric, and the Times Higher Education Ranking systems, which are extensively utilized globally. The research underscores that these tools are holistic and recommends their application in HEIs. However, it also points out that these tools do not account for the inter-relationships among the indicators and tend to give weight to all indicators equally.

Challenges identified include the complexity of sustainability assessment in HEIs, the need for greater institutional commitment and resources, and the difficulty of measuring the effectiveness of sustainability initiatives. However, there are opportunities for addressing these challenges through collaboration, knowledge sharing, and capacity building among HEIs. Moreover, there are opportunities for leveraging technology and data analytics to improve sustainability assessment and reporting. Despite these contributions, there are still research gaps identified in the literature. These include the need for more comprehensive and standardized sustainability indicators and assessment tools tailored to different contexts and regions. There is also a lack of consensus on the most effective approaches for integrating sustainability into higher education systems, as well as gaps in understanding the impacts of HEIs on sustainable development. Future research directions include the development of standardized sustainability assessment frameworks and indicators, the exploration of innovative methodologies and technologies for sustainability

assessment, and the enhancement of collaboration and knowledge exchange networks among HEIs globally. Additionally, there is a need for longitudinal studies to evaluate the long-term impacts of sustainability initiatives in HEIs and to monitor progress toward achieving sustainability goals. Furthermore, there is potential for expanding research into the integration of sustainability across different disciplines and curricula within HEIs.

4.3. Sustainability Assessment in the Environmental Dimension

Studies in this section relate to the environmental dimension of sustainability, mainly focusing on green building, sustainable transportation, reduction of the carbon footprint, reduction of the ecological footprint, and the existing tools in the field that serve help policymakers develop efficient assessment methods, based on which the papers are categorized into several sub-themes as shown in Table 7. All the studies ultimately lead to the goal of reducing the negative effects of climate change and environmental degradation. Extensive research has been conducted on carbon footprint evaluation in campuses, which showcases the profound importance of keeping this under control in the context of drastically increasing global-warming threats.

Table 7. Sustainability assessment in the environmental dimension.

Themes	Year	Authors	Focus
Environment sustainability assessment initiatives, models, and methods for evaluation	2023	Ali and Agbozo [49]	Investigates the impact of campus-based sustainable initiatives on the environmental quality of university campuses, focusing on universities from eight countries by employing random-effects and fixed-effects models to analyze the results.
	2022	Obrecht, Feodorova, and Rosi [50]	Introduces a novel conceptual framework designed to systematically analyze the incorporation of environmental sustainability into study programs and courses.
	2022	Menon and Suresh [51]	Evaluates the environmental sustainability of an HEI by developing a conceptual assessment model by utilizing the fuzzy-logic method and applying this to a university in India to modify their processes if required.
	2020	Buzaboon et al. [52]	Reviews existing ranking systems to evaluate the environmental sustainability of HEIs.
	2018	Freidenfelds, Kalnins, and Gusca [53]	Creates a framework based on indicators for evaluating the enduring environmental sustainability of HEIs.
	2018	Sanchez et al. [54]	Suggests a multi-criteria method for choosing and prioritizing campus sustainability indicators at an HEI (PUC-Rio, Brazil), with a specific emphasis on one of its environmental agenda thematic areas.
Green campus initiatives to aid environmental sustainability	2022	Dalla Gasperina et al. [55]	Demonstrates the advantages of implementing smart campuses and how this can help HEIs to achieve SDGs.
	2022	Chen, Cheng, and Li [56]	Aims to create a framework for upgrading higher education institution (HEI) campuses by integrating sustainability indicators with usage demands and by exploring the connection between usage demands and sustainability indicators in retrofitting, using sample campuses for analysis.
	2021	Adenle et al. [57]	Identifies indicators contributing to smart campus in HEIs and develops an RII (relative importance index) to prioritize them.
	2019	Khoshbakht, Gou, and Dupre [58]	Suggests frameworks and policy implications related to investment decisions, facility management, operational quality control, and planning and design to improve the effectiveness of green building initiatives in HEIs.

