Original Paper

Assessing campus sustainability practices.
A systematic literature review

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Keywords: campus sustainability; higher education institutions; sustainability assessment; sustainability framework; systematic literature review.

Abstract. *Higher education institutions (HEIs) play a critical role in advancing global sustainability goals through their operations, academic programs, and community engagement. This systematic literature review evaluates sustainability practices in HEIs, focusing on assessment frameworks and methodologies. Using a PRISMA-based process and Scopus as the primary database, 39 relevant articles were analyzed. The findings*

reveal the adoption of diverse frameworks, including the STARS system and UI GreenMetric, as well as the integration of sustainability principles into curricula, campus operations, and research. However, challenges such as resource constraints, limited stakeholder awareness, and infrastructural barriers hinder effective implementation. The study highlights the need for comprehensive, localized assessment tools to enhance HEIs' contributions to promoting sustainability. Future research should develop innovative frameworks and strategies to foster sustainability literacy and practices within academic communities. By addressing current trends, challenges, and opportunities, this review advances the discourse on sustainability in HEIs and offers actionable insights for enhancing institutional practices.

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1. Introduction

Higher Education Institutions (HEIs) play a pivotal role in shaping future generations and addressing global sustainability challenges. As centres of knowledge creation and innovation, HEIs are uniquely positioned to influence sustainable development practices both locally and globally. Recent years have seen a growing focus on sustainability in higher education, driven by the need to address pressing environmental, social, and economic concerns (Henderson et al., 2022). Incorporating sustainability into HEIs can profoundly impact campus operations, academic outcomes, and community engagement.

Sustainability initiatives within HEIs typically aim to reduce carbon emissions, enhance resource efficiency, and promote social responsibility through equitable policies and community programs. By integrating sustainability into their operations and curricula, HEIs can act as exemplars and drivers of sustainable change.

HEIs function as "small cities," managing significant resources and generating waste. Without sustainable practices, these activities can lead to considerable environmental degradation. Establishing environmental management systems allows universities to not only comply with environmental standards but also integrate sustainability principles into teaching, research, and outreach. Such

systems can enhance operational efficiency while mitigating environmental impacts (Alshuwaikhat and Abubakar, 2008).

A holistic approach to sustainability also emphasizes public engagement and social accountability. Engaging students, faculty, and the broader community fosters inclusivity and encourages collaborative efforts to address sustainability challenges. Initiatives like green buildings, sustainable transportation, and energy efficiency programs highlight the potential for campuses to lead by example. Beyond reducing negative environmental impacts, sustainability strategies contribute to broader economic, social, and environmental well-being.

Despite their potential, HEIs face significant barriers to implementing sustainability programs. Challenges include competing institutional priorities, limited resources, and organizational complexity. Effective sustainability efforts require embedding sustainability principles within institutional culture, governance, and policies, rather than treating them as isolated initiatives. Evaluating the effectiveness of sustainability programs is crucial for identifying gaps, ensuring accountability, and fostering continuous improvement (Basheer et al., 2023).

Systematic assessment tools enable HEIs to measure progress, highlight areas for enhancement, and demonstrate accountability. Without a structured evaluation framework, institutions risk losing focus and failing to meet sustainability goals. Assessments provide critical insights for stakeholders, administrators, and policymakers, facilitating data-driven decision-making and strategic planning (Ma et al., 2022). By examining global frameworks and methodologies, HEIs can refine their approaches to achieving sustainability.

This study aims to address the following research questions:

1. To what extent has research on sustainability assessment in higher education institutions been undertaken?
2. What frameworks and methodologies are used to evaluate sustainability initiatives?
3. What areas require further investigation to improve sustainability practices in HEIs?

Understanding sustainability assessment processes enables HEIs to adapt frameworks to their specific needs, addressing gaps and leveraging opportunities. The findings of this study contribute to academic literature and support global efforts to achieve sustainable development goals.

The structure of this paper is organized as follows. Section 2 outlines the methodology, employing the PRISMA framework for systematic reviews. Section 3 presents the results and discussion, highlighting key findings and implications. Section 4 concludes the paper with recommendations and suggestions for future research.

2. Methodology

This study employs the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure a transparent and replicable selection process. PRISMA is widely utilized in systematic literature reviews to filter and refine relevant studies from large databases (Page et al., 2021). While traditionally used in health sciences, PRISMA has increasingly been applied in sustainability research, particularly in evaluating environmental and higher education sustainability studies (Zhu et al., 2022; Alghamdi et al., 2023). By adopting PRISMA, this study ensures a structured approach to identifying and selecting relevant literature on campus sustainability assessment.

This study uses Scopus as the principal source for gathering articles pertinent to the research issue. Scopus was selected because of its status as one of the largest and most reputable academic databases, encompassing a diverse array of fields. While Scopus provides extensive coverage, potential limitations include the exclusion of non-English sources and articles outside indexed journals, which could marginalize relevant findings.

A search was performed utilizing the following query: TITLE-ABS-KEY ("campus sustainability") AND TITLE-ABS-KEY ("Assess"). This combination was crafted to ensure that the selected articles concentrate on campus sustainability and related evaluative techniques. The keywords were chosen based on their relevance to the research topic and their capacity to encompass a broad range of sustainability assessments.

To assess the effectiveness of the chosen search query, we conducted preliminary tests with alternative keyword combinations, including:

- TITLE-ABS-KEY ("higher education sustainability") AND TITLE-ABS-KEY ("assessment frameworks")
- TITLE-ABS-KEY ("university sustainability") AND TITLE-ABS-KEY ("evaluation methods")

- TITLE-ABS-KEY ("green campus initiatives") AND TITLE-ABS-KEY ("performance measurement")

The preliminary tests indicated that while alternative queries retrieved additional studies, they also increased the inclusion of articles that were tangentially related to campus sustainability assessments, reducing specificity. The final keyword selection was determined based on a balance between precision and recall, ensuring the focus remained on relevant academic contributions to sustainability assessment within HEIs. A total of 116 articles that met the criteria were successfully identified at completion of the search process.

