A holistic approach to sustainability in higher education institutes: social, economic, educational, and mobility perspectives

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Higher education institutions (HEIs) are pivotal in driving the transition to sustainability. HEIs educate future generations and adopt sustainable practices, setting an example for private and public sector organizations. This paper reviews studies and initiatives covering the fields of education, physical/mental health, economy, social sustainability, and transportation. This review aims to: (1) Identify key obstacles hindering the implementation of sustainable HEI practices. (2) Explore measures/indicators to evaluate the effectiveness of HEI sustainability initiatives. (3) Provide key recommendations to promote sustainability in HEIs. Our conclusions emphasize the critical role of HEIs in advancing social sustainability. Recommendations include developing sustainability plans, integrating sustainability into academic programs, enhancing health and well-being, ensuring economic viability through cost−benefit analyses, and promoting sustainable transportation. Stakeholder engagement, strategic assessment, and transparent reporting are essential for accountability and improvement. By implementing these strategies, HEIs can establish resilient and sustainable communities, serving as exemplary models for broader societal change.

KEYWORDS

higher-education, social sustainability, green campus, health and environment, transportation, education for sustainable development, sustainable campus initiatives

1 Introduction

Over the past five decades, the environmental crisis has worsened, characterized by climate change, biodiversity loss, and pollution. This crisis extends beyond the environment, impacting the global economy and human health, particularly among socioeconomically vulnerable groups and developing countries. To ensure a decent standard of living for the projected 10 billion people by 2050, significant changes in our development, production, and consumption habits are urgently needed (UN Environment, 2019). These changes necessitate a global shift towards sustainable development.

1.1 Sustainable development

The concept of sustainable development offers a framework for achieving progress that integrates economic and social well-being, ensuring a balance between present needs and preserving the ability of future generations to meet their own needs (Ozili, 2022).

The concept emerged in 1987 with the Brundtland Report, issued by the World Commission on Environment and Development (WCED) (Brundtland, 1987). This landmark report defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987).

At its core, sustainable development integrates three key dimensions: environment, society, and economy. Recently, a fourth dimension—the institutional dimension—has been proposed. This dimension emphasizes the importance of strong governance structures and inclusive decision-making processes within institutions and communities, fostering effective implementation of sustainable practices (Machado and Davim, 2023).

The 1992 United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, marked a significant turning point for the concept of sustainability. A key outcome of the conference was Agenda 21, a comprehensive program outlining strategies for achieving sustainable development in the 21st century. Agenda 21 emphasized the need for innovative approaches in education, resource conservation, and sustainable economic practices (United Nations Conference on Environment and Development, 1992). Building upon this momentum, the United Nations adopted the ambitious 2030 Agenda for Sustainable Development (United Nations, 2015). This agenda serves as a global blueprint for achieving peace and prosperity, with the Sustainable Development Goals (SDGs) at its core. These 17 goals, encompassing everything from poverty eradication to responsible consumption, provide a specific framework for translating the principles of sustainability into action (The 17 Goals, 2015).

1.2 Sustainability in higher education institutions (HEI)

The concept of "sustainability in higher education" emerged with the 1972 Stockholm Declaration, highlighting the critical link between human society and the environment for achieving environmental sustainability (Alshuwaikhat and Abubakar, 2008). Higher education institutions (HEIs) play a vital role in shaping the future by educating and empowering upcoming generations. They hold a unique responsibility in fostering environmental awareness and equipping future leaders and citizens with the knowledge and skills to understand and implement sustainability principles (Amaral et al., 2020; Jain et al., 2017).

Beyond their educational role, HEIs are microcosms of society, often resembling small cities with extensive infrastructure and resource consumption (Anthony Jnr, 2021; Jain et al., 2017). These small cities necessitate the implementation of green initiatives and sustainable practices such as waste reduction, water conservation, and energy efficiency. Such efforts not only contribute to a healthier environment but also improve the quality of life within the institution

and enhance its economic performance. Furthermore, HEIs can serve as powerful examples for other institutions, promoting sustainability practices across the wider community (Anthony Jnr, 2021).

HEIs have a critical role in fostering a culture of sustainability through a two-pronged approach (Jain et al., 2017; Amaral et al., 2020; Cortese, 2003). Firstly, they can integrate sustainability principles into formal education (courses, professional development) and informal learning opportunities (workshops, events) to equip students and staff with the knowledge and skills to become environmentally responsible citizens. Secondly, HEIs can implement green initiatives, including waste reduction, water conservation and energy efficiency within their physical infrastructure to minimize their environmental footprint and serve as models for the surrounding community.

A growing number of HEIs are actively pursuing these goals. Examples include incorporating sustainability into curricula, adopting environmental management systems (ISO 14001), publishing sustainability reports, and collaborating on international sustainability efforts (Filho, 2011; Amaral et al., 2020; Jain et al., 2017; Dawodu et al., 2022). Furthermore, robust assessment tools like the Sustainability Tracking, Assessment & Rating System (STARS) and Green Metric rankings have been developed to measure progress and identify areas for improvement (Dawodu et al., 2022).

Several international and national initiatives have been established to address the challenges faced by HEIs in implementing sustainability practices:

- Green University Networks initiative—established by the United Nations Environment Program's Environmental Education and Training Unit (EETU). This initiative aims to align HEIs with environmental, low-carbon, and sustainability principles in education, campus operations, and student engagement. Currently, Green Campus Networks are being established in Kenya, Uganda, Morocco, West Asia, and West Africa, with China already having an operational network (UN Environment, 2017).
- ISCN—the International Sustainable Campus Network—a global platform for HEIs to share insights, concepts, and optimal approaches for achieving sustainable campus operations while integrating sustainability into research and education (International Sustainable Campus Network, 2011).
- AASHE—the Association for the Advancement of Sustainability in Higher Education—a US association dedicated to establishing sustainability innovation and actions, as well as promoting the development of future sustainability leaders (AASHE, 2023).
- EAUC—the Environmental Association for Universities and Colleges—the environmental and sustainability association in the UK and Ireland (EAUC, 2024).
- Other initiatives include national green campus programs such as the initiative in Israel, operated by the Israeli Ministry of environment Protection (MOEP, 2021), and green campus Ireland (GreenCampus, 2024), operated by the Foundation for Environmental Education (FEE).

Despite an increase in sustainability efforts, full implementation of sustainability across campus remains elusive for many HEIs (Mohammadalizadehkorde and Weaver, 2018). Challenges include a lack of institutional commitment, limited resources, and insufficient staff involvement. Concerns exist regarding "greenwashing" where

HEIs declare voluntary sustainability goals for self-promotion without consequences for non-achievement (Mohammadalizadehkorde and Weaver, 2018). A comprehensive review by Amaral et al. (2020) identified lack of funding, resources, and leadership support as the most significant barriers. Other common hurdles include a general lack of interest and a shortage of relevant expertise within the institution.

1.3 Scope and objectives of the review

This review expands on the existing body of knowledge regarding sustainability in HEIs. Concurrently with this paper, we publish an additional paper that explores the physical aspects of sustainability, including an examination of infrastructure, green buildings, energy use, water management, waste reduction, and gardening practices (Barnett-Itzhaki et al., 2025). The current review delves into additional sustainability domains relevant to HEIs, including physical and mental health, economic considerations, social sustainability, transportation, education, and marketing. Our primary objectives are threefold:

1 Identifying barriers: We aim to identify the key obstacles hindering the implementation of sustainable practices in these various areas within HEIs
2 Evaluating success: We will explore measures and indicators that can be used to evaluate the effectiveness of sustainability initiatives and operations undertaken by HEIs
3 Providing key recommendations to promote sustainability in HEIs.

Ultimately, this review seeks to provide a comprehensive overview of existing ideas and approaches aimed at promoting and implementing sustainable strategies on campuses worldwide. By synthesizing this knowledge, we hope to assist stakeholders and policymakers in effectively integrating these strategies into their decision-making processes.

2 Methodology

This review presents an overview of over 130 scientific studies, reports and initiatives around the world which demonstrate strategies HEIs utilize to promote sustainability solutions in the fields of economy, education, transportation, health, campaigns, and social sustainability. The bibliographic data for this study were collected from the Web of Science database in August 2023 to December 2024. The initial search query used the following keywords: ("sustainable campus" or "green campus") combined with: ("social sustainability" or "economy" or "transportation" or "campaigns" or "health and higher education"), yielding 318 publications.

To refine the results, we manually reviewed titles and abstracts, excluding articles that were not directly related to green campuses or sustainability in higher education. Exclusion criteria included non-peer-reviewed sources, articles in languages other than English, and studies not focused on sustainability topics. Articles selected for inclusion met the following criteria: (a) Peer-reviewed scholarly articles, (b) Articles written in English, (c) Published within the past 20 years unless deemed highly influential. The manual selection results in 109 publications. We further

expanded our dataset by reviewing articles that cited the initial publications and those cited by these publications, ensuring a comprehensive review of related literature.

Additionally, we conducted a targeted web search for green or sustainable campus initiatives, focusing on institutions recognized by the STARS, which is a transparent, self-reporting framework for colleges and universities to measure their sustainability performance (Dawodu et al., 2022). This supplementary search allowed us to include practical implementations alongside academic research. The selected publications were grouped by themes (e.g., economy, health) and analyzed using a qualitative coding framework to synthesize findings across studies.

3 Measures of sustainability in HEIs

3.1 Measuring the three pillars of sustainability

While sustainability inherently encompasses three pillars—ecology, economy, and society—most assessment measures prioritize the ecological dimension over the economic and social aspects (Dawodu et al., 2022). Reviews of existing HEI sustainability measures reveal a significant variation in the emphasis placed on each pillar (Alghamdi et al., 2017). For instance, social considerations are included in some frameworks, such as the STARS rating system (STARS, 2024) and presented in some studies, such as the work of Lozano's (2006). Other frameworks such as those suggested by Alshuwaikhat and Abubakar (2008), Boer (2013), Velazquez et al. (2006) and the Sustainability Assessment Questionnaire (ULSF—University Leaders for a Sustainable Future, 2015), give social aspects minimal attention, while some frameworks neglect them entirely (Razzaq et al., 2023b). This inconsistency highlights the need for a more balanced approach to measuring HEI sustainability that incorporates all three pillars.

3.2 Common dimensions in campus sustainability assessment tools

While there are differences in the weight each measure gives each of the three pillars, there are also commonalities. A recent literature review of campus assessment tools identified 12 dimensions that are commonly present in all three pillars (Dawodu et al., 2022). The governance dimension includes vision, policy, gender equality, and staff management. Operations-environmental covers space use, audits, assets, land, and green-tech. Water focuses on consumption, conservation, and recycling. Waste deals with hazardous waste, management, and renovation. Building addresses property and function distribution. Transportation concerns vehicles, circulation, and parking. Operational-social relates to living conditions and human rights. Operations-financial pertains to sustainability investments. Education covers student and staff training. Research encompasses sustainable research and dissemination. Engagement-campus deals with public participation. The Survey dimension conducts sustainability-related surveys among staff and students.