Table 7. *Cont.*

Themes	Year	Authors	Focus
Sustainable mobility	2023	Cappelletti et al. [59]	Evaluates the sustainable mobility of a university of Foggia using the life-cycle approach.
Carbon footprint evaluation and assessment of HEIs	2023	Ma et al. [60]	Offers a comprehensive review of university carbon footprints, employing innovative methods. By providing valuable insights into the dynamics of academic institutions' carbon footprint, it equips policymakers with information to enhance sustainable development and proposes relevant policy suggestions.
	2023	Giusti et al. [61]	Examines the ecological and societal consequences linked to consumption footprint behaviors in traditional in-person and virtual classes at a Brazilian higher education institution, both prior to and during the pandemic.
	2023	Martínez-Acosta et al. [62]	Determines the carbon footprint of digital activities in a company during the confinement caused by COVID-19 through a challenge-based learning methodology.
	2023	Maulidevi et al. [63]	Proposes an intelligent model to monitor the carbon footprint in HEIs and evaluates the sustainability status of the buildings under study.
Ecology footprint strategies	2019	Genta et al. [64]	Outlines strategies for a green campus project at an Italian university and assesses the ecological footprint (EF) reduction in various scenarios involving open spaces. Data from various university departments and administrative units are gathered to quantify the impact of campus activities on the ecosystem.

Some studies embrace the concept of a smart campus to make the campus more sustainable. Tools like the random-effects model, the fixed-effects model, and the RII (relative importance index) have been utilized in many studies. Real-time monitoring of data has been made possible in research by developing a dashboard application. This section helps in educating about how the environmental element can be effectively integrated in education in HEIs. The research also emphasizes the importance of the environmental dimension in ensuring sustainability. For instance, several studies such as those by Ali and Agbozo on universities across eight countries [49], Menon and Suresh [51], and Sanchez et al. in a Brazilian university [54], propose methodologies or frameworks for the environmental assessment, development, and selection of sustainability indicators, as well as decision-making processes related to campus sustainability. These studies aim to propose methods for better sustainability assessments that are more comprehensive and easier to communicate. Others, like Obrecht et al. [50] and Dalla Gasperina et al. [55], focus on assessing the integration of sustainability into higher education curricula and practices. Meanwhile, works by Buzaboon et al. [52] and Freidenfelds et al. [53] evaluate existing ranking systems and definitions of environmentally sustainable HEIs. In addition to these research contributions, there is a recognized need for more comprehensive frameworks and validated methodologies for environmental assessment and sustainability integration. Challenges often revolve around institutional resistance to change, the lack of consensus on sustainability criteria, and the complexity of balancing multiple stakeholder interests. However, opportunities lie in leveraging technological advancements, fostering interdisciplinary collaborations, and enhancing stakeholder engagement to address these challenges.

Consequently, future directions in this field include the further refinement and validation of assessment frameworks, integration of sustainability across all aspects of HEIs, development of transparent and inclusive ranking methodologies, and exploration of innovative solutions like Arduino and machine learning to reduce the ecological footprint of university campuses. Additionally, there is a growing emphasis on digital sustainability and the need to quantify and mitigate the digital carbon footprint of HEIs, as highlighted by Martínez-Acosta et al. [62] and other studies. Overall, these papers collectively contribute to advancing knowledge and practices for promoting sustainability in higher education.

4.4. Sustainability Assessment in the Field of Education

This section focuses on how sustainability can be integrated into the education dimension of sustainability and how HEIs can equip themselves with a tool that can effectively measure and track how successful their measures are in their sustainability journey. In addition, this section delves into diverse indicators of education that contribute to the sustainability of HEIs. Innovation, curriculum, green technology/software/IT, competencies, and research are the major areas of focus of research and, hence, the themes identified in Table 8. Hence, the general theme across these papers revolves around fostering sustainability within HEIs through educational, organizational, and structural interventions.