Subsequently, the study implemented a series of filtering procedures to guarantee that the examined papers correspond with the research issue, namely campus sustainability and its evaluation methodologies. Figure 1 illustrates the article filtration procedure employed in this study utilizing the PRISMA framework.

The initial filtering phase involved the titles, during which the study excluded publications with titles irrelevant to the research subject. Criteria for exclusion included terms unrelated to sustainability, such as financial audits or unrelated assessments. This method led to the removal of 41 articles, resulting in 75 articles considered pertinent.

The second filtering phase concentrated on the abstracts. At this point, the abstracts of each publication were assessed to confirm their relevance to the research topic. 17 papers were removed from this evaluation due to their abstracts not corresponding with the research topic. Subsequent to this phase, 58 articles fulfilled the criteria. A comprehensive full-text search was performed to verify the complete accessibility of the pertinent articles. Three papers were inaccessible and were therefore excluded, resulting in 55 articles for subsequent analysis.

The final filtering stage entailed a comprehensive examination of the complete content of the surviving articles. At this juncture, the study scrutinized each article meticulously to verify its pertinence to the subject of campus sustainability. Consequently, 16 articles were removed for lacking relevance to the subject matter. The filtering technique resulted in the selection of 39 articles for subsequent study. Figure 1 depicts the PRISMA procedure.

To determine whether the selected 39 papers comprehensively represent the field, we performed additional validation steps. First, we examined whether the selected studies frequently cited each other. The analysis showed that a majority of the selected papers referenced key sustainability assessment frameworks and

prior research in HEIs, reinforcing their relevance. Additionally, a manual review of references in the 39 selected studies identified a few frequently cited works that were not included in our dataset. While this suggests that some critical studies may have been overlooked, the overall representation of the key literature was deemed sufficient. Lastly, thematic mapping of the selected studies aligned with major sustainability trends in HEIs, confirming that the dataset's composition accurately reflected the broader discourse on campus sustainability assessment.

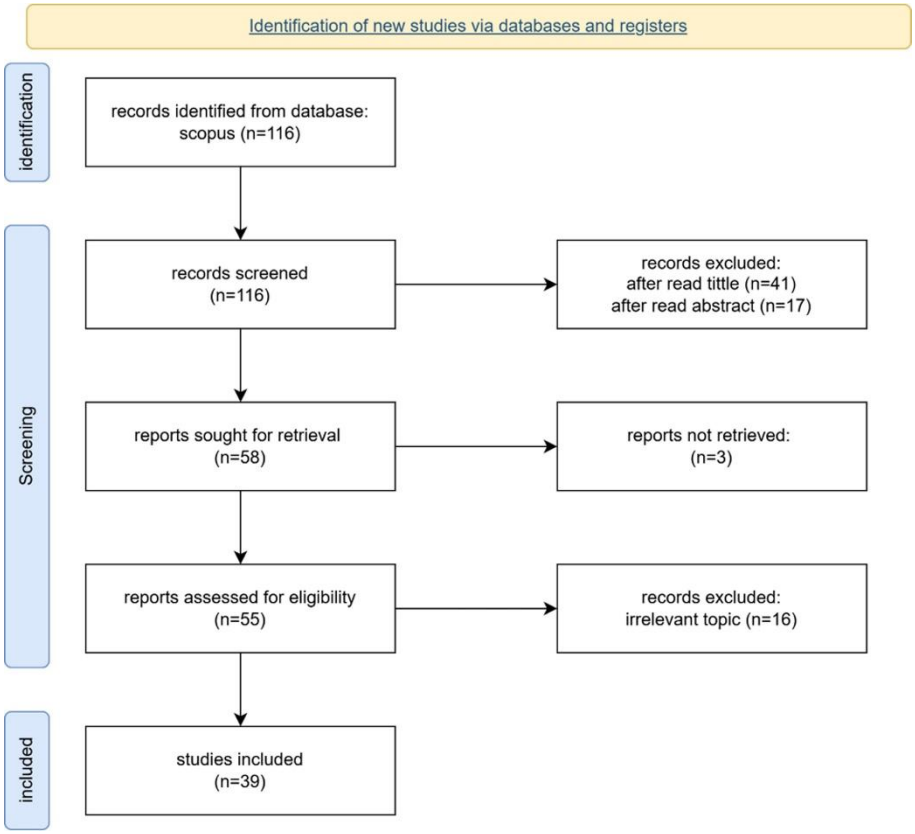

Figure 1. PRISMA procedure

3. Results and Discussion

3.1 Descriptive statistics

A vital aspect of systematic analysis is comprehending the temporal distribution of publications. Figure 2 depicts the quantity of articles concerning campus sustainability categorized by their year of publication. This analysis seeks to discern temporal trends in research and examine the evolution of attention to this topic across time. The apex of publications transpired in 2020, denoting the year with the greatest number of articles in this dataset. This increase likely reflects growing global awareness following the adoption of the Sustainable Development Goals (SDGs) in 2015 and their progressive integration into institutional frameworks.

In contrast, the fewest publications were noted during the initial years of the analysis period, specifically from 2003 to 2011, when publications were scarce, with certain years reporting no papers whatsoever. This highlights the relatively recent emergence of campus sustainability as a research priority.