Among these dimensions, "operations-environmental" and "education" receive the most emphasis in current assessment measures

(30 and 17%, respectively) (Dawodu et al., 2022), highlighting their importance within HEI sustainability initiatives.

3.3 Sustainability assessment tools for higher education

Several well-established tools were developed to guide HEIs in measuring and improving their sustainability practices. These tools differ in their comprehensiveness, and in their differential focus on the three pillars of sustainability (ecology, economy, and society).

The STARS raring system by AASHE (2023) provides a comprehensive framework. It evaluates sustainability in HEIs across academics, engagement, operations, and planning. STARS offers both a self-reporting and a rating system, enabling valuable comparisons between institutions.

Lozano's (2006) Graphical Assessment of Sustainability in Universities (GASU) offers a user-friendly tool that visually represents ecological, economic, social, and educational aspects using "radar charts" Finally, the Greening Universities Toolkit (UNEP, 2014) provides practical guidance for eco-friendly campus transitions, focusing on sustainable planning and management. However, it lacks standardized assessment indicators and prioritizes ecology over social and economic factors. HEIs can select assessment tools based on their specific needs to strategically enhance sustainability initiatives.

4 Academic aspects

4.1 Integrating the UN sustainable development goals into higher education institutions

HEIs play a pivotal role in achieving the United Nation's 2030 Agenda for Sustainable Development (Leal Filho et al., 2023). This agenda outlines a comprehensive framework for addressing global challenges and fostering a more sustainable future through the 17 SDGs. SDG 4 (Quality Education) highlights the need to equip learners with the knowledge and skills to promote sustainable development through education itself, as well as fostering human rights, gender equality, and global citizenship. SDG 17 emphasizes partnerships as key to achieving these goals, highlighting their importance for knowledge sharing and collaboration between institutions. However, the impact of sustainability in HEIs extends beyond these specific targets. A holistic approach to sustainability in higher education can contribute to achieving various SDGs, including clean energy, decent work and economic growth, reduced inequalities, sustainable communities, and climate action.

While many HEIs align their sustainability efforts with the SDGs, particularly SDG 4.7 on education for sustainable development, the level of integration varies (Leal Filho et al., 2023; Menon and Suresh, 2020). A recent systematic mapping review by Alfathy et al. (2024) confirms this variability, highlighting that while many HEIs have initiated SDG-related strategies, the depth and consistency of curricular integration remain uneven. Despite good intentions, most HEIs lack explicit references to the SDGs within their strategic development plans. For successful integration of sustainability education, Leal Filho et al. (2023) recommend incorporating explicit references to the SDGs in strategic plans, and outlining methods and resource allocation for achieving them.

4.2 Sustainability programs and competencies

HEIs can strengthen sustainability education by offering dedicated courses and programs (Sertyeşilışık et al., 2018), and can even integrate sustainability content into existing curricula. This could encompass undergraduate and graduate programs in sustainability studies, environmental science, sustainable business management, and related fields. Such added knowledge can broaden student exposure to sustainability practices and methodologies, as well as provide them with 'big picture' thinking regarding sustainability. The Sustainability Course Attribute (SUST) in the University of Utah is awarded to courses that incorporate key sustainability concepts and align learning outcomes with the UN SDGs. These courses are available across various departments at the university (University of Utah, 2024). Biancardi et al. (2023) found that students who participated in sustainability courses demonstrated a heightened understanding of sustainability concepts and their importance in transforming industries and career prospects.

Defining graduate competencies is key to effective sustainability programs (Cebrián et al., 2020), guiding educators in equipping students for a sustainable future. Wiek et al. (2011) identified five core competencies: systems thinking, anticipatory thinking, normative/values thinking, strategic thinking, and interpersonal/collaborative skills, to enable students to "plan, conduct, and engage in sustainability research and problem solving" (Wiek et al., 2011). Furthermore, they proposed a meta-competency—integrated problem-solving—which refers to the ability to apply these frameworks to complex sustainability challenges and develop viable solutions (Wiek et al., 2011; Brundiers et al., 2020). To maximize the development of these competencies and enhance student sustainability literacy, a hybrid learning approach that combines formal, non-formal, and informal educational experiences is recommended (Caldana et al., 2021).

4.3 Interdisciplinarity approaches

Interdisciplinary studies are fundamental to advancing global sustainability (Žalėnienė and Pereira, 2021). Moving beyond siloed sustainability programs, universities must integrate sustainability themes across various disciplines (Mokski et al., 2022). For example, incorporating sustainability into engineering courses can equip students with the knowledge and skills to tackle sustainability challenges in their specific fields (Cebrián et al., 2020). Similarly, business programs can integrate sustainable business practices to better prepare future leaders for the corporate world. Humanities courses can explore the ethical dimensions of environmental issues, fostering critical thinking and interdisciplinary perspectives on social, environmental, and economic interconnectedness (Cebrián et al., 2020). Interdisciplinary research projects present valuable opportunities for students and faculty to collaborate on real-world sustainability challenges, applying knowledge and skills to complex issues (Žalėnienė and Pereira, 2021). "Hackathon" competitions can spark interdisciplinary initiatives with the potential to evolve into full-fledged sustainability projects. Effectively integrating interdisciplinarity into education for sustainable development requires

a comprehensive approach that emphasizes active learning, systems thinking, and community engagement—all crucial competencies for graduates navigating a sustainable future.

4.4 Initiatives and collaborations

Universities can cultivate a culture of sustainability through various collaborative practices. Interdisciplinary research centers serve as platforms for faculty and students from diverse disciplines to tackle complex environmental challenges (Mokski et al., 2022). By fostering a comprehensive understanding of sustainability issues across disciplines, these centers can generate holistic solutions.

Campus sustainability initiatives provide practical learning experiences. Examples include energy-efficient buildings, waste reduction programs, and student-led projects on energy conservation, waste reduction, or sustainable transportation (Disterheft et al., 2015; Sertyeşilışık et al., 2018). Engaging students through informational boards, publications, and student clubs further promotes their involvement.

HEIs can extend their impact beyond the campus itself by serving as models for sustainable practices and collaborating with surrounding communities. These collaborations can include creating local employment opportunities, establishing living laboratories, and partnering with industry and stakeholders (Leal Filho et al., 2019; Mokski et al., 2022). Effective community engagement requires incentives, resources, and coordinated efforts, allowing students to apply their knowledge and make meaningful contributions to sustainability challenges.

HEIs can significantly contribute to global sustainability efforts by fostering collaboration, innovation, and knowledge exchange across borders. Key strategies include co-creating knowledge, establishing inter-university campuses, pooling resources, and integrating education, research, and innovation with the SDGs (Arnaldo Valdés and Gómez Comendador, 2022). These strategies facilitate collaboration among students, researchers, faculty, and staff, empowering them to drive societal change towards a more sustainable future.

Engagement with sustainability organizations plays a crucial role in knowledge exchange and achieving sustainability goals (Bieler and McKenzie, 2017). Prominent examples include the AASHE and the United Nations' Global Universities Partnership on Environment and Sustainability (GUPES) (2024) initiative. These organizations offer guidance, recognition, and collaborative platforms for HEIs committed to environmental, social, and economic responsibility (AASHE, 2023; Global Universities Partnership on Environment and Sustainability (GUPES), 2024). Through the collaboration and knowledge sharing facilitated by these organizations, HEIs can emerge as global leaders in advancing sustainability.

4.5 Barriers and success evaluation

4.5.1 Barriers to sustainability integration in higher education

The integration of sustainability into HEIs continues to encounter significant barriers. A major challenge is the lack of awareness and understanding among educators, students, and decision-makers about sustainability and its relevance across academic disciplines (Abo-Khalil, 2024; Shih et al., 2025). This is compounded by insufficient training and specialization in sustainability for both faculty and administrative staff, which limits effective engagement with sustainability initiatives (Mulà et al., 2017; Németh et al., 2023; Idoiaga Mondragon et al., 2023). The absence of dedicated working groups or institutional structures and limited interdisciplinary collaboration further impede the mainstreaming of sustainability throughout university operations and curricula (Ávila et al., 2017; Maiorescu et al., 2020; Shih et al., 2025).

Resource constraints, particularly inadequate funding and limited financial resources are also significant barriers that hinder the implementation of sustainability projects, research, and campus transformations (Ávila et al., 2017; Owens, 2017; Németh et al., 2023). This is often exacerbated by a lack of institutional commitment and insufficient support from university leadership, making it difficult to prioritize and sustain long-term sustainability efforts (Ávila et al., 2017; Shih et al., 2025). Institutional resistance to change, including entrenched cultural and behavioral norms, further complicates the adoption of sustainable practices within universities (Abo-Khalil, 2024; Shih et al., 2025).

The complexity of sustainability-which requires integrating environmental, social, and economic dimensions-necessitates breaking down traditional academic silos and fostering interdisciplinary approaches, a challenge for many institutions (Ankareddy et al., 2025; Shih et al., 2025; Abo-Khalil, 2024). Furthermore, the lack of clear assessment and reporting methodologies makes it difficult to objectively evaluate and compare the progress of sustainability integration across HEIs (Ávila et al., 2017). Without standardized tools and frameworks, universities often struggle to measure the effectiveness of their sustainability initiatives and identify areas for improvement (Pompeii et al., 2019; Umar et al., 2024).

4.5.2 Success evaluation of sustainability integration

Evaluating the success of sustainability integration in higher education requires comprehensive assessment tools that address both academic and administrative dimensions. Recent frameworks, such as those aligned with the SDGs and the STARS, provide structured approaches for measuring sustainability performance in universities (AASHE, 2023; Obrecht et al., 2022; Leal Filho et al., 2023; Umar et al., 2024). These tools typically evaluate curriculum integration, research output, campus operations, and stakeholder engagement.

Key success factors include strong institutional commitment, the establishment of interdisciplinary research centers, and the promotion of cross-departmental collaboration (Leal Filho et al., 2025; Shih et al., 2025). Effective integration is also linked to ongoing professional development for faculty, dedicated funding streams, and the inclusion of sustainability in institutional policies and strategic planning (Finnveden et al., 2020; Németh et al., 2023; Shih et al., 2025).

Stakeholder engagement, particularly involving students, faculty, and external partners, is crucial for driving transformative change and ensuring the relevance of sustainability initiatives (Shih et al., 2025; Németh et al., 2023). Universities that prioritize holistic strategies-such as integrating sustainability into curricula, fostering partnerships, and securing long-term institutional support-are better positioned to contribute meaningfully to the SDGs (Finnveden et al., 2020; Shih et al., 2025).

In summary, overcoming barriers and achieving successful sustainability integration in higher education depends on raising awareness, enhancing training, securing resources, fostering interdisciplinary collaboration, and implementing robust assessment frameworks. Addressing these challenges enables HEIs to become pivotal drivers of sustainable development and societal transformation.