Table 8. Sustainability assessment in the field of education.

Theme	Year	Authors	Focus
Factors for innovation for sustainability	2018	Washington-Ottombre and Bigalke [65]	Creates a comprehensive research study of innovations in campus sustainability and unravels the intricate factors influencing the development of innovations.
Sustainability through green IT/green technology/green software.	2023	Alamsyah et al. [66]	Identifies indicators that enables the understanding and development of green IT in the education industry.
	2023	León-Toro et al. [67]	Analyzes past research in the area to identify the main concepts and methodologies implemented.
Quality assessment and evaluation of educational indicators of sustainability	2023	Schlickmann and Bortoluzzi [68]	Develops a model to assess the quality of environmental education in HEIs by using multi-criteria methodology to aid the policymakers in decision making.
	2021	Luna-Krauletz et al. [69]	Creates and validates an instrument to evaluate the integration of environmental education in HEIs.
	2020	Wahyuningsih et al. [70]	Assesses the education indicator within the Faculty of Engineering at Universitas Egeri Semarang concerning its ranking in the UI GreenMetric. A mixed evaluation approach was employed to examine the curriculum, study implementation plans, and sustainable research.
Assessment of sustainability in curricula	2019	Trad [71]	Develops and applies a tool for assessing the incorporation of sustainability into the curriculum.
	2020	Kioupi and Voulvoulis [72]	Creates an evaluation framework for educational institutions to assess the impact of their educational programs on sustainability. This involved reviewing how well the intended learning outcomes align with the enabling conditions for a sustainability vision based on the SDGs.
	2023	Lemarchand et al. [73]	Evaluates the integration of sustainability in the curricula by analyzing keywords using the AASHE criteria.
	2022	Poza-Vilches et al. [74]	Examines the presence of SDGs in curricula of HEIs with reference to education, humanities and environmental sciences.

Table 8. *Cont.*

Theme	Year	Authors	Focus
Analysis and identification of competencies for sustainability	2023	Hammer and Lewis [75]	Proposes a framework of competencies for sustainability and analyzes their importance in a university in Switzerland.
	2022	Kioupi and Voulvoulis [76]	Develops a framework that aids the achievement of competencies for sustainability and applies this to a case study.
	2022	Lozano et al. [77]	Constructs two frameworks to investigate the integration of innovation through competencies in HEIs.
	2021	Imara and Altinay [78]	Offers an extensive summary of the literature dedicated to the incorporation of competencies related to education for sustainable development (ESD) into teacher education over the past ten years.
	2021	Galofré and Segalas [79]	Proposes a methodology to assess the sustainable competencies and SDGs in engineering degree education at HEIs.
	2021	Brundiers et al. [80]	Investigates the alignment of competencies in sustainability programs.
	2021	Martín-Garin [81]	Analyzes the pedagogical tools developed by a multidisciplinary team of sociologists and psychologists to embed soft-skill competencies in students.
	2021	Leal Filho et al. [82]	Discusses findings from a cross-national investigation that aims to determine the significance attributed by teaching staff in various HEIs to the desired competencies in sustainable development.
	2020	Abubakar, Aina, and Alshuwaikhat [83]	Evaluates the progress in establishing institutional frameworks for sustainable development in universities in Saudi Arabia as most of the universities in the global south lack this.
Analysis of sustainability through research in education	2023	Saric et al. [84]	Describes the valued added to HEIs by the implementation of research and development services and their associated weakness.
	2018	Kessler [85]	Concentrates on examining the existing literature to identify research gaps in sustainability within higher education, particularly in the design aspect. It underscores the significance of research for the effective integration of sustainability into higher education curricula and suggests guidelines to bridge the current gap between research and curriculum design.