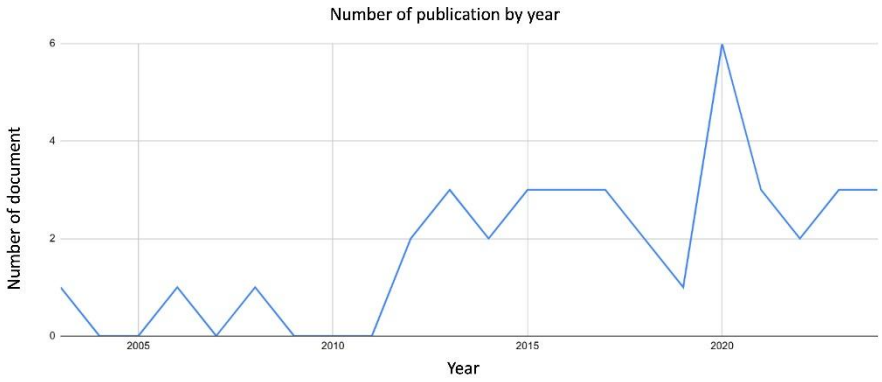

Figure 2. Number of publications by year

The examination of publication counts by journal seeks to pinpoint the principal sources for research pertaining to campus sustainability. This is crucial for identifying key outlets and supporting researchers in locating credible reference sources. Figure 3 illustrates the quantity of publications by journal pertaining to this subject. The International Journal of Sustainability in Higher Education

stands out with 12 articles, likely due to its specialized focus on sustainability and higher education. Sustainability (Switzerland) follows closely with 11 pieces, reflecting its broad scope and commitment to sustainability topics.

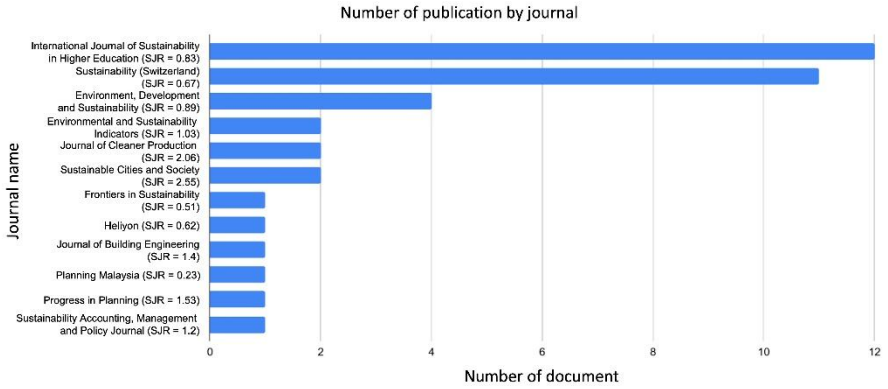

Figure 3. Number of publications by journal

The examination of the most prolific authors in campus sustainability research identifies key contributors to the field. Figure 4 highlights Adenle, Alshuwaikhat, and Abubakar, each with three publications, as the most active authors. Their research primarily focuses on sustainability frameworks, environmental management systems, and policy integration in higher education institutions. Additionally, Aina and Chan with two publications each, complement the dataset by contributing relevant insights, including case studies and practical applications, as the most active authors. Their work emphasizes sustainability frameworks and environmental management systems in higher education.

An analysis of citation counts reveals influential publications in campus sustainability. Figure 5 identifies Alshuwaikhat and Abubakar's (2008) paper with 653 citations as the most referenced work. Subsequent studies have built upon their findings by adapting and expanding the University Environmental Management System (UEMS) model to suit diverse institutional and regional contexts, further validating its impact. Its high citation count highlights its impact in shaping sustainability discussions and guiding institutional practices.

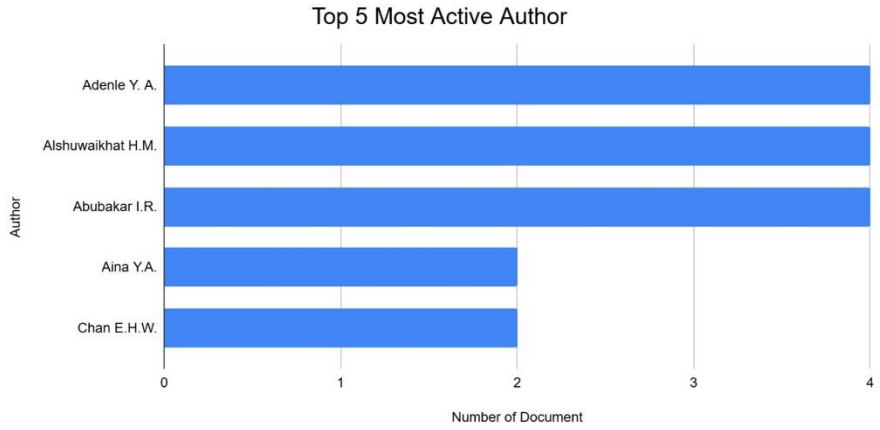

Figure 4. Top 5 most active author.

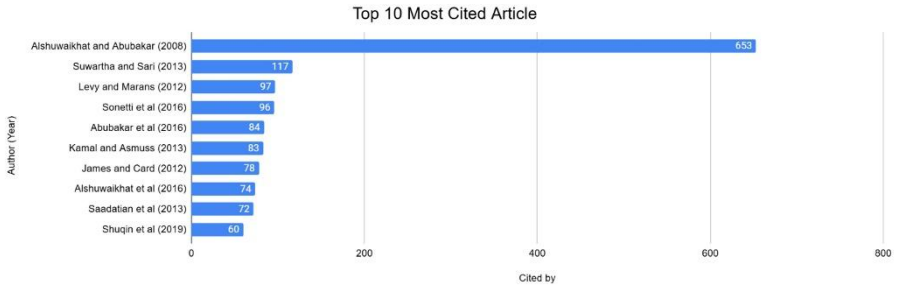

Figure 5. Top 10 most cited article

3.2 Keywords co-occurrence analysis

To analyze the thematic structure of campus sustainability research, we employed VOSviewer for keyword co-occurrence analysis. VOSviewer groups keywords into clusters based on their co-occurrence patterns in the selected studies, forming visualized networks where closely related terms appear together (van Eck & Waltman, 2010). This clustering method helps reveal underlying themes in the literature by identifying frequently associated terms and grouping them into meaningful categories. The keyword co-occurrence method provided valuable insights by highlighting dominant themes and confirming expected

research trends. It reinforced findings from our literature review by emphasizing well-established areas such as environmental policies and energy efficiency in HEIs.