5 Social sustainability in HEIs

Although sustainability rests on three pillars: ecology, economy, and society, social sustainability is often overlooked in HEIs (Boström, 2012; Opp, 2016). This neglect may stem from the historical focus on ecological sustainability and the challenges of defining and measuring social impact (Boyer et al., 2016; Wolff and Ehrström, 2020; Eizenberg and Jabareen, 2017). Despite these challenges, the three pillars are interconnected. Social issues can arise from environmental problems, and vice versa (Barron et al., 2023). Moreover, social sustainability can both hinder and enable ecological sustainability (Boyer et al., 2016). Therefore, a holistic approach that considers all three pillars is crucial for creating truly sustainable campuses.

Similar to broader field of sustainability, campus sustainability initiatives often prioritize ecological aspects over social ones (Dawodu et al., 2022). Similar to broader sustainability efforts, campus initiatives often emphasize ecological over social aspects (Dawodu et al., 2022). Likewise, universities focus more on economic and environmental dimensions than social sustainability in their reporting (Larrán Jorge et al., 2019).

A study by Swearingen White (2014), analyzing 27 campus sustainability plans revealed that while ecological themes were present in all plans, only 30% mentioned social equity or justice, and only 15% of those explicitly addressed social issues. Moreover, in these instances, the focus on social concerns was less detailed compared to operational or academic sustainability efforts (Swearingen White, 2014). Review papers on campus sustainability exhibit a similar trend, with most briefly mentioning social aspects (Dawodu et al., 2022; Machado and Davim, 2023; Sugiarto et al., 2022) and some entirely omitting them (Shawe et al., 2019).

The program names used by HEIs further illustrate this disparity. Many initiatives use terms like "campus sustainability" to reflect a comprehensive approach (Dawodu et al., 2022; Machado and Davim, 2023; Swearingen White, 2014). In contrast, other initiatives such as those labelled "green campus," highlight the ecological emphasis (Anthony Jnr, 2021; Ribeiro et al., 2021). Researchers argue that HEIs cannot effectively promote a "green" image without appropriately addressing social challenges faced by students and staff (Hudler et al., 2019). To address this imbalance, HEIs must actively create and implement programs addressing social issues including accessibility, diversity, inclusion, and combating discrimination (Hudler et al., 2019).

5.1 Defining social sustainability

Social sustainability is a multifaceted concept with various definitions (Barron et al., 2023; Dempsey et al., 2011; Eizenberg and Jabareen, 2017; Pareja-Eastaway, 2012). Key themes consistently emerge, including fairness, inclusion, and well-being (Dempsey et al.,

2011; Pareja-Eastaway, 2012). The concept is aligned with the United Nations' Sustainable Development Goals (SDGs), with nine of the 17 SDGs addressing social aspects, such as poverty reduction, education, and gender equality (Mangukiya and Sklarew, 2023). The United Kingdom's Sustainable Communities plan defines sustainable communities as places that prioritize the well-being of current and future residents, fostering a safe, inclusive, and high-quality living environment (UK Parliament, 2003). This definition further underscores the interconnectedness of social sustainability with ecological and economic sustainability.

The World Bank emphasizes that social sustainability thrives when individuals feel included in the development process and share in its benefits (Barron et al., 2023). This collaborative spirit is crucial for overcoming challenges and building a thriving campus community. In the context of higher education, social sustainability can be understood as fostering a just and equitable environment where everyone feels empowered to participate (Wolff and Ehrström, 2020).

5.2 Social sustainability interventions in HEIs

While the curriculum plays a significant role in promoting social sustainability, universities can also leverage several other domains (ULSF—University Leaders for a Sustainable Future, 2015). Currently, the focus often leans heavily, or exclusively, on courses designed to equip students with knowledge and skills necessary to advance social goals (Wolff and Ehrström, 2020). Service learning, an experiential approach in which the students engage with the community, exemplifies such efforts (Furco, 1996). However, these courses can be time-consuming for instructors, who often receive limited support (Hoover and Harder, 2015; Tifferet and Teman, 2021).

The role of HEIs extends beyond student education. Social sustainability principles should permeate not only the curriculum but also the institution's overall operations and its engagement with the broader community (Wolff and Ehrström, 2020). For example, Harvard University's Office for Sustainability fosters a "living lab" environment where students, faculty, and staff collaborate on real-world challenges (Purcell et al., 2019). Despite good intentions, a disconnect often exists between the social sustainability principles HEIs teach and their own institutional practices (Hammond and Churchman, 2008).

To bridge this gap and effectively model sustainable behavior change, HEIs must embrace a comprehensive approach to social sustainability (Wolff and Ehrström, 2020). Additionally, by exemplifying social stewardship, HEIs can instill these values in their students, thereby fostering a more sustainable future (Leal Filho et al., 2019).

5.3 Social sustainability themes in higher education

Consistent with the UN's 2030 Agenda and its Sustainable Development Goals (SDGs), HEIs are encouraged to embrace a holistic framework that integrates sustainability principles into policies and translating them into actionable plans (Lozano et al.,

2015). Regular monitoring is essential for ensuring the effective implementation of these plans.

Social sustainability practices within HEIs can address various themes, including justice, equality, inclusion, safety, and well-being (see Figure 1).

- Justice is demonstrated through equitable employment practices. The growing casualization of academic work creates a bifurcated workforce, where sessional staff often experience precarious employment and limited involvement in research and policy decisions. This dynamic undermines institutional performance and integrity (Hammond and Churchman, 2008).
- Equality and inclusion are crucial for both staff and students. Persisting gender disparities and symbolic hierarchies hinder the effectiveness of equity programs. HEIs must confront underlying biases and recognize diversity as a catalyst for excellence and innovation (Hammond and Churchman, 2008). This includes promoting access to education for the broader population and ensuring affordability of programs (Dawodu et al., 2022).
- Safety and well-being are fundamental aspects of a sustainable campus. Bystander intervention programs help combat sexual assault (Malamuth et al., 2018; Mujal et al., 2019). Additionally, the well-being of faculty and staff is crucial. Implementing measures to address workload and resource limitations can create a more positive academic environment, which may benefit both employees and students (Hammond and Churchman, 2008).

Addressing the often-neglected pillar of social sustainability within HEIs is crucial for fostering a well-rounded and thriving academic community (Boyer et al., 2016). While ecological sustainability has historically taken precedence, recognizing the interconnectedness of the three pillars—ecology, economy, and society—is essential for a prospering, modern academic environment. HEIs must actively design and implement programs that promote social sustainability, addressing issues of justice, equality, inclusion, social cohesion, democracy, safety, and well-being. By prioritizing social sustainability, HEIs can set an example as sustainable stewards and create a more vibrant and inclusive academic ecosystem, ultimately benefiting both students and society at large.

FIGURE 1
Components of social sustainability in HEIs.

6 Integrating health considerations in green campus initiatives

Health is directly connected to green initiatives. For example, promoting green transportation through cycling and walking not only reduces pollution but also benefits the health of those who adopt these methods. However, the potential impact of green campus initiatives on the health of students, faculty, and staff is often overlooked. Studies reveal that existing green campus assessment tools often overlook health (Leal Filho et al., 2019; Dawodu et al., 2022), highlighting a significant challenge in integrating health into HEI sustainability efforts. A broad analysis of over 1,000 articles on campus sustainability found that health was excluded from the core dimensions that were used to assess sustainable campuses (Dawodu et al., 2022). These dimensions include governance, operations, education, research, and engagement, but failed to explicitly consider health outcomes.

A more holistic approach, as represented by Anthony Jnr's (2021) suggested framework for Malaysian HEIs, considers health as a major indicator alongside traditional measures such as energy efficiency. This framework recognizes the significance of health for the overall well-being of the campus community and its connection to a high quality of life. By integrating both environmental and social components, this approach is consistent with the multidimensional nature of health issues in global green campus efforts.

6.1 Physical health

Green campus initiatives can influence the physical health of the campus community in several ways (see Figure 2). Green design features in campus buildings are an important factor. Studies show that indoor air quality, acoustics, and spatial arrangements can all impact the health and well-being of the building's occupants (Dawodu et al., 2022). For example, poor ventilation, pollutants, noise from inadequate soundproofing, and large, poorly designed spaces can all lead to both short-term and chronic health problems. Furthermore, studies on Sick Building Syndrome (SBS) in educational settings highlight the prevalence of short-term symptoms like headaches, irritation, fatigue, and difficulty concentrating, which can potentially affect academic performance (Niza et al., 2023). Green Office programs, which often focus on energy efficiency, can also positively impact health (Dawodu et al., 2022).

Indoor air quality is another key factor. Volatile Organic Compounds (VOCs) from building materials and cleaning products have become a major concern (McDonald et al., 2018). These VOCs can react with ozone to produce harmful pollutants, which have been associated with various health issues (Temkin et al., 2023; Coleman et al., 2008; Destaillats et al., 2006; Rosales et al., 2022). Indoor plants can improve air quality and reduce stress (Anthony Jnr, 2021).

Green campuses require well-functioning ventilation systems in laboratories to prevent air pollution from hazardous materials and safeguard the health of the campus community (Park et al., 2014). However, clear and accessible laboratory codes and operational standards are equally important for sustainable practices (Woolliams et al., 2005). Confusion among staff regarding these guidelines can hinder both safety and environmental goals.