The research highlights that in addition to traditional contributions from research and curricula, the IT section is now gaining attention as well. This shift is underscored by Alamsyah et al. [66], who identified indicators that enable the understanding and development of green IT in the education industry, demonstrating universities' increasing competence in integrating sustainability across various sectors. Additionally, Hammer and Lewis [75] focused on identifying and cultivating sustainability competencies at a Swiss university, which was aimed at fostering these qualities among both students and faculty. Hence, HEIs also ensure that students, teachers, and other administrative staff have enough competencies to embrace sustainability and to put in effort, and contribute to the sustainability of their institution. Competencies like problem solving, futures thinking, values thinking, and interpersonal and strategic competencies have taken their place in research, proving how deeply stakeholders are striving to integrate sustainability. A considerable number of papers also analyze existing assessment tools to check their feasibility and ease of implementation in every institute. This section also gives insights into various frameworks to

equip researchers to track their research and to align them toward sustainability. The set of papers also reinforce the need for funders to include research in their implementation plan and to find several approaches to fund the implementation to ensure efficiency.

Several frictional factors identified include institutional inertia, resource constraints, and the need for interdisciplinary collaboration to address complex sustainability issues effectively. Additionally, there may be challenges in defining and measuring sustainability competencies and integrating them into existing curricula. Opportunities lie in leveraging technology, fostering partnerships with stakeholders, and adopting innovative pedagogical approaches to enhance sustainability education and practices within HEIs. However, there is a need for further exploration of the effectiveness of specific interventions, such as green IT development and sustainability curriculum integration, across different institutional contexts and disciplines. Additionally, gaps exist in understanding the long-term impacts of sustainability education on student competencies and institutional practices. Further research is also needed to develop comprehensive assessment frameworks and indicators for evaluating sustainability performance in HEIs. Hence, the future of research in education lies in the effective implementation of the latest technologies in methodologies and finding accurate means to collect data. Future research in this domain could delve deeper into the effectiveness of specific sustainability-focused teaching methods, the impact of technology on sustainability education, and strategies for enhancing competencies that align with evolving global sustainability goals. Additionally, exploring the scalability and long-term impact of sustainable initiatives within HEIs could be a promising avenue for further investigation.

4.5. Sustainability Assessment in the Economic/Financial Dimension

This section analyzes various factors in the financial dimension that can contribute to sustainability development in HEIs. Moreover, the history of evolution of research in this field is also examined. With fewer papers under this theme, sub-themes were not identified, as shown in Table 9. Scholars have delved into sustainable financial practices, exploring areas such as budgeting, resource allocation, and investment strategies.

Table 9. Sustainability assessment in the economic/financial dimension.

Theme	Year	Authors	Focus
Methods to evaluate and analyze financial sustainability in HEIs	2018	Cernostana [86]	Establishes a set of indicators for evaluating the financial sustainability of a private higher education institution (PHEI).
	2018	Fedulov, Borisov, and Fedulov [87]	Examines the characteristics of monitoring the financial and economic performance of HEIs, identifying integral (group) indicators and exploring key approaches for assessing them.
	2021	Abad-Segura and González-Zamar [88]	Investigates the evolution of sustainable economic development through scientific production and research trends in HEIs at a global level.

While Cernostana [86] focuses on measuring the financial sustainability of private HEIs in Latvia, emphasizing the importance of financial stability for long-term viability through quantitative assessments of key financial metrics such as revenue streams, expenditure patterns, and asset management practices, Fedulov et al. [87] propose a different approach. They introduce a methodology for evaluating the financial sustainability of HEIs using "compatible" cognitive maps. This approach likely combines qualitative and quantitative elements, incorporating stakeholders' perceptions and expert knowledge to develop a holistic understanding of financial sustainability. Abad-Segura and González-Zamar [88] take a broader view, examining sustainable economic development in HEIs within the framework of the SDGs. This paper likely adopts a global perspective, considering the role of HEIs in