In the visualized network, a network map is formed by applying nodes and lines connecting the nodes. A node symbolizes a particular bibliographic item, such as keywords, article, journal, institution, or country. The node size denotes the counting of the evaluated item, i.e., citation or occurrence. The link denotes the co-citation, co-occurrence, or collaboration relationship. There are three steps to construct the map. In the first step, a similarity matrix is calculated. VOSviewer uses a similarity measure known as the association strength (van Eck & Waltman, 2010; van Eck et al., 2006). Using this association strength, the similarity s_{ij} between two items i and j is calculated as

$$s_{ij} = c_{ij} / (w_i \cdot w_j) \quad (1)$$

where c_{ij} denotes the number of co-occurrences of co-cited of items i and j; and w_i and w_j denote either the total number of occurrences (or co-cited) of items i and j or the total number of co-occurrences (or co-cited) of these items. The second step is constructing the map based on the similarity matrix obtained in the previous step. Let n denote the number of items to be mapped. The mapping technique constructs a two-dimensional map in which the items 1, 2, …, n are located in such a way that the distance between any pair of items i and j reflects their similarity s_{ij} as accurately as possible. Items that have a high similarity should be located close to each other, while items that have a low similarity should be located far from each other. The idea of the mapping technique is to minimize a weighted sum of the squared Euclidean distances between all pairs of items. The higher the similarity between two items, the higher the weight of their squared distance in the summation. To avoid trivial maps in which all items have the same location, the constraint is imposed that the average distance between two items must be equal to 1. In a mathematical notation, the objective function to be minimized is given by

$$V(\mathrm{k}_1, \mathrm{k}_2, \ldots, \mathrm{k}_n) = \sum_{i<j} s_{ij} \left\| k_i - k_j \right\|^2 \quad (2)$$

where the vector $\mathrm{k}_i = (k_{i1}, k_{i2})$ denotes the location of item i in a two-dimensional map; and $||\bullet||$ denotes the Euclidean norm. Minimization of the objective function is performed subject to the constraint

$$\frac{2}{n(n-1)}\sum_{i<j}\left\|k_i - k_j\right\| = 1 \quad (3)$$

The optimization problem discussed in the second step does not have a unique globally optimal solution. It is of course important to produce a consistent result, i.e., the same co-occurrence matrix should therefore always yield the same map (ignoring differences caused by local optima). To accomplish this, in the third step, it is necessary to transform the solution obtained for the optimization problem discussed in the second step. There are three transformations applied, namely, translation (the solution is translated in such a way that it becomes centered at the origin), rotation (the solution is rotated in such a way that the variance on the horizontal dimension is maximized), and reflection (if the median of k_{11}, …, k_{n1} is larger than 0, the solution is reflected in the vertical axis; on the other hand, if the median of k_{12}, …, k_{n2} is larger than 0, the solution is reflected in the horizontal axis). Those three transformations are sufficient to ensure consistent results.

Figure 6 illustrates the outcomes of the network visualization, emphasizing the relationships among keywords derived from the examined literature. The identified clusters were compared against the full-text analysis of the 39 selected studies to assess their alignment with key research themes. The clusters largely reflected major topics in sustainability assessment, including environmental impact, institutional sustainability policies, and student engagement. This assessment confirms that the clusters largely align with major research themes such as environmental impact, sustainability policies, and student engagement, but also reveals some unexpected patterns, such as the lower frequency of terms related to climate adaptation. Prior research has similarly assessed campus sustainability using different evaluation methods (Ulkhaq et al., 2016, 2019a; Pramono et al., 2017; Setyorini et al., 2016). However, some clusters contained broad or overlapping terms that required further contextual interpretation. For example, the cluster around "sustainability curriculum" included terms related to both policy implementation and pedagogical strategies, highlighting the multidimensional nature of sustainability education.

The results categorized the terms into six groups based on proximity and connection, illustrating the primary themes of this research. Table 1 presents a comprehensive analysis of the keywords in each cluster. These clusters highlight key themes, including 'environmental management,' 'policy frameworks,' 'assessment methods,' 'institutional governance,' 'community engagement,' and 'education for sustainability.' These themes reflect distinct yet interconnected

focal points in campus sustainability research. The analysis of term clustering enables researchers to discern principal subject areas and their interconnections, offering a systematic view of academic discourse around sustainability in higher education. Table 1 presents a comprehensive analysis of the keywords in each cluster. These clusters represent separate yet interrelated research domains, reflecting diverse focal points in campus sustainability research.

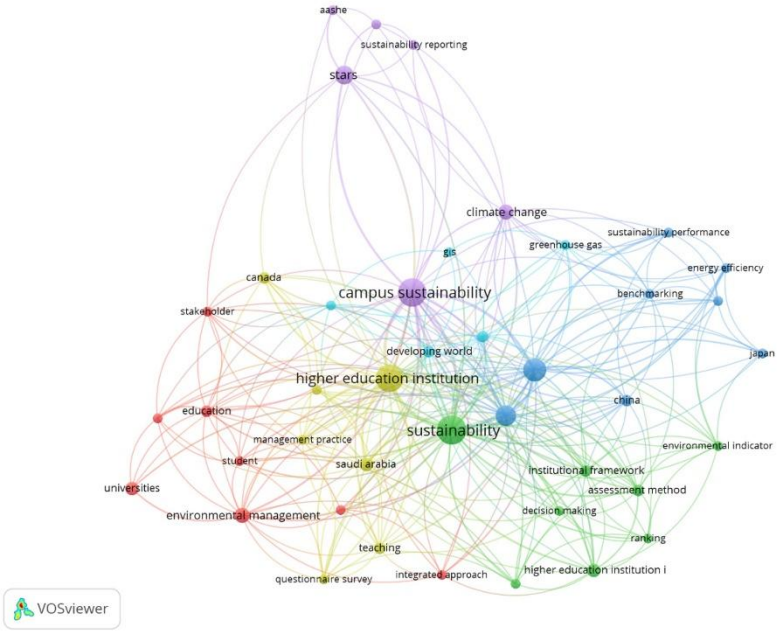

Figure 6. Keywords co-occurrence network

The findings of the network visualization highlight multiple facets, such as education, environmental management, performance assessment, and institutional governance. Each cluster represents a distinct perspective, providing valuable insights for further research. This thematic diversity underscores the multifaceted nature of sustainability in HEIs, emphasizing the need for a comprehensive approach to studying and promoting this domain.