FIGURE 2
Green campus initiatives for enhancing community health.
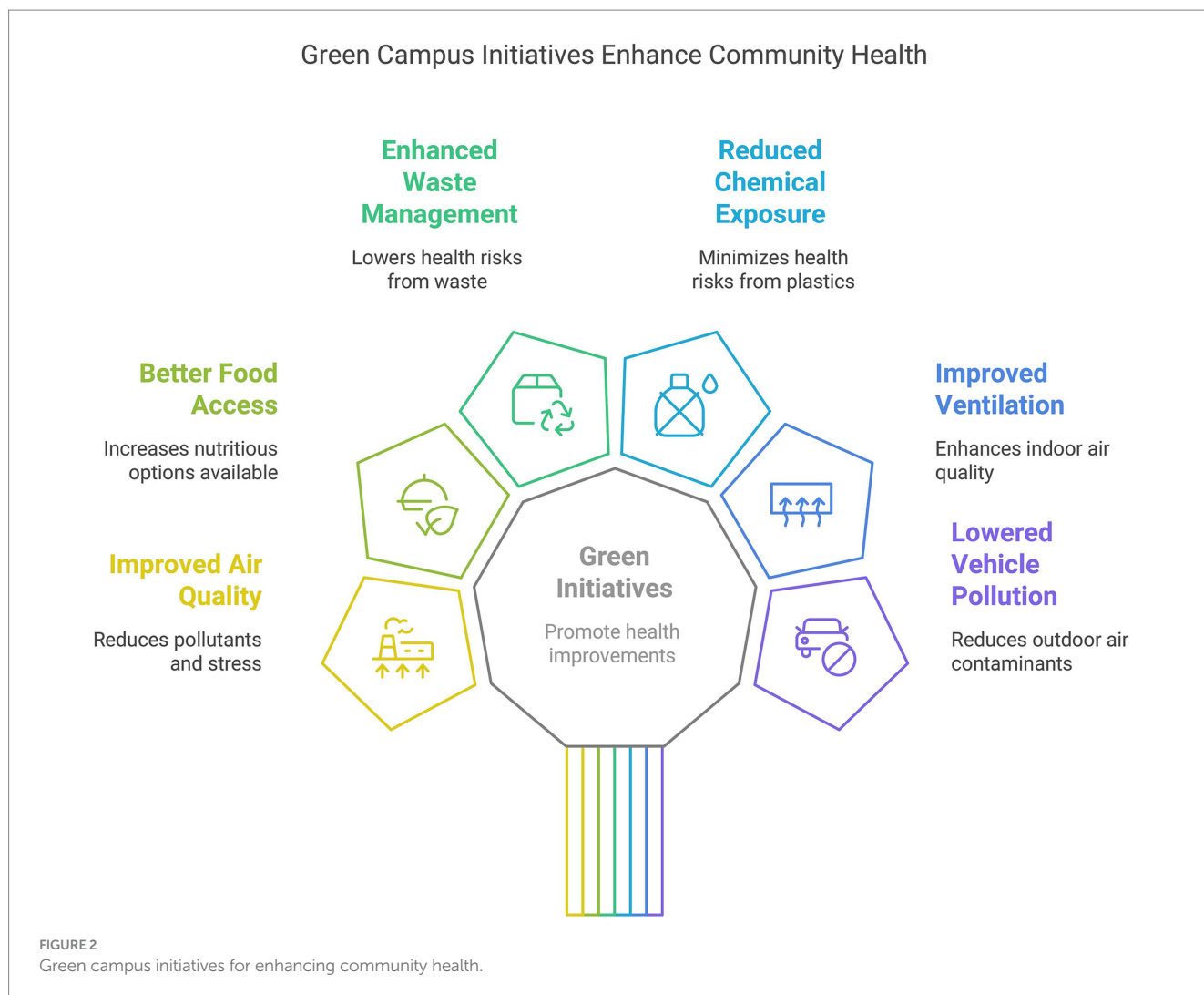
Chemical exposure remains a significant health concern on campuses even with green initiatives in place (Ramirez et al., 2023). Prolonged exposure to chemical exposures can poses risks, especially for faculty and staff. Additionally, the daily use of disposable plasticware can lead to the ingestion of microplastics and endocrine-disrupting chemicals (EDCs) (Seblos et al., 2023). Microplastics have been detected in various human organs, raising concerns about their long-term health effects (CUSP, 2024). EDCs in plastics have been associated with various health issues (Giuliani et al., 2020; Hlisníková et al., 2020; Wang and Qian, 2021). It is therefore vital that green campuse initiatives will address the health risks associated with chemical exposure from plastics and incorporate strategies to mitigate these risks.

Motor vehicle exhaust is a major source of outdoor air pollution on campuses, and is associated with health issues such as dizziness and nausea (Sholihin et al., 2020). Implementing restrictions on vehicle access—a popular green campus initiative—can improve air quality and promote the well-being of the campus community.

Green campuses should also address the health impacts of food options. Studies highlight the importance of providing affordable and nutritious food choices (Murray et al., 2021; Shaw et al., 2018). However, cost and food insecurity can pose significant barriers

(Murray et al., 2021; Shaw et al., 2018). To overcome these barriers, universities can develop strategies to improve access to affordable, sustainable, and locally sourced healthy food options.

Lastly, waste management practices on campus can also impact health. Improper handling of hazardous materials in laboratories, for example, can lead to chemical exposure risks (Freire and Bortoleto, 2018). Electronic waste (e-waste) exposure is another concern, which is associated with both physiological and mental health issues (Dawodu et al., 2022). Green campus initiatives that promote proper waste management, including e-waste recycling programs, can improve both environmental sustainability and campus community health (Saldaña-Durán and Messina-Fernández, 2020). While the primary goal of green waste management practices is to protect the environment, such practices can help to lower potential physiological and mental health risks.

6.2 Mental health

Access to green spaces is a cornerstone of green campus initiatives that promote mental well-being (Hipp et al., 2016; Liu et al., 2022). Research shows that exposure to nature reduces stress

in both academic and non-academic settings, which is particularly significant for college students suffering from depression (Kelz et al., 2013; Liu et al., 2022). Spending time in green spaces across campuses is associated with a stronger sense of belonging and improved mental health (Thompson et al., 2023). Even the mere perception of a green campus can benefit well-being (Hipp et al., 2016).

The notion of Health on a green campus extends beyond just physical and mental well-being, encompassing a broad range of factors affecting quality of life (Norshahidi et al., 2021). Green campuses can cultivate a sense of belonging, enhance social well-being, and ensure safety through infrastructural design features, while also encouraging physical activity and community interaction (Anthony Jnr, 2021; Thompson et al., 2023). These elements, while not traditionally considered health aspects, are crucial for a healthy campus environments. Therefore, the inclusion of quality of life and physical and mental well-being in discussions concerning green campuses expands the way we envision a green campus beyond merely energy efficiency and highlights the importance of social aspects in creating healthy and sustainable campuses (Sonetti et al., 2016).

6.3 Challenges for healthy green campuses

Despite the importance of comprehensively integrating health into green campuses, this process presents several challenges. Firstly, sustainability rankings often prioritize energy efficiency over social aspects of health, potentially marginalizing health concerns in green campus initiatives (Leal Filho et al., 2019; Dawodu et al., 2022). Secondly, the expansive nature of health, which encompasses social, environmental, and personal aspects, complicates the straightforward definition of clear health goals within green campus programs (Sonetti et al., 2016). Finally, inadequate awareness among faculty and staff regarding the impact of environmental conditions on health hinders the implementation of health-focused measures (Leal Filho et al., 2024).

Overcoming these challenges requires a shift in focus. Prioritizing health as a primary objective in green campuses, establishing clear health goals, and implementing comprehensive staff training programs can effectively assist in achieving the goal of creating an environmentally responsible campus, that supports the health of its community members (American College Health Association, 2023).

Despite the under-representation of health concerns in green campus initiatives, health-related issues are still integrated within specific, targeted projects such as air pollution, waste management, building design, interior design, maintenance and transportation to green spaces, safety on campus, and quality of life factors. Consequently, when planning long-term transitions to sustainable or green campuses, a more comprehensive and holistic approach to health should be prioritized.

7 Economic perspective

Although Green campuses are a priority for HEIs globally, the economic viability and efficiency of these initiatives are critical factors in determining their success and long-term impact across different countries.

7.1 Economic benefits and operational savings

Green campuses offer myriad economic benefits, including reduced operational costs, enhanced asset value, and the possibility of generating revenues through sustainable initiatives. Energy-efficient buildings and sustainable waste management practices lead to substantial cost savings for academic institutions (Mylonas et al., 2019). Moreover, adopting energy-efficient technologies and renewable energy sources can significantly reduce electricity and heating costs, which are among the highest operational expenses for universities (Soares et al., 2015; Tsunekawa et al., 2009). LEED-certified buildings have maintenance costs that are 20% lower than those of typical commercial buildings, underscoring the financial viability of sustainable practices (U.S. Green Building Council, 2024).

7.2 Investment, payback periods, and financial incentives

The initial investment in green campus initiatives can be substantial, yet the long-term savings often justify these initial costs. According to Razzaq et al. (2023b), the payback period for energy-efficient retrofits and renewable energy installations on campuses varies from 2.3 to 10.6 years, depending on the scale of the investment and local energy prices (Razzaq et al., 2023a). Specifically, the study highlighted that the payback periods for building envelope retrofits and electrical appliances were 2.96 and 2.62 years, respectively. Notably, the installation of a solar system has a payback period of just 2.3 years, underscoring the economic viability of incorporating sustainable technologies into campus environments. Moreover, Sharma et al. (2022) evaluated building retrofit strategies, and showed that the most comprehensive approach (RS3) reduces energy use by 24.12% and CO_2 emissions by 18.56%, with a payback period of 10.6 years, highlighting its efficiency and economic viability.

Securing funding for green initiatives can pose financial challenges. However, various financial incentives, including government grants, tax incentives, and private investments, provide crucial support for these projects. Innovative financing models such as green bonds and sustainability-linked loans are emerging as viable options for funding large-scale sustainable projects in academic settings (Versal and Sholoiko, 2022).

7.3 Economic risks and uncertainties

The primary economic challenge of green campus initiatives lies predominately in the high upfront costs and uncertainty regarding returns on investments. Furthermore, understanding the financial impact of external factors such as fluctuations in energy prices and government policies is crucial for effectively assessing such initiatives. Scenario analysis can help assess these impacts and prepare for various economic conditions, thereby ensuring that institutions can navigate the uncertainties of sustainability investments with greater confidence (Duinker and Greig, 2007).

To stabilize the financial outcomes of green initiatives, institutions must employ risk mitigation strategies. Hedging energy prices, securing fixed-rate financing, and diversifying energy sources are

considered effective approaches to reducing the financial uncertainties of sustainability projects. These strategies help in managing the economic risks associated with green campuses, ensuring a more predictable and secure financial future for sustainability investments (Taghizadeh-Hesary and Yoshino, 2020).

7.4 Strategic considerations and frameworks for sustainability

A review by Dawodu et al. (2022) of over 1,000 campus sustainability studies highlights the need for assessment tools that consider environmental, social, and educational goals, alongside financial viability (Dawodu et al., 2022). Building on this, Hodge et al. (2021) debate whether sustainability efforts enhance finances or merely add costs. They propose a holistic approach, where positive economic impacts can be achieved through a comprehensive evaluation of long-term financial effects (Hodge et al., 2021).

Jain et al. (2017) introduced the CaNSEC model, which assesses sustainability across environmental, economic, and social dimensions (Jain et al., 2017). This model emphasizes lifecycle cost–benefit analyses and the selection projects with favourable payback periods, and demonstrates the importance of financial viability. Anthony Jnr (2021) further explored economic aspects using a triple bottom line approach, highlighting the need for financial feasibility assessments to ensure that environmental ambitions are translated into financially sustainable projects (Anthony Jnr, 2021).

Economic indicators like cost savings and return on green investments were proposed to enhance sustainability evaluations (Dawodu et al., 2022). Monitoring these metrics allows institutions to gauge cost-effectiveness and make data-driven decisions. Similarly, El Marsafawy et al. (2017) advocated for strategic resource allocation, intertwining environmental stewardship with fiscal prudence to ensure financial sustainability alongside environmental progress (El Marsafawy et al., 2017).

da Silva et al. (2023) focus on strategic decarbonization as a key green development tactic, emphasizing its dual benefits of environmental responsibility and economic efficiency (da Silva et al., 2023). Kwami et al. (2014) propose a broader framework integrating economic viability with social equity and environmental integrity. They advocated for equitable resource distribution and sustainable policies, an approach also supported by Bayhantopcu and Aymerich Ojea (2023), whose case study confirms the value of this integrated approach (Bayhantopcu and Aymerich Ojea, 2023; Kwami et al., 2014).