promoting economic sustainability alongside environmental and social objectives. Hence, the findings emphasize the critical role of financial sustainability in supporting the broader goals of environmental and social responsibility within academic institutions. However, there may be a lack of standardized approaches and benchmarks for comparison across different types of HEIs. Additionally, the focus on private institutions in [86] may overlook important insights applicable to public or nonprofit HEIs. Even though Abad-Segura and González-Zamar [88] highlight economic development within the SDG framework, they do not provide specific tools or methodologies for evaluating financial sustainability. Consequently, future research could bridge these gaps by developing comprehensive frameworks that integrate financial sustainability metrics with environmental and social indicators, aligning with the principles of sustainable development. Comparative studies across different types of HEIs and regions could also elucidate the common challenges and best practices for achieving financial sustainability. Moreover, there is an opportunity to explore innovative methodologies, such as cognitive mapping, in assessing financial sustainability, potentially enhancing the accuracy and relevance of evaluation models. Additionally, integrating economic development goals with broader sustainability objectives could foster a more holistic approach to HEI planning and management.

4.6. Sustainability Assessment in the Social Dimension

This section analyses the set of research studies that contributes to the social dimension of sustainability, which can help HEIs to improve their social presence by working on factors like leadership, community participation, soft skills, etc. The sub-themes identified include papers that track the implementation of sustainability or study the impact of ESG (environmental social governance), intellectual capital, organizational transformation, and green HRM, as illustrated in Table 10.

Table 10. Sustainability assessment in the social dimension.

Theme	Year	Authors	Focus
Social responsibility integration and sustainability	2021	Pizzutilo and Venezia [89]	Proposes a framework for the integration of social responsibility into HEIs after developing relevant set of indicators.
Intellectual capital influence on sustainability	2020	Pedro, Leitão, and Alves [90]	Establishes a structural equation model to examine the correlation between the intellectual capital of HEIs, with the aim of investigating whether the sustainable development practices adopted by HEIs have any connection with the quality of life experienced by their stakeholders.
Integration of SDGs into strategy	2023	Filho et al. [91]	Examines HEIs, focusing on the extent to which SDGs are integrated into their strategic activities.
	2021	Grano and Prieto [92]	Measures the HEIs' strategic commitment level by developing qualitative sustainability indicators with reference to the Times Higher Education Ranking system.
Green human resource management (GHRM)	2023	Asfahani [93]	Investigates how green HRM affects the environmental performance and competitive advantage of HEIs in Saudi Arabia by utilizing PLS-SEM models.

Table 10. *Cont.*

Theme	Year	Authors	Focus
Evolution of ESG practices	2023	Lima et al. [94]	Investigates past research to study the evolution of ESG themes at universities.
	2020	Niedlich et al. [95]	Contributes to the discourse on sustainability governance in HEIs by scrutinizing the significance of sustainability assessment and presenting an assessment tool influenced by systemic thinking, focused on a "governance equalizer".
Organizational change management	2021	Rieg, Gatersleben, and Christie [96]	Conducts a systematic quantitative literature review to identify the initiatives taken to aid organizational change management in HEIs.
Sustainability transformation	2021	Fahim et al. [97]	Focuses on the transformation of the quality of HEIs to achieve sustainability by conducting a SWOT analysis.

The research into the social dimension of sustainability in HEIs has provided valuable insights into various aspects, including strategic initiatives [91,92]; green human resources [93], illustrated through a case study in Saudi Arabia; leadership dynamics; environmental, social, and governance (ESG) practices; and change management strategies. Scholars have explored how HEIs can align their strategies with social sustainability goals, fostering inclusive and equitable practices within academic and administrative frameworks. The integration of green human resources emphasizes the importance of cultivating a workforce that is socially responsible and environmentally conscious. Leadership studies have delved into the role of university leaders in driving social sustainability, emphasizing the need for visionary and responsible leadership. Interestingly, ESG considerations have gained prominence, emphasizing accountability and ethical practices in higher education. Additionally, research on change management explores the challenges and opportunities in implementing social sustainability initiatives across HEIs. Future work in this domain may involve refining strategies for effective integration, exploring innovative leadership models, and further assessing the impact of ESG practices on social sustainability within HEIs. Continued research efforts will contribute to the evolution of socially responsible practices in HEIs, fostering positive societal impacts and sustainable development.