Table 1. Cluster analysis

Cluster	Keywords
cluster 1 (Education and Environmental Management)	education, environment, environmental management, green campus, integrated approach, stakeholder, student, universities
cluster 2 (Institutional Frameworks and Sustainability Assessment)	academic research, assessment method, decision making, environmental indicator, higher education institution, institutional framework, ranking, sustainability
cluster 3 (Sustainability Performance and Regional Development)	benchmarking, China, energy efficiency, Japan, sustainability performance, sustainable development, university campus, university sector
cluster 4 (Governance and Management Practices)	Canada, governance approach, higher education institutions, management practice, questionnaire survey, Saudi Arabia, teaching
cluster 5 (Campus Sustainability Reporting and Learning)	AASHE, campus sustainability, climate change, organizational learning, stars, sustainability reporting
cluster 6 (Developing World and Sustainability Assessment)	developing world, environmental education, GIS, greenhouse gas, sustainability assessment

An overlay visualization was also generated to illustrate the temporal dynamics of term occurrences. Figure 7 presents this visualization, depicting the average year of keyword occurrences with a color gradient ranging from blue for earlier terms to yellow for more recent terms. This analysis reveals emerging research topics, such as ranking, benchmarking, and assessment methods, indicating growing interest in measuring and quantifying sustainability performance. These findings align with recent global sustainability trends and efforts to integrate sustainability indicators into institutional practices. The results emphasize the importance of establishing standardized frameworks to ensure accountability and enhance the effectiveness of sustainability initiatives in HEIs., depicting the average year of keyword occurrences with a color gradient ranging from blue for earlier terms to yellow for more recent terms. This analysis reveals emerging research topics, such as ranking, benchmarking, and assessment methods, indicating growing interest in measuring and quantifying sustainability performance. These findings highlight the importance of establishing standardized frameworks to ensure accountability and enhance the effectiveness of sustainability initiatives in HEIs.

While the keyword groupings mostly aligned with our thematic analysis, some unexpected patterns emerged. Certain terms, such as "climate adaptation," appeared less frequently than anticipated despite its relevance in sustainability discourse. This may suggest either a gap in the selected literature or the underrepresentation of specific sustainability subtopics in our dataset.

Additionally, terms related to social equity and governance appeared in multiple clusters rather than forming distinct groups, indicating their cross-cutting relevance across various sustainability domains.

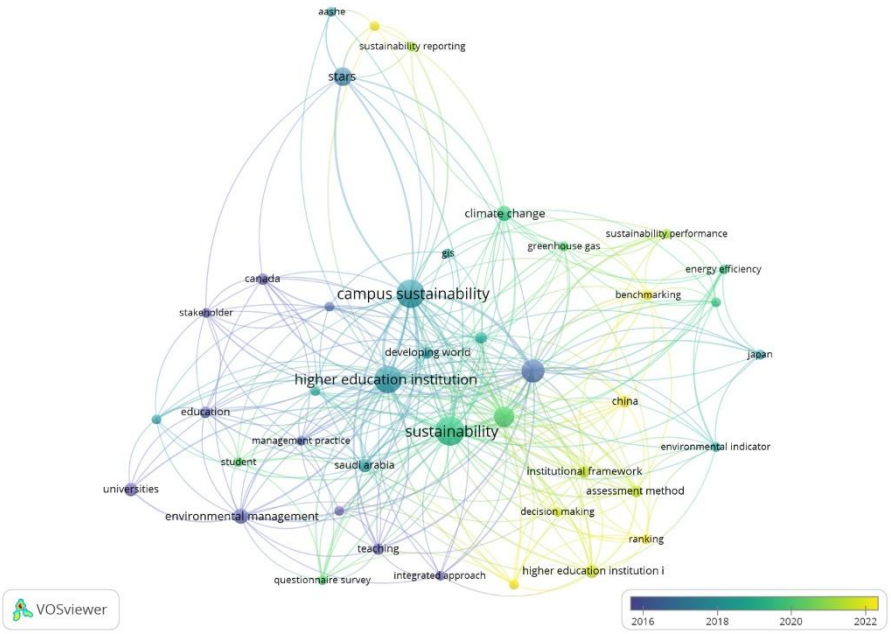

Figure 7. Keywords co-occurrence network – Overlay visualization

3.3 Article classification

Campus sustainability research is characterized by a diverse range of methodological approaches, broadly categorized into qualitative and quantitative methods (see Table 2). Qualitative research focuses on providing detailed and contextual insights through descriptive and exploratory analyses. Within this category, descriptive methods such as case studies and literature reviews are dominant. For instance, Ikegami (2020) and Chen & Vanclay (2021) utilize case studies to examine specific institutional practices, while reviews by Urbanski & Filho (2015), Suwartha & Sari (2013), and Alshuwaikhat & Abubakar (2008) synthesize existing knowledge to offer a comprehensive understanding of the field. Exploratory analyses, often employing GIS tools as demonstrated by Adenle et al. (2020), allow researchers to analyse spatial patterns and sustainability

practices across institutions. These approaches provide nuanced insights into the complexities of campus sustainability, highlighting unique challenges and innovative practices.