7.5 Economic impact: local community and beyond

Green campuses generate positive economic benefits that extend beyond the institutions themselves. Sustainable operations create local jobs in green technologies and services, stimulating the local economy. Furthermore, universities serve as sustainability role models, inspiring local businesses and residents to adopt similar practices. This effect leads to broader economic advantages, such as reduced energy costs and improved environmental quality (Beringer and Adomßent, 2008).

The transition towards green campuses presents both opportunities and challenges. Key challenges include high initial investment costs and the difficulty in integrating sustainability into existing infrastructure. Gholami et al. (2020) identify meticulous planning, stakeholder engagement, and sound financial management as crucial for the successful economic realization of these initiatives (Gholami et al., 2020).

In conclusion, green campuses represent strategic investments for the future, providing benefits to both institutions and their communities, and by incorporating economic considerations in planning, evaluation, and operation processes, institutions can ensure the financial viability of their environmental efforts. A comprehensive framework encompassing expenses, savings, return on investment, incentives, and funding opportunities is essential. Additionally, rigorous economic analysis has the potential to translate sustainability goals from abstract ideals into financially viable and measurable projects. These projects, which align economic efficiency with ecological objectives, ensure that endeavors are both environmentally responsible and economically sustainable. This dual focus paves the way for initiatives that are both ecologically sound and financially viable, laying the foundation for a more sustainable and economically resilient future in higher education.

7.6 Evaluation

Evaluating the economic success of sustainability initiatives requires the establishment of clear financial metrics and indicators. Institutions must focus on analyzing cost savings, return on investment, and the overall economic impact of their sustainability efforts. Frameworks that incorporate lifecycle cost–benefit analyses can help HEIs assess the long-term financial viability of their projects (Leal Filho et al., 2016). By closely monitoring these economic indicators, institutions can ensure that sustainability initiatives align with their financial goals and will serve as examples for the coexistence of environmental responsibility and fiscal prudence in Higher Education Institutions (Lozano, 2006; Aleixo et al., 2018).

8 Transportation

Transportation systems are integral to advancing sustainability goals within HEIs, aligning with global efforts to mitigate climate change. A growing body of research explores strategies for enhancing transportation efficiency on and off campuses (e.g., Günaydın and Yücekaya, 2020; Becker and Carmi, 2019). These strategies encompass a variety of modes and services, promoting eco-friendly initiatives and a deeper understanding of how campuses can operate more sustainably. The following sections will describe some of these initiatives.

8.1 Reducing vehicle use

HEIs can promote sustainability by reducing their reliance on vehicles. One strategy involves decreasing vehicle infrastructure while expanding green spaces, as exemplified by Kilis 7 Aralık University (KIYU) (Günaydın and Yücekaya, 2020). KIYU increased green areas by 75% while reducing vehicle roads by over 60%. Additionally, implementing parking restrictions and fees, along with promoting alternative transportation options, can significantly reduce energy consumption and greenhouse gas emissions (Cruz et al., 2017).

8.2 Promoting public transportation

HEIs can also improve sustainability by enhancing public transportation services. Examples include Jordan University of Science and Technology (JUST) which offers free shuttle buses and consolidating travel trips, and University Malaya (UM) which facilitates local commuting through private shuttles and promotes public transportation use (Abu Qdais et al., 2019; Anthony Jnr, 2021). Similarly, University Putra Malaysia (UPM) provides eco-friendly public transportation options.

8.3 Encouraging non-motorized transportation

HEIs can significantly reduce greenhouse gas emissions by promoting non-motorized commuting, especially cycling and walking. Brazilian universities employ this approach by improving pedestrian and bicycle infrastructure, restricting parking, and enhancing bus services (Ribeiro et al., 2021). Several Malaysian universities actively encourage non-motorized options. University Putra Malaysia is developing bicycle lanes, while UniMAP promotes cycling as an alternative to traditional fuel-based transportation (Anthony Jnr, 2021). The Clínica de Direito Ambiental Paulo Nogueira Neto in São Paulo, Brazil, provides secure bicycle parking to further incentivize cycling (Crispino et al., 2018). These efforts contribute to a more sustainable campus environment.

8.4 Teleworking for reduced traffic congestion

As a conclusion drawn from the strategies presented earlier, teleworking (remote work) offers HEIs a strategy to decrease traffic congestion and its associated air and noise pollution, as well as greenhouse gas emissions (Levi et al., 2020). The COVID-19 pandemic demonstrated the feasibility of teleworking within higher education. However, some challenges still exist regarding remote work, such as potential declines in productivity and teamwork quality, technical hurdles, and the social or psychological impacts of employees.

To maximize the benefits of traffic congestion reduction from teleworking, HEIs should implement it alongside complementary strategies. A well-functioning public transportation system is crucial, ensuring its continued use even with a decrease in overall commuting needs. Furthermore, urban and campus planning that prioritizes accessibility to public transportation will enhance the benefits of teleworking. Economic incentives can also be effective, encouraging continued use of sustainable transportation options for those who still need to commute occasionally. This multi-faceted approach addresses the "induced demand effect" and maximizes the positive impact of teleworking on traffic congestion.

8.5 Challenges in promoting sustainable transportation on campuses

This section summarizes key challenges that emerge from the discussion above and reinforces the need for integrated solutions.

Transitioning to sustainable campus transportation faces several challenges. Student participation in green initiatives can be low despite awareness (Ribeiro et al., 2021), and stakeholder engagement is crucial to avoid stalled progress (Dawodu et al., 2022). Overcoming car dependency remains a key obstacle (Anthony Jnr, 2021).

Financial constraints pose another major obstacle. Securing funding for sustainable transportation projects can be challenging, often requiring support from external sources (Crispino et al., 2018). Investments in infrastructure for pedestrians, cyclists, and public transportation can be substantial, further straining budgets (Anthony Jnr, 2021). Even prominent green universities struggle to secure sufficient resources to sustain their sustainability efforts (Abu Qdais et al., 2019). Bureaucratic hurdles, such as obtaining approvals for projects in historic areas, can also act as roadblocks (Crispino et al., 2018).

HEIs play a crucial role in promoting sustainability through their transportation practices. Universities worldwide showcase their commitment to eco-friendly initiatives, including expanding green spaces, promoting cycling, and implementing sustainable shuttle services, reducing energy consumption, mitigating greenhouse gas emissions, and fostering environmental awareness within campus communities. By prioritizing green infrastructure, implementing sustainable practices, and collaborating on impactful endeavors, HEIs can create a more sustainable future, not just on campuses but beyond.

9 Communication campaigns for promoting sustainability in HEIs

Cultivating a positive public image for social responsibility is crucial for generating interest in campus sustainability efforts (Posner and Stuart, 2013). Effective communication campaigns are essential to overcoming key obstacles identified by Gholami et al. (2020), including lack of awareness, limited knowledge, resistance to change, and ineffective communication itself.

Strategic communication campaigns address these barriers and play a critical role in achieving campus sustainability (Ribeiro et al., 2019, 2021). These campaigns aim to raise awareness (Chen et al., 2022) and foster community engagement (Too and Bajracharya, 2015). Increased awareness of sustainability initiatives positively impacts student behavior (Ribeiro et al., 2021). Effective campaigns cultivate a sense of pride and encourage student participation (Figueredo and Tsarenko, 2013). Mason et al. (2003) further emphasize the need for a formal environmental management system that connects and enhances communication channels between stakeholders, including university leadership, faculty, and students.

9.1 Communication tools for promoting campus sustainability campaigns

Universities worldwide utilize diverse communication methods to influence student awareness, behavior, and engagement in sustainability initiatives (Kim et al., 2018; Ribeiro et al., 2021). The success of these communication tools in

promoting social sustainability depends on careful planning, design, and content (Dade and Hassenzahl, 2013; Fernández-Vázquez, 2021). Kim et al. (2018) categorized communication tools at the University of Washington into news sources (radio, television, print, online), social media (Facebook, Twitter), and local sources (flyers, advertisements, classes, booths, billboards). Their findings suggest that these tools raise awareness but may not significantly impact behavior, potentially due to pre-existing engagement in sustainable practices (Kim et al., 2018). Ribeiro et al. (2021) identified a broader range of tools used in four Brazilian universities, including workshops, lectures, leaflets, posters, websites, campus media, faculty involvement, and staff engagement. Their research suggests that these tools not only increase awareness but also lead to participation in initiatives like recycling (Ribeiro et al., 2021). Carpenter et al. (2016) highlight the importance of staff serving as "ambassadors" for sustainability initiatives. A large-scale study, by Helferty and Clarke (2009), reviewed communication tools used by 65 universities, identifying methods like posters, petitions, tabling, film screenings, speakers, and banners to raise student awareness. However, this study did not assess the relative effectiveness of these tools (Helferty and Clarke, 2009).

Finally, studies indicate that many universities lack comprehensive sustainability sites or have websites with limited content and interactivity, which hinders their effectiveness (Dade and Hassenzahl, 2013; Fernández-Vázquez, 2021).

University leaders promote sustainability by endorsing relevant declarations that set unified goals and actions (Anthony Jnr, 2021; Alshuwaikhat and Abubakar, 2008). The Talloires Declaration, for example, outlines a 10-point action plan for integrating sustainability into university operations (Alshuwaikhat and Abubakar, 2008). Sippel (2023) suggests the use of storytelling initiatives to encourage campus engagement in sustainability efforts through climate communication. Joint committees comprised of students, faculty, and staff can also be effective (Moreira et al., 2018). These committees can promote sustainability by organizing educational events and activities, raising awareness within the campus community (Moreira et al., 2018). Multi-stakeholder involvement is crucial for sustainability campaigns, as seen in campus environmental committees (Mason et al., 2003). The dialogic communication model fosters two-way engagement, making sustainability initiatives more inclusive and effective (Carpenter et al., 2016).

9.2 Tailoring communication tools for targeted sustainability campaigns

Effective campus sustainability campaigns require a variety of communication tools tailored to specific target groups (Widiastuti et al., 2019; Kim et al., 2018). Widiastuti et al. (2019) highlight the importance of engaging the community, not just informing them. Their example of an unsuccessful waste sorting campaign demonstrates the need for clear instructions and ongoing promotion alongside various communication tools (Widiastuti et al., 2019). Cole and Fieselman (2013) showcase a successful campaign that utilized a mix of printed materials

(signs, flyers), digital channels (emails, calendars), and incentives (competitions) to reach diverse audiences (Cole and Fieselman, 2013). Kim et al. (2018) further emphasize the importance of tailoring communication tools according to the needs and characteristics of a specific group. For example, social media may be more effective for undergraduates, while news sources might be better suited for graduate students and staff (Kim et al., 2018).

Greening the campus can be enhanced through storytelling exchange projects in HEIs, based on key climate communication principles like aligning with people's values and inspiring action. The Campus Storytelling Exchange promotes sustainability by sharing real-world climate initiatives within HEIs. Examples include a professor leading carbon accounting, a student in the green office, or a cafeteria chief adopting climate-friendly meals. These stories can be shared through university channels, including social media (Sippel, 2023).