In summary, the research delves deeply into overall sustainability assessments, with a specific focus on environmental sustainability, revealing its widespread acceptance compared with other dimensions. Moreover, the majority of researchers have utilized existing SATs for assessing HEIs. While some have attempted to modify these frameworks by adding indicators through surveys, questionnaires, and expert opinions, others have used these tools to identify areas for improvement in their sustainability development efforts. The most prominently used tools are STARS, the UI Green Metric, and the Times Higher Education Ranking system, which are globally recognized in HEI sustainability rankings. Despite this, researchers believe that these tools lack comprehensive sustainability elements, particularly in strategy and policies. Furthermore, the process of adopting sustainability assessments is time-consuming and involves continuous learning, and, thus, it is not yet fully integrated into HEIs. Challenges related to the difficulty of measurement, feasibility, and associated costs are some of the major barriers identified. Figure 14 provides a summary of the review of past research on sustainability assessment in HEIs. This spider graph utilizes a two-tiered structure to effectively convey information. The first tier highlights the main themes prevalent in most applications, with the circle sizes reflecting their frequency across domains. Within each theme, a secondary layer details specific keywords, representing nuances, with the sub-circle sizes indicating their prominence based on density and related research publications. This intricate graph offers a concise overview of sustainability as-

sessment in HEIs, showcasing ongoing research and practical applications in the field. The study pays particular attention to education, elucidating key competencies and the broader application of educational sustainability in both research and curriculum development. However, it also sheds light on the comparatively limited attention given to the social and financial dimensions of sustainability by scholars. Furthermore, the research observes the emergence of SATs across various aspects of sustainability development within HEIs.