Table 2. Article Classification

Type of Research	Methods	Article
Qualitative	Case study	Ikegami (2020), Chen & Vanclay (2021)
	Review	Urbanski & Filho (2015), Suwartha & Sari (2013), James & Card (2012), Levy & Marans (2012), Alshuwaikhat & Abubakar (2008), Fisher (2003), Ghaus et al. (2017)
	GIS	Adenle et al. (2020)
	Case study	Alsharif et al. (2020)
	Review	Hoque et al. (2017)
Quantitative	AHP	Adenle et al. (2021)
	Case Study	Almashhour & Samara (2022), Chen & Vanclay (2022)
	Fuzzy Inference Systems	Karasan et al. (2023)
	GIS	Alshuwaikhat et al. (2017)
	QAT	Du et al. (2023)
	USFQ	Velasco et al. (2018)
	Regression	Washington-Ottombre (2024), Dawodu et al. (2024), Ulkhaq & George Joseph (2024), Lad & Akerlof (2022), Horan & O'regan (2021), Abubakar et al. (2020), Ali & Anufriev (2020), Washington-Ottombre & Bigalke (2018), Abubakar et al. (2016), Alshuwaikhat et al. (2016), Lidstone et al. (2015), Horhota et al. (2014), Huang et al. (2014), Kamal & Asmuss (2013), Lang (2019), Shuqin et al. (2019), Speer et al. (2020), Jiang & Kurnitski (2023), Saadatian et al. (2013), Beringer (2006)

Quantitative research, on the other hand, is the predominant approach due to its ability to produce measurable, generalizable, and comparative outcomes. This category encompasses a wide array of analytical techniques, including the Analytic Hierarchy Process (AHP), fuzzy inference systems, and regression analysis. Adenle et al. (2021) employ AHP to develop decision-making frameworks, while Karasan et al. (2023) utilize fuzzy inference systems to model complex sustainability variables. Regression analysis emerges as the most frequently used method, applied in studies such as Washington-Ottombre (2024) and Dawodu et al. (2024), highlighting its effectiveness in predicting and validating relationships among sustainability metrics. Additionally, methods like GIS, QAT (Du et al., 2023), and USFQ (Velasco et al., 2018) provide alternative approaches for evaluating institutional performance.

The integration of qualitative and quantitative methodologies offers significant potential for advancing campus sustainability research. While qualitative methods

excel in providing detailed, context-specific insights, quantitative approaches ensure structured, comparative, and replicable findings. Emerging methods such as fuzzy inference systems and GIS demonstrate the innovative trajectory of sustainability research, bridging the gap between qualitative depth and quantitative rigor. To further enhance the field, future studies should focus on standardizing frameworks and integrating complementary methodologies, enabling a more holistic understanding of sustainability challenges and practices across higher education institutions.

3.4 Discussion

Prior research has examined multiple facets of sustainability, encompassing student evaluations of campus sustainability, institutional sustainability frameworks, sustainability metrics for smart campuses, and the influence of individual interpretations of sustainability on perceptions of sustainability culture. Certain research has concentrated on universities in Saudi Arabia, shown by the study conducted by Abubakar et al. (2016), which indicated that while students possess a significant awareness of sustainability, their participation in campus sustainability activities is very low. A study by Abubakar et al. (2020) emphasized the absence of sustainability reporting in Saudi universities, despite the presence of sustainability visions in most institutions. Research by Alsharif et al. (2020) similarly highlighted that decision-makers' understanding and awareness of sustainability are inconsistent, with cost serving as a significant impediment. These studies illuminate the problems and potential for promoting sustainability in higher education institutions.

Research in several locales, including Adenle et al. (2021), using an analytic hierarchy process (AHP) to determine essential sustainability indicators on Nigerian campuses, with transportation recognized as the paramount sustainability factor. Simultaneously, Alexander et al. (2022) illustrated how individual interpretations of sustainability can affect campus community perceptions of sustainable culture. Moreover, numerous studies have concentrated on creating instruments or frameworks to assess campus sustainability. Alshuwaikhat et al. (2017) created a GIS-based approach to evaluate the operational sustainability of campuses, emphasizing the importance of spatial factors in sustainability assessment. These contributions highlight the variety of techniques and methodologies in campus sustainability research.

Bantanur et al. (2015) emphasized the significance of evaluating sustainability strategies in higher education institutions in India. The study indicated that knowledge of sustainability is rising; nevertheless, the application of factors like

land usage and energy differs markedly according to geographical location and climatic circumstances. Bethurem et al. (2021) investigated Allegheny College's initiatives to diminish the use of single-use plastic water bottles via refill stations, awareness campaigns, and a complimentary bottle program. Survey findings revealed a notable reduction in plastic bottle usage since 2014, although inadequate facilities in dormitories persisted as a significant obstacle.

Washington-Ottombre (2024) assessed organizational learning outcomes resulting from the use of sustainability reporting systems, including STARS, at the organizational level. The results demonstrated that although these methods effectively disseminate extensive knowledge, profound organizational learning is still constrained. A further study by Washington-Ottombre and Bigalke (2018) determined that campus sustainability innovations are affected by external factors, like climate zones, and internal factors, such as the influence of change agents. Chen & Vanclay (2023, 2021) examined the significance of "social license to operate" for international institutions, highlighting the necessity of robust community participation and benefit-sharing to improve social sustainability and institutional reputation. These studies emphasize the interaction of external influences, internal dynamics, and community interactions in promoting sustainability in higher education.

Additionally, Cho (2019) introduced a comprehensive model to elucidate student recycling behavior on campus, demonstrating that self-motivation and recycling intents substantially impact actual practice. Cohen et al. (2018) underscored the significance of interdepartmental collaboration to facilitate sustainability activities at small campuses. Dawodu et al. (2024) emphasized the necessity for more integrated participatory approaches in sustainability assessment tools for campuses, especially among Sino-foreign universities in China. This study offered a context-driven strategy incorporating many stakeholders to improve the efficacy of sustainability assessments.