10 Discussion and recommendations

10.1 Discussion

Achieving a truly sustainable green campus requires a holistic and interconnected approach that integrates environmental, social, and economic aspects. HEIs serve as pivotal platforms for fostering sustainable practices, not only within their premises and infrastructures but also by extending their influence on the students, and thereby positively influencing the student's future career and lifestyle, the local community and beyond.

Traditionally, the examination of green campuses has focused mainly on environmental aspects such as energy, water conservation, waste management, gardens, and green laboratories. These elements were addressed in our previous paper (Barnett-Itzhaki et al., 2025). In this study, we delved into additional dimensions that equally constitute the essence of sustainability: economy, and social aspects. Furthermore, we explored elements that are crucial to a comprehensive understanding of sustainability and its diverse components: education, health, transportation, and campaigns for sustainability. We systematically identify barriers, success indicators, and best practices across a wide range of international contexts, drawing on over 130 peer-reviewed sources, and institutional reports and initiatives. This synthesis could enable stakeholders to benchmark and adapt successful strategies to their own institutional settings.

All these elements are holistically integrated to achieve a truly substantial sustainable campus: green campuses that use green renewable energy (Barnett-Itzhaki et al., 2025), in which walking and non-motorized transportation are encouraged (Günaydın and Yücekaya, 2020, Becker and Carmi 2019), and that ultimately contribute to the physical and mental health of both the staff and the students. Access to green spaces (including gardens) and recreational facilities contributes to mental well-being and overall quality of life (Hipp et al., 2016; Liu et al., 2022). Finally, we believe that Integrating health as a key indicator, alongside traditional environmental measures, is crucial for a comprehensive approach to sustainable campuses.

Economic viability is a critical factor in ensuring the long-term sustainability of green campus initiatives. While these initiatives offer long-term economic benefits through operational cost savings and resource efficiency, they require substantial initial investments and strategic financial planning. Rigorous economic analysis, which considers actions like return on investment, strategic resource allocation, and decarbonization tactics, is essential for translating sustainability goals into financially sound projects. Institutions must employ risk mitigation strategies, such as hedging energy prices, securing fixed-rate financing, and diversifying energy sources, to manage the economic uncertainties associated with sustainability investments (Mylonas et al., 2019; Gholami et al., 2020).

Integrating environmental, social, and economic dimensions requires a balanced approach that considers all three pillars. Assessment tools like the STARS rating system and frameworks proposed by scholars like Anthony Jnr (2021) and Dawodu et al. (2022) offer comprehensive models that address these interconnected aspects. In this study, by incorporating both academic literature and real-world campus initiatives (e.g., STARS, Green Metric, national programs), we bridge the gap between theoretical frameworks and practical implementation, providing a resource for both scholars and practitioners.

The social pillar of sustainability is often overlooked in green campus initiatives, despite its crucial role in fostering an inclusive, equitable, and thriving academic community (Boström, 2012; Opp, 2016). Social sustainability encompasses themes such as justice, equality, inclusion, safety, and well-being (see Figure 1), which are intrinsically linked to the broader notion of sustainability and the United Nations' SDGs. Addressing social issues like fair employment practices, gender disparities, access to education, campus safety, and faculty/staff well-being is essential for creating a socially sustainable campus environment (Hudler et al., 2019).

HEIs also serve as living laboratories, providing practical learning environments where students and researchers can engage in real-time sustainability practices and initiatives (Barnett-Itzhaki et al., 2025). However, the implementation of green campus initiatives faces significant challenges, including initial investment costs, the willingness of staff to make the changes that are not in their comfort zone, the need for meticulous planning, and the integration of sustainability into existing infrastructures.

10.2 Limitations and directions for future research

A notable limitation of this review is its reliance primarily on secondary sources rather than original empirical data collected directly from higher education institutions. Although the current review provides comprehensive insights by synthesizing existing findings from various contexts and geographies, future research could benefit from incorporating primary data collection, such as targeted surveys or case studies within specific institutions. Such empirical validation would strengthen the practical applicability of the recommendations presented. Additionally, future studies might explore comparative analyses between institutions or

longitudinal examinations of sustainability practices, further enriching the practical and theoretical contributions to this important area.

10.3 Conclusions and recommendations

10.3.1 General conclusions

The pursuit of social sustainability on green campuses necessitates a multifaceted approach that integrates comprehensive planning, inclusive decision-making, community engagement, educational initiatives, health considerations, economic viability, sustainable transportation, and effective communication strategies. HEIs play a pivotal role in fostering sustainable communities by embedding sustainability principles across all aspects of campus life. This review underscored the importance of stakeholder engagement, continuous assessment and the use of strategic tools, and transparent reporting to ensure accountability and continuous improvement in sustainability efforts.

10.3.2 Key recommendations

The following recommendations, categorized by key thematic areas, are intended for national education ministries policymakers, boards of higher education institutions, campus chief executive officers, and senior management teams:

10.3.2.1 General

- Developing a comprehensive sustainability plan through inclusive stakeholder engagement, aligned with institutional goals and values.
- Establishing inclusive decision-making processes that involve diverse stakeholders, including students, faculty, staff, and community members, to ensure that sustainability initiatives address the needs and concerns of all groups.
- Regular use of metrics and benchmarks to assess the institution's progress towards sustainability. It is recommended to communicate these assessment through periodic reports.
- Encouraging community engagement by consulting with representative boards, which will include students, faculty members and staff on central issues. In addition, promoting local involvement through tours, vendor collaborations, campus-wide surveys and advisory groups representing multiple disciplines and stakeholder groups.

10.3.2.2 Education

- Creating promotive learning environments that highlight the benefits of sustainable practices utilizing tools such as posters, seminars, and other integrated communication methods.
- Systematically embedding the UN SDGs across disciplines and degree programs, ensuring that sustainability is treated as a cross-cutting theme rather than a standalone topic.

- Encouraging interdisciplinary teaching approaches that combine environmental, social, and economic perspectives, preparing students to address complex sustainability challenges.
- Integrating sustainability principles and case studies into academic programs, courses, and co-curricular activities to equip students with the knowledge, skills, and values necessary for promoting sustainability in all its dimensions.,
- Award tuition discounts to students contributing to sustainability initiatives, such as green energy research.
- Organizing sustainability-themed hackathons where students develop practical solutions for green infrastructure, waste management, and climate resilience.

10.3.2.3 Health

- Investing in green spaces, recreational facilities, and health-promoting initiatives to support the mental and physical well-being of the campus community.
- Reducing chemical exposure from consumer products on campus by implementing stricter regulations and promoting safer alternatives.
- Improving ventilation systems in all buildings to reduce indoor pollutants and conducting routine air quality monitoring to identify and address pollution sources.
- Using low-VOC products in interior design, office supplies, and maintenance practices.
- Deploying real-time air quality sensors in classrooms, dormitories, and common areas, ensuring proper ventilation and reducing exposure to pollutants. HEIs can implement automated air purification systems integrated with IoT sensors.
- Conducting regular health assessments and environmental audits to identify and address symptoms of Sick Building Syndrome (SBS).
- Encouraging plant-based meal options, local food sourcing, and zero-waste cafeterias to promote healthier, more sustainable eating habits.

10.3.2.4 Economy

- Integrating economic viability into sustainability efforts by conducting lifecycle cost–benefit analyses, monitoring economic indicators like cost savings and return on green investments, and ensuring strategic resource allocation.
- Conducting rigorous economic analyses to ensure the financial viability of sustainability projects and initiatives, while considering factors like return on investment, strategic resource allocation, and decarbonization tactics.
- Establishing a circular economy procurement system, prioritizing vendors that provide biodegradable, upcycled, or low-carbon products.

10.3.2.5 Transportation

- Prioritizing sustainable transportation options by encouraging active modes such as walking and cycling, providing efficient public transit, and promoting carpooling and ride-sharing programs.
- Fostering partnerships with municipal and regional authorities to enhance and improve public transportation to and from the institution.
- Deploying real-time AI algorithms to optimize shuttle bus routes based on demand, reducing congestion and energy consumption.
- Implementing vehicle-free zones with priority given to pedestrian-friendly pathways, bicycle lanes, and shared micro-mobility services.

10.3.2.6 Communication and campaigns

- Collecting continuous feedback from campus users through surveys and other means to refine communication methods and enhance the integration of sustainability principles into campus activities.
- Combining multiple communication sources, such as news, blogs, social media, and local sources, to impact different target groups and encourage peer-to-peer support for fostering behavioral changes.
- Promoting awareness to sustainable practices by creating engaging learning environments and providing information through vivid, up-to-date and innovative illustrations in posters and seminars.

By implementing these recommendations (see also Table 1), HEIs can enhance their social sustainability efforts, creating more resilient, inclusive, and sustainable campus communities and serve as pivotal platforms for fostering sustainable practices, not only within their premises but also within the local community and beyond.

Author contributions

ZB-I: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. ST: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. YE: Conceptualization, Formal analysis, Investigation, Writing – original draft. IG: Conceptualization, Formal analysis, Investigation, Writing – original draft. OR: Formal analysis, Investigation, Writing – original draft. GB: Formal analysis, Investigation, Writing – original draft. IV-Y: Formal analysis, Investigation, Writing – original draft, Writing – review & editing. GC: Formal analysis, Investigation, Validation, Writing – original draft. AL: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing.

Funding

TABLE 1 Summary of obstacles and main recommendations.