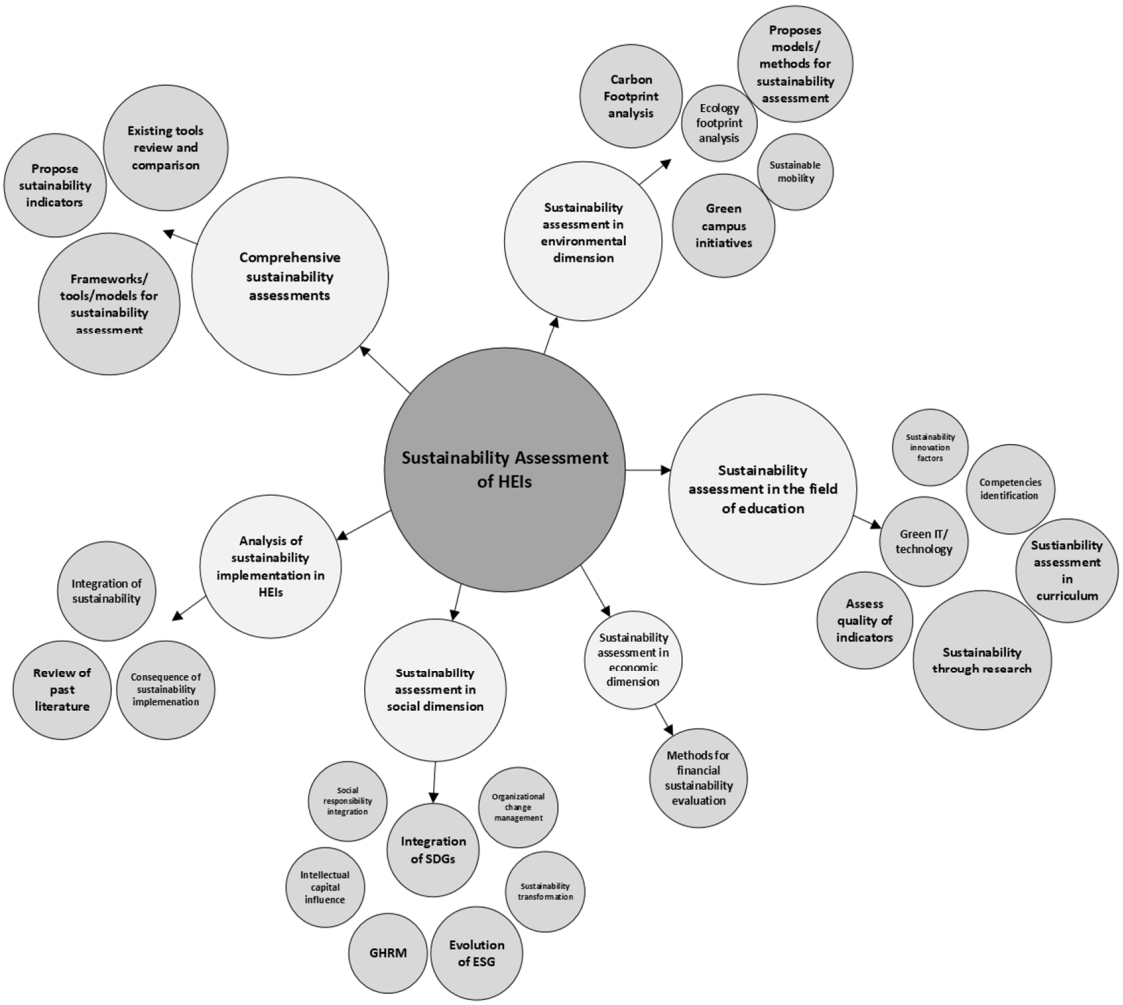


Figure 14. Summary of content analysis on sustainability assessment in HEIs.

5. Conclusions

Sustainability development in education has a pivotal role in shaping responsible and informed global citizens. Integrating sustainability into educational frameworks not only imparts essential knowledge about environmental, social, and economic challenges but also fosters a mindset that values long-term well-being over short-term gains. Sustainability assessment in HEIs is crucial for fostering responsible practices. It plays a crucial role in evaluating and guiding institutions toward environmental, social, and economic sustainability. By incorporating sustainability into curricula, institutions cultivate a generation of conscious individuals equipped to address future challenges. These assessments provide a framework for measuring progress, encouraging continuous improvement and accountability. HEIs, as influential hubs of knowledge, contribute significantly to shaping a more sustainable and resilient society.

The initial step of this work was to conduct a detailed examination of the sustainability assessment in HEIs through a content analysis of the literature in this field. The content analysis yielded crucial findings that highlight the advancements in the field of sustainability assessment, especially in HEIs. Considering different dimensions of sustainability, like

the social, environmental, and economic dimensions, sheds light onto the various tools and techniques used to assess sustainability. Moreover, it also paves the way for possible areas of research in the future.