The research conducted by Ali & Anufriev (2020) examined Russian institutions, emphasizing the significance of environmental management on campuses to improve sustainability; nonetheless, the results indicated a deficiency in student awareness regarding pro-environmental efforts. Hoque et al. (2017) examined sustainability practices at universities in Bangladesh, revealing that although some initiatives are present, environmental management practices on these campuses are still constrained. Horan & O'Regan (2021) established a framework of sustainability indicators applicable to higher education institutions globally, enabling the assessment and ranking of sustainability efforts. These studies highlight the disparate levels of sustainability implementation across areas and

the necessity for standardized methods to facilitate global improvement initiatives.

Additional research, like that of Horhota M. et al. (2014), uncovered behavioral impediments to campus sustainability through a multi-method approach. Their studies indicated that inadequate communication, inconvenience, budgetary limitations, and insufficient engagement were the principal barriers. Huang et al. (2014) established a quantitative decision-making framework to aid universities in strategizing and prioritizing sustainability initiatives through the STARS system. Ikegami & Neuts (2020) performed a cluster study of higher education institutions in Japan, identifying that critical elements for campus sustainability were associated with asset management and networking, which exerted a more significant impact on sustainability efforts. These studies underscore the varied problems and options in promoting sustainability within higher education institutions across multiple environments.

Jiang and Kurnitski (2023) proposed a performance-based indicator framework to assess the sustainability of university campuses moving towards carbon neutrality. This concept entails quantifying greenhouse gas emissions and evaluating social performance. Karasan A. et al. (2023) devised a fuzzy rating system to evaluate institution sustainability, integrating qualitative criteria via human assessments. Kaza et al. (2016) advocated for the advancement of sustainable leadership via professional development initiatives for professors, emphasizing curriculum modifications that tackle sustainability issues. Lad and Akerlof (2022) assessed sustainability literacy and culture inside academic institutions, underscoring the significance of data-driven evaluations and the difficulties associated with assessing and executing sustainability at the campus population level.

3.5 Assessing campus sustainability through key variables

Campus sustainability encompasses multiple dimensions that collectively determine the effectiveness of sustainability practices within higher education institutions. The key variables presented in Table 3 were identified through a systematic analysis of the 39 selected studies. These variables were extracted by conducting a thematic synthesis of recurring concepts, frameworks, and indicators employed in campus sustainability assessments. To ensure a structured extraction process, we applied a content analysis approach, categorizing sustainability-related themes based on their frequency and significance in the reviewed literature.

A qualitative coding process was employed to identify dominant sustainability aspects discussed across multiple sources. Specifically, we analyzed articles that evaluated sustainability in HEIs using established frameworks such as the STARS system, UI GreenMetric, and other institutional sustainability models (Alshuwaikhat & Abubakar, 2008; Ma et al., 2022). The variables in Table 3 emerged as common themes in sustainability assessments, reinforcing their relevance to campus sustainability discourse.

Table 3 provides a structured overview of these key sustainability variables and their significance, substantiated by prior research from the 39 selected articles. These variables have been established as critical elements in sustainability assessments, as demonstrated by their repeated emphasis across multiple studies. Each variable is linked to one or more reviewed studies, ensuring that the findings are grounded in empirical evidence. Furthermore, these findings align with existing sustainability evaluation tools such as STARS, UI GreenMetric, and the University Environmental Management System (EMS). Integrating these variables into assessment frameworks allows HEIs to systematically measure and enhance their sustainability performance.

As shown in Table 3, these variables range from environmental management and green infrastructure to financial strategies and socio-cultural aspects, providing a comprehensive framework for assessment. Environmental management and improvement focus on minimizing negative environmental impacts through pollution prevention, energy efficiency, and resource conservation. Effective waste reduction and recycling initiatives further support sustainability efforts by reducing operational footprints and fostering resource optimization. Similarly, the concept of a green campus emphasizes eco-friendly infrastructure, such as green buildings and sustainable transportation systems, which serve as tangible demonstrations of institutional commitment to environmental responsibility.

Public participation also plays a crucial role in advancing campus sustainability. Partnerships with government agencies, private sectors, and NGOs, along with community engagement through advisory panels and group discussions, facilitate inclusivity and shared decision-making processes. Universities further extend their influence through community service initiatives that raise public awareness and empower communities to adopt sustainable practices. Social justice is another integral aspect, promoting equity, fairness, and inclusiveness through institutional policies that address human rights, gender equality, health, and safety. This emphasis on social dimensions underscores the need for universities to balance environmental goals with broader social responsibilities.

Table 3. Key variables of campus sustainability

Variable	Definition	Supporting References
Environmental management and improvement	Minimize negative impacts of operation, pollution prevention, energy efficiency, resource conservation, environmental improvement, waste reduction, recycling.	Alshuwaikhat & Abubakar (2008), Washington-Ottombre (2024), Jiang & Kurnitski (2023), Machado & Davim (2023)
Green campus	Green buildings, green transportation, campus preservation.	Jiang & Kurnitski (2023), Machado & Davim (2023), Dawodu et al. (2024), Cho (2019)
Public participation	Partnerships between universities, government agencies, private sectors, and NGOs; community participation through group discussions, interviews, advisory panels.	Alshuwaikat & Abubakar (2008), Cho (2019), Cohen et al. (2018), Washington-Ottombre & Bigalke (2018), Alsharif et al. (2020)
Community service	University-led sustainability awareness projects and initiatives.	Washington-Ottombre & Bigalke (2018), Bethurem et al. (2021), Grosseck et al. (2019)
Social justice	Fair treatment, equitable distribution of social benefits, gender equality, and health promotion in sustainability policies.	Abubakar et al. (2016), Ali & Anufriev (2020), Hoque et al. (2017)
Conferences, seminars, and workshops	Platforms for interdisciplinary sustainability knowledge exchange and collaboration.	Alshuwaikhat & Abubakar (2008), Lad & Akerlof (2022), Kaza et al. (2016), Huang et al. (2014)
Sustainability in courses and curriculum	Integrating sustainability into university curricula.	Alshuwaikhat & Abubakar (2008), Grosseck et al. (2019), Ma et al. (2022), Cohen et al. (2018)
Research and development (R&D)	Developing innovative solutions to environmental and social issues, including climate change mitigation and renewable energy.	Chen & Vanclay (2022), Jiang & Kurnitski (2023), Velasco et al. (2018)
Financial management	Revenue diversification, cost efficiency in sustainability projects, and investment in green initiatives.	Ali & Anufriev (2020), Dawodu et al. (2024), Jiang & Kurnitski (2023)
Socio-cultural aspect	Promoting local cultural heritage through sustainability efforts.	Sonetti et al. (2015), Cho (2019), Velasco et al. (2018)