Topic	Main obstacles	Main recommendations
Academic	• Institutional reluctance and faculty unawareness of sustainability principles and how to integrate them into courses.	• Integrate sustainability principles and case studies into academic programs, courses, and co-curricular activities. Create promotive learning environments using tools like posters and seminars. Offer dedicated courses/programs and integrate content into existing curricula. Define graduate competencies. Foster interdisciplinarity. Organize sustainability hackathons. • Systematically incorporate the SDGs into all academic disciplines by mapping course content to relevant SDG targets, promoting faculty training on sustainability education, and ensuring that sustainability becomes a transversal element across teaching, learning outcomes, and assessment strategies.
Social	• Often overlooked compared to ecological and economic aspects. • Disconnect between principles taught and institutional practices. • Gender disparities and biases. • Faculty/staff workload and resource limitations.	• Foster a just and equitable environment. • Embrace a holistic approach. • Actively create and implement programs addressing accessibility, diversity, inclusion, and combating discrimination. • Prioritize and address issues of justice, equality, inclusion, safety, and well-being.
Health	• Often overlooked in existing green campus assessment tools and discussions. Sustainability rankings prioritize energy efficiency over social aspects of health. Expansive nature of health complicates defining clear goals. Inadequate awareness among faculty and staff.	• Integrate health as a major indicator alongside traditional environmental measures. Prioritize health as a primary objective, establish clear health goals, and implement staff training programs. Invest in green spaces, recreational facilities, and health-promoting initiatives. Reduce chemical exposure and improve indoor air quality through various measures. Encourage healthier food options. Ensure proper waste management.
Economic	• High upfront costs and uncertainty regarding returns on investments. Fluctuations in energy prices and government policies. Difficulty integrating sustainability into existing infrastructure. Securing funding can be challenging. Investment costs can strain budgets.	• Integrate economic viability into sustainability efforts. Conduct rigorous economic analyses and lifecycle cost–benefit analyses. Monitor economic indicators like cost savings and return on green investments. Ensure strategic resource allocation. Employ risk mitigation strategies. Establish a circular economy procurement system.
Economic	• High upfront costs and uncertainty regarding returns on investments. Fluctuations in energy prices and government policies. Difficulty integrating sustainability into existing infrastructure. Securing funding can be challenging. Investment costs can strain budgets.	• Integrate economic viability into sustainability efforts. Conduct rigorous economic analyses and lifecycle cost–benefit analyses. Monitor economic indicators like cost savings and return on green investments. Ensure strategic resource allocation. Employ risk mitigation strategies. Establish a circular economy procurement system.
Communication	• Lack of awareness among students, faculty, and staff about sustainability initiatives, and limited knowledge about sustainability practices and their benefits, leading to superficial engagement. • Ineffective communication strategies that fail to significantly impact sustainable behaviors. • Lack of Formal Evaluation Tools: No structured assessments to measure the effectiveness of communication campaigns. • Websites and digital platforms lack engaging content, limiting active participation in sustainability initiatives.	• Use strategic communication campaigns to raise awareness and foster engagement. Utilize diverse communication methods tailored to target groups. Use mixed channels (digital, incentives). Encourage staff as "ambassadors." • Establish joint committees and multi-stakeholder involvement and use strategic communication campaigns to raise awareness. Tailor messages to different campus groups using diverse channels, including digital media, in campus signage and incentives. Employ storytelling to highlight real-life sustainability success stories on campus. • Adopt a dialogic communication model to promote two-way engagement. Continuously collect feedback from campus members to refine communication strategies and ensure their effectiveness. Conduct regular surveys or structured evaluations to assess awareness, attitudes, and behavioral outcomes, and use results for evidence-based improvements. • Enhance digital interactivity with updated, relevant, and engaging content, including real-time sustainability data, success stories, and interactive tools for user participation. • Ensure ongoing promotion of sustainability initiatives through periodic events, continuous updates, newsletters, and social media presence.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

AASHE (2023). Association for the Advancement of sustainability in higher education. Available at: https://www.aashe.org/ (Accessed May 12, 2025).

Abo-Khalil, A. G. (2024). Integrating sustainability into higher education challenges and opportunities for universities worldwide. *Heliyon* 10:e29946. doi: 10.1016/j.heliyon.2024.e29946

Abu Qdais, H., Saadeh, O., Al-Widyan, M., Al-tal, R., and Abu-Dalo, M. (2019). Environmental sustainability features in large university campuses. *Int. J. Sustain. High. Educ.* 20, 214–228. doi: 10.1108/IJSHE-06-2018-0102

Aleixo, A. M., Azeiteiro, U., and Leal, S. (2018). The implementation of sustainability practices in Portuguese higher education institutions. *Int. J. Sustain. High. Educ.* 19, 146–178. doi: 10.1108/IJSHE-02-2017-0016

Alfathy, R. M., Saputro, S., and Ramli, M. (2024). Implementation of sustainable development goals in higher education modalities: literature review. *J. Turk. Sci. Educ.* 21, 22–43. doi: 10.36681/tused.2024.002

Alghamdi, N., den Heijer, A., and de Jonge, H. (2017). Assessment tools' indicators for sustainability in universities: an analytical overview. *Int. J. Sustain. High. Educ.* 18, 84–115. doi: 10.1108/IJSHE-04-2015-0071

Alshuwaikhat, H. M., and Abubakar, I. (2008). An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices. *J. Clean. Prod.* 16, 1777–1785. doi: 10.1016/j.jclepro.2007.12.002

Amaral, A. R., Rodrigues, E., Gaspar, A. R., and Gomes, Á. (2020). A review of empirical data of sustainability initiatives in university campus operations. *J. Clean. Prod.* 250:119558. doi: 10.1016/j.jclepro.2019.119558

American College Health Association (2023). The healthy campus framework. Silver Spring, MD: American College Health Association.

Ankareddy, S., Dorfleitner, G., Zhang, L., and Ok, Y. S. (2025). Embedding sustainability in higher education institutions: a review of practices and challenges. *Cleaner Environ. Syst.* 17:100279. doi: 10.1016/j.cesys.2025.100279

Anthony Jnr, B. (2021). Green campus paradigms for sustainability attainment in higher education institutions – a comparative study. *J. Sci. Technol. Policy Manag.* 12, 117–148. doi: 10.1108/jstpm-02-2019-0008

Arnaldo Valdés, R. M., and Gómez Comendador, V. F. (2022). European universities initiative: how universities may contribute to a more sustainable society. *Sustain. For.* 14:471. doi: 10.3390/su14010471

Ávila, L. V., Leal Filho, W., Brandli, L., Macgregor, C. J., Molthan-Hill, P., Özuyar, P. G., et al. (2017). Barriers to innovation and sustainability at universities around the world. *J. Clean. Prod.* 164, 1268–1278. doi: 10.1016/j.jclepro.2017.07.025

Barnett-Itzhaki, Z., Tifferet, S., Berkowic, D., Arviv, T., Daya, A., Carasso Romano, G. H., et al. (2025). Strategies and challenges for green campuses. *Front. Sustain. Cities* 7:1469274. doi: 10.3389/frsc.2025.1469274

Barron, P., Cord, L., Cuesta, J., Espinoza, S., Larson, G., and Woolcock, M. (2023). Social sustainability in development: Meeting the challenges of the 21st century. The World Bank.

Bayhantopcu, E., and Aymerich Ojea, I. (2023). Integrated sustainability management and equality practices in universities: a case study of Jaume I university. *Int. J. Sustain. High. Educ.* 25, 631–648. doi: 10.1108/ijshe-02-2023-0054

Becker, N., and Carmi, N. (2019). Changing trip behavior in a higher education institution: the role of parking fees. *Int. J. Sustain. Transp.* 13, 268–277. doi: 10.1080/15568318.2018.1463418

Beringer, A., and Adomßent, M. (2008). Sustainable university research and development: inspecting sustainability in higher education research. *Environ. Educ. Res.* 14, 607–623. doi: 10.1080/13504620802464866

Biancardi, A., Colasante, A., and D'Adamo, I. (2023). Sustainable education and youth confidence as pillars of future civil society. *Sci. Rep.* 13:955. doi: 10.1038/s41598-023-28143-9

Bieler, A., and McKenzie, M. (2017). Strategic planning for sustainability in Canadian higher education. *Sustain. For.* 9:161. doi: 10.3390/su9020161

Boer, P. (2013). "Assessing sustainability and social responsibility in higher education assessment frameworks explained" In Sustainability Assessment Tools in Higher Education Institutions: Mapping Trends and Good Practices Around the World. Eds. S.

Caeiro, L. Walter, J. Charbel and U. Azeiteiro (Springer International Publishing) pp. 121–137.

Boström, M. (2012). A missing pillar? Challenges in theorizing and practicing social sustainability: introduction to the special issue. *Sustain. Sci. Pract. Policy* 8, 3–14. doi: 10.1080/15487733.2012.11908080

Boyer, R., Peterson, N., Arora, P., and Caldwell, K. (2016). Five approaches to social sustainability and an integrated way forward. *Sustain. For.* 8:878. doi: 10.3390/su8090878

Brundiers, K., Barth, M., Cebrián, G., Cohen, M., Diaz, L., Doucette-Remington, S., et al. (2020). Key competencies in sustainability in higher education—toward an agreed-upon reference framework. *Sustain. Sci.* 16, 13–29. doi: 10.1007/s11625-020-00838-2

Brundtland, G. H. (1987). Report of the world commission on environment and development: our common future. Available online at: https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

Caldana, A. C. F., Eustachio, J. H. P. P., Lespinasse Sampaio, B., Gianotto, M. L., Talarico, A. C., and Batalhão, A. C. d. S. (2021). A hybrid approach to sustainable development competencies: the role of formal, informal and non-formal learning experiences. *Int. J. Sustain. High. Educ.* 24, 235–258. doi: 10.1108/ijshe-10-2020-0420

Carpenter, S., Takahashi, B., Lertpratchya, A. P., and Cunningham, C. (2016). Greening the campus: a theoretical extension of the dialogic communication approach. *Int. J. Sustain. High. Educ.* 17, 520–539. doi: 10.1108/IJSHE-02-2015-0036

Cebrián, G., Junyent, M., and Mulà, I. (2020). Competencies in education for sustainable development: emerging teaching and research developments. *Sustain. For.* 12:579. doi: 10.3390/su12020579

Chen, G., Cheng, L., and Li, F. (2022). Integrating sustainability and users' demands in the retrofit of a university campus in China. *Sustain. For.* 14:10414. doi: 10.3390/su141610414

Cole, E. J., and Fieselman, L. (2013). A community-based social marketing campaign at Pacific University Oregon. *Int. J. Sustain. High. Educ.* 14, 176–195. doi: 10.1108/14676371311312888

Coleman, B. K., Lunden, M. M., Destaillats, H., and Nazaroff, W. W. (2008). Secondary organic aerosol from ozone-initiated reactions with terpene-rich household products. *Atmospheric Environment*, 42, 8234–8245.

Cortese, A. (2003). The critical role of higher education in creating a sustainable future. *Plan. High. Educ.* 31, 15–22.

Crispino, A. B., Rocha, C. V. B., Mantelli, G. A. S., de Arruda Câmara, L. M., de Almeida, L. S. P., Monteiro, M. V. P., et al. (2018). Sustainability on University of São Paulo's campi: the case of the environmental law clinic and its contributions. In: Towards Green Campus Operations. World Sustainability Series. Eds. W. Leal Filho, F. Frankenberger, P. Iglecias and R. Mülfarth (eds). Cham: Springer.

Cruz, L., Barata, E., Ferreira, J.-P., and Freire, F. (2017). Greening transportation and parking at University of Coimbra. *Int. J. Sustain. High. Educ.* 18, 23–38. doi: 10.1108/IJSHE-04-2015-0069

CUSP (2024). What are the impacts of micro-and nanoplastics on the human body? Published September 2, 2021. Available online at: https://cusp-research.eu/ (Accessed November 24, 2022).

da Silva, L. A., de Aguiar Dutra, A. R., and de Andrade Guerra, J. B. S. O. (2023). Decarbonization in higher education institutions as a way to achieve a green campus: a literature review. *Sustain. For.* 15:4043. doi: 10.3390/su15054043

Dade, A., and Hassenzahl, D. M. (2013). Communicating sustainability. *Int. J. Sustain. High. Educ.* 14, 254–263. doi: 10.1108/IJSHE-08-2011-0053

Dawodu, A., Dai, H., Zou, T., Zhou, H., Lian, W., Oladejo, J., et al. (2022). Campus sustainability research: indicators and dimensions to consider for the design and assessment of a sustainable campus. *Heliyon* 8:e11864. doi: 10.1016/j.heliyon.2022.e11864

Dempsey, N., Bramley, G., Power, S., and Brown, C. (2011). The social dimension of sustainable development: defining urban social sustainability. *Sustain. Dev.* 19, 289–300. doi: 10.1002/sd.417

Destaillats, H., Lunden, M. M., Singer, B. C., Coleman, B. K., Hodgson, A. T., Weschler, C. J., et al (2006). Indoor secondary pollutants from household product

emissions in the presence of ozone: a bench-scale chamber study. *Environmental Science and Technology*, 40, 4421–4428.

Disterheft, A., Caeiro, S., Azeiteiro, U. M., and Filho, W. L. (2015). Sustainable universities – a study of critical success factors for participatory approaches. *J. Clean. Prod.* 106, 11–21. doi: 10.1016/j.jclepro.2014.01.030

Duinker, P. N., and Greig, L. A. (2007). Scenario analysis in environmental impact assessment: improving explorations of the future. *Environ. Impact Assess. Rev.* 27, 206–219. doi: 10.1016/j.eiar.2006.11.001

EAUC. (2024). EAUC Home. Available online at: https://www.eauc.org.uk/ (Accessed June 2024).

Eizenberg, E., and Jabareen, Y. (2017). Social sustainability: a new conceptual framework. *Sustain. For.* 9:68. doi: 10.3390/su9010068

El Marsafawy, H., Al Zayani, M., and Van Kessel, D. (2017). "Believing, learning, and practicing green: gulf university reflections on sustainability." in INTED proceedings.

Fernández-Vázquez, J.-S. (2021). Measuring environmental website communications in Latin American universities: multimodal and ecolinguistic benchmarking. *Int. J. Sustain. High. Educ.* 22, 599–614. doi: 10.1108/IJSHE-07-2020-0248

Figueredo, F. R., and Tsarenko, Y. (2013). Is "being green" a determinant of participation in university sustainability initiatives? *Int. J. Sustain. High. Educ.* 14, 242–253. doi: 10.1108/IJSHE-02-2011-0017

Filho, W. L. (2011). About the role of universities and their contribution to sustainable development. *High. Educ. Policy* 24, 427–438. doi: 10.1057/hep.2011.16

Finnveden, G., Friman, E., Mogren, A., Palmer, H., Sund, P., Carstedt, G., et al. (2020). Evaluation of integration of sustainable development in higher education in Sweden. *Int. J. Sustain. High. Educ.* 21, 685–698. doi: 10.1108/IJSHE-09-2019-0287

Freire, B. V., and Bortoleto, A. P. (2018). Evaluation of environmental impacts from a molecular evolution laboratory's waste management system—a Brazilian case study. In: *Towards Green Campus Operations. World Sustainability Series*. Eds. Leal Filho, W., Frankenberger, F., Iglecias, P., Mülfarth, R. Springer, Cham.

Furco, A. (1996). Service-learning: a balanced approach to experiential education. Expanding Boundaries: Serving and Learning. Washington DC: Corporation for National Service, 2–6.

Gholami, H., Bachok, M. F., Saman, M. Z. M., Streimikiene, D., Sharif, S., and Zakuan, N. (2020). An ISM approach for the barrier analysis in implementing green campus operations: towards higher education sustainability. *Sustain. For.* 12:363. doi: 10.3390/su12010363

Giuliani, A., Zuccarini, M., Cichelli, A., Khan, H., and Reale, M. (2020). Critical review on the presence of phthalates in food and evidence of their biological impact. *Int. J. Environ. Res. Public Health* 17:5655. doi: 10.3390/ijerph17165655

Global Universities Partnership on Environment and Sustainability (GUPES) (2024). Green gown awards. Available online at: https://www.greengownawards.org/global-universities-partnership-on-environment-1

GreenCampus, G. (2024). Green-campus. Green-Campus Ireland. Available online at: https://www.greencampusireland.org/

Günaydın, A. S., and Yücekaya, M. (2020). An investigation of sustainable transportation model in campus areas with space syntax method. *Iconarp Int. J. Archit. Plan.* 8, 262–281. doi: 10.15320/iconarp.2020.113

Hammond, C., and Churchman, D. (2008). Sustaining academic life. *Int. J. Sustain. High. Educ.* 9, 235–245. doi: 10.1108/14676370810885862

Helferty, A., and Clarke, A. (2009). Student-led campus climate change initiatives in Canada. *Int. J. Sustain. High. Educ.* 10, 287–300. doi: 10.1108/14676370910972594

Hipp, J. A., Gulwadi, G. B., Alves, S., and Sequeira, S. (2016). The relationship between perceived greenness and perceived restorativeness of university campuses and student-reported quality of life. *Environ. Behav.* 48, 1292–1308. doi: 10.1177/0013916515598200

Hlisníková, H., Petrovičová, I., Kolena, B., Šidlovská, M., and Sirotkin, A. (2020). Effects and mechanisms of phthalates' action on reproductive processes and reproductive health: a literature review. *Int. J. Environ. Res. Public Health* 17:6811. doi: 10.3390/ijerph17186811

Hodge, K. S., Stewart, J., and Grella, L. (2021). "Economics of campus sustainability" in Oxford research encyclopedia of environmental science. Oxford Research Encyclopedia of Environmental Science. Available at: https://oxfordre.com/environmentalscience/view/10.1093/acrefore/9780199389414.001.0001/acrefore-9780199389414-e-511 (Accessed June 13, 2025).

Hoover, E., and Harder, M. K. (2015). What lies beneath the surface? The hidden complexities of organizational change for sustainability in higher education. *J. Clean. Prod.* 106, 175–188. doi: 10.1016/j.jclepro.2014.01.081

Hudler, K., Dennis, L., DiNella, M., Ford, N., Mendez, J., and Long, J. (2019). Intersectional sustainability and student activism: a framework for achieving social sustainability on university campuses. *Educ. Citizensh. Soc. Justice* 16, 78–96. doi: 10.1177/1746197919886860

Idoiaga Mondragon, N., Yarritu, I., Saez de Cámara, E., Beloki, N., and Vozmediano, L. (2023). The challenge of education for sustainability in higher education: key themes and competences within the University of the Basque Country. *Front. Psychol.* 14:1158636. doi: 10.3389/fpsyg.2023.1158636

International Sustainable Campus Network (2011). In Green education: An A-to-Z guide. Ed. J. Newman (Ed.) SAGE Publications, Inc., pp. 230–233. (Accessed May 15, 2025).

Jain, S., Agarwal, A., Jani, V., Singhal, S., Sharma, P., and Jalan, R. (2017). Assessment of carbon neutrality and sustainability in educational campuses (CaNSEC): a general framework. *Ecol. Indic.* 76, 131–143. doi: 10.1016/j.ecolind.2017.01.012

Kelz, C., Evans, G. W., and Röderer, K. (2013). The restorative effects of redesigning the schoolyard. *Environ. Behav.* 47, 119–139. doi: 10.1177/0013916513510528

Kim, A. A., Sadatsafavi, H., Medal, L., and Ostergren, M. J. (2018). Impact of communication sources for achieving campus sustainability. *Resour. Conserv. Recycl.* 139, 366–376. doi: 10.1016/j.resconrec.2018.08.024

Kwami, H. I., Che-Ani, A. I., Tawil, N. M., Tahir, M. M., and Basri, H. (2014). Approach to campus sustainability at Universiti Kebangsaan Malaysia (UKM): a review. *E3S Web Conf.* 3:01011. doi: 10.1051/e3sconf/20140301011

Larrán Jorge, M., Andrades Peña, F. J., and Herrera Madueño, J. (2019). An analysis of university sustainability reports from the GRI database: an examination of influential variables. *J. Environ. Plan. Manag.* 62, 1019–1044. doi: 10.1080/09640568.2018.1457952

Leal Filho, W., Dinis, M. A. P., Lange Salvia, A., Sierra, J., Vasconcelos, H., Henderson-Wilson, C., et al. (2024). Assessing climate change and health provisions among staff in higher education institutions: a preliminary investigation. *PLoS One* 19:e0304019. doi: 10.1371/journal.pone.0304019

Leal Filho, W., Shiel, C., and Paço, A. (2016). Implementing and operationalising integrative approaches to sustainability in higher education: the role of project-oriented learning. *J. Clean. Prod.* 133, 126–135. doi: 10.1016/j.jclepro.2016.05.079

Leal Filho, W., Simaens, A., Paço, A., Hernandez-Diaz, P. M., Vasconcelos, C. R. P., Fritzen, B., et al. (2023). Integrating the sustainable development goals into the strategy of higher education institutions. *Int. J. Sustain. Dev. World Ecol.* 30, 564–575. doi: 10.1080/13504509.2023.2167884

Leal Filho, W., Vargas, V. R., Salvia, A. L., Brandli, L. L., Pallant, E., Klavins, M., et al. (2019). The role of higher education institutions in sustainability initiatives at the local level. *J. Clean. Prod.* 233, 1004–1015. doi: 10.1016/j.jclepro.2019.06.059

Leal Filho, W., Viera Trevisan, L., Sivapalan, S., Mazhar, M., Kounani, A., Mbah, M. F., et al. (2025). Assessing the impacts of sustainability teaching at higher education institutions. *Discov. Sustain.* 6:227. doi: 10.1007/s43621-025-01024-z

Levi, A., Kessler, N., Klein, I., and Ben-Elia, E. (2020). Implementation of teleworking policy in Israel—benefits, challenges and the day after COVID-19. *SSRN Electron. J.* doi: 10.2139/ssrn.3718382

Liu, W., Sun, N., Guo, J., and Zheng, Z. (2022). Campus green spaces, academic achievement and mental health of college students. *Int. J. Environ. Res. Public Health* 19:8618. doi: 10.3390/ijerph19148618

Lozano, R. (2006). A tool for a graphical assessment of sustainability in universities (GASU). *J. Clean. Prod.* 14, 963–972. doi: 10.1016/j.jclepro.2005.11.041

Lozano, R., Ceulemans, K., Alonso-Almeida, M., Huisingh, D., Lozano, F. J., Waas, T., et al. (2015). A review of commitment and implementation of sustainable development in higher education: results from a worldwide survey. *J. Clean. Prod.* 108, 1–18. doi: 10.1016/j.jclepro.2014.09.048

Machado, C. F., and Davim, J. P. (2023). Sustainability in the modernization of higher education: curricular transformation and sustainable campus—a literature review. *Sustain. For.* 15:8615. doi: 10.3390/su15118615

Maiorescu, I., Sabou, G. C., Bucur, M., and Zota, R. D. (2020). Sustainability barriers and motivations in higher education – a student's perspective. *Amfiteatru Econ.* 22, 362–375. doi: 10.24818/EA/2020/54/362

Malamuth, N. M., Huppin, M., and Linz, D. (2018). Sexual assault interventions may be doing more harm than good with high-risk males. *Aggress. Violent Behav.* 41, 20–24. doi: 10.1016/j.avb.