The body of literature surveyed in this research encompasses a wide array of topics, primarily centering on comprehensive sustainability assessments within HEIs. The discourse within these papers is notably dedicated to scrutinizing the infusion of sustainability principles into HEIs. These contributions span investigations into various sustainability tools and methodologies, the subject areas of research, and the ramifications of implementing sustainability policies. A recurring theme throughout these analyses is the escalating importance of sustainability within HEIs, who are urging the ubiquitous adoption of SDGs across all institutional departments. This emphasis on progress tracking, facilitated through evaluation mechanisms like frameworks and implementation indices, emerges as paramount for ensuring the efficacy of sustainability endeavors. Nonetheless, a discernible trend in the literature underscores a disproportionate emphasis on environmental and educational facets, revealing a pressing need for heightened attention and awareness among stakeholders. Particularly noticeable are the identified barriers, such as inadequate leadership support and a shortage of sustainability dissemination. These reviews offer invaluable insights into the myriad of challenges, opportunities, advantages, and disadvantages encountered by HEIs in their pursuit of sustainability. Of particular note is the scrutiny of extant SATs, accompanied by recommendations advocating holistic methodologies that account for motivational factors and that leverage emerging technologies such as machine learning. Within the environmental dimension, a focal point is on curtailing the carbon and ecological footprints, while educational research explores avenues such as innovation, curriculum design, and the fostering of sustainability competencies. The financial dimension accentuates the importance of sustainable fiscal practices, while the social dimension delves into strategic initiatives, cultivating green human resources, navigating leadership dynamics, implementing ESG practices, and deploying effective change management strategies. Future research trajectories are envisioned to encompass scaling and the evaluation of the enduring impact of sustainable initiatives, crafting tailored financial metrics, refining strategies for social sustainability, and assessing the influence of ESG practices on societal outcomes within HEIs. These findings constitute a robust foundation, offering actionable insights and serving as a pragmatic roadmap for institutions endeavoring to seamlessly integrate sustainability into their operational paradigms.

The bibliometric analysis delved deeply into the landscape of sustainability assessment within HEIs, employing a rich dataset sourced from the Scopus database. Through systematic analysis, the study unveils emerging trends, key contributors, and prevalent themes in this dynamic field. Utilizing VOSviewer for visualization, the analysis begins with a co-occurrence map based on text data extracted from the titles and abstracts of selected publications. This map shows the complex network of terms prevalent in sustainability assessment research within HEIs. Notably, terms like "student", "sustainable development", and "assessment tool" emerge as central nodes, underlining the multifaceted nature of research in this domain. Furthermore, direct connections with "sustainability assessment" highlight the robust growth of sustainability-focused scholarship within the educational sphere. Additionally, the analysis extends to keyword co-occurrence, revealing prominent themes and research areas. Keywords such as "higher education institutions", "sustainable development", and "sustainability" dominate the landscape, underscoring the pervasive influence of sustainability principles in educational contexts. Notably, "environmental impact" emerges as a focal point, reflecting a growing emphasis on environmental sustainability within HEIs. The examination of country co-authorship patterns unveils a global landscape of sustainability research, with European countries like the United Kingdom and Spain leading the charge. However, notable contributions from countries across Asia and South America underscore the widespread recognition of sustainability's importance in education. Furthermore, the analysis of document types and research methodologies clarifies the diverse approaches employed in sustainability assessment research. The exam-

ination revealed a significant amount of research aimed at creating assessment tools and frameworks, underlining the importance of monitoring sustainability efforts. Studies also assessed sustainability across various institutional aspects, with a particular emphasis on environmental sustainability and stakeholder competencies.

In the field of sustainability assessment in HEIs, there are several possible future areas of work that can be explored to further enhance and advance sustainability practices within these institutions. Some possible future areas of work include:

- Enhancing data collection and analysis techniques and developing more systematic and standardized methods for collecting and analyzing sustainability data in HEIs to provide more accurate and reliable information on the institution's sustainability performance. This can involve the use of innovative technologies such as sensors and data analytic platforms to track and measure various sustainability indicators, including energy consumption, waste management, water usage, greenhouse gas emissions, and student engagement in sustainability activities.
- Widening the focus of sustainability implementation and including more areas while implementing sustainability to contribute to better accuracy. For instance, including more motivational factors to increase awareness can contribute to faster sustainability implementation and better accuracy of assessment.
- Increasing research on student acceptance of the sustainability initiatives and possible changes that can be implemented to speed up the process.
- Real-time tracking of sustainability implementation while adopting any sustainability assessment method to ensure efficiency at every step of implementation.
- Ensuring the collaboration of all stakeholders, students, faculty, staff, administrators, local communities, and industry partners in all aspects of sustainability implementation.
- Focusing on environmental sustainability exists in the majority of institutions. Encouraging all institutions to work together to progress all the domains in sustainability can make an easy path toward achieving SDGs.

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