Additionally, universities function as hubs for research, learning, and collaboration. As indicated in Table 3, hosting conferences, seminars, and workshops creates platforms for interdisciplinary knowledge exchange, enabling academics, policymakers, and industries to address pressing sustainability challenges collectively. Incorporating sustainability into courses and curricula ensures that students acquire the skills and perspectives needed to tackle environmental, social, and economic issues, preparing them to become advocates for sustainable practices in their careers and communities. Research and development (R&D) further drive innovation, generating insights and technologies that address global challenges such as climate change, renewable energy, and poverty.

Financial management is pivotal to ensuring the long-term viability of sustainability initiatives. Universities must diversify revenue streams, manage endowment funds effectively, and reduce operational costs through energy efficiency and strategic planning. In parallel, sustainable procurement policies, such as prioritizing recycled products and eco-friendly materials, reinforce institutional commitments to responsible consumption. Socio-cultural aspects also complement these efforts by preserving cultural heritage through events and programs that promote community engagement and cultural sustainability.

While these variables provide a robust framework, challenges remain in translating concepts into measurable outcomes, particularly in areas like social justice and socio-cultural preservation. Effective integration of curriculum development, research priorities, and operational strategies requires institutional alignment and interdisciplinary collaboration. Furthermore, financial sustainability poses a persistent challenge, particularly for resource-constrained institutions, necessitating innovative financing models and partnerships. Regional adaptations also play a key role, as sustainability priorities often vary based on environmental, economic, and cultural contexts. Therefore, universities must adopt flexible, context-specific approaches to implement and assess sustainability effectively.

This analysis highlights the complexity and interconnectedness of campus sustainability variables, as summarized in Table 3, and underscores the importance of adopting holistic strategies to address both environmental and social dimensions. By leveraging these frameworks, institutions can enhance their sustainability practices and contribute meaningfully to global development goals.

4. Conclusions

This study aimed to assess campus sustainability practices through a systematic literature review, guided by three key research questions:

1. To what extent has research on sustainability assessment in higher education institutions been undertaken?

Our analysis of 39 selected studies revealed a significant increase in campus sustainability research, particularly after the adoption of the SDGs in 2015. The analysis of publication trends showed a peak in research activity in 2020, highlighting an increasing academic focus on sustainability. The most frequently cited journals in this field, including *International Journal of Sustainability in Higher*

Education and *Sustainability (Switzerland)*, indicate that sustainability research is gaining prominence within academic discourse.

2. What frameworks and methodologies are used to evaluate sustainability initiatives?

The findings indicate that sustainability assessment in higher education institutions predominantly relies on established frameworks such as STARS, UI GreenMetric, and other institutional sustainability evaluation tools. Despite their widespread use, these frameworks face challenges such as resource constraints, limited stakeholder engagement, and infrastructural barriers. The descriptive statistics also revealed that regression-based methodologies and GIS mapping are frequently employed to analyse sustainability data in HEIs.

3. What areas require further investigation to improve sustainability practices in HEIs?

The study identified research gaps based on a synthesis of the reviewed literature. The descriptive statistics revealed several *gaps* from the selected studies, including the need for more research on integrating sustainability literacy into curricula, improving institutional accountability, and developing holistic assessment methodologies. These gaps were highlighted across multiple studies that noted the lack of standardized frameworks and metrics for measuring sustainability progress in HEIs (Washington-Ottombre, 2024; Jiang & Kurnitski, 2023). Additionally, our findings suggest that innovative digital tools and participatory approaches remain underutilized, an observation supported by several reviewed studies (Dawodu et al., 2024; Chen & Vanclay, 2022). Future research should focus on refining evaluation frameworks, improving stakeholder collaboration, and leveraging advanced analytical techniques to enhance sustainability practices in higher education.

While this study provides valuable insights into sustainability assessment in HEIs, it is not without limitations. The use of PRISMA, while systematic and transparent, may introduce certain biases. Prior research has noted that PRISMA's stringent inclusion criteria often exclude exploratory or conceptual studies that provide early-stage insights into emerging trends (Page et al., 2021). Moreover, reliance on Scopus as the primary database may have led to the omission of relevant studies published in non-indexed journals, potentially limiting the diversity of perspectives included in the review (Gusenbauer & Haddaway, 2020).

Another limitation is the reliance on existing literature, which means that any biases or gaps in prior studies are inherently carried into our findings. Some aspects of sustainability in HEIs, such as the role of cultural factors or informal sustainability initiatives, may not have been adequately addressed due to the limited availability of studies in these areas (Sonetti et al., 2015). Some studies also have explored the effectiveness of university sustainability programs from students' perspectives, highlighting the gaps in university-led initiatives (Ulkhaq et al., 2017) and the variations in student attitudes toward sustainability across institutions (Ulkhaq et al., 2019b). Future research should consider incorporating mixed-method approaches, including qualitative case studies, to provide a more comprehensive understanding of sustainability practices in HEIs.

Despite these limitations, this study offers a structured and evidence-based analysis of campus sustainability assessment. By acknowledging these challenges, we aim to enhance the transparency and credibility of our findings. Future research should explore alternative methodologies and additional data sources to address these limitations and further advance the discourse on sustainability in higher education institutions.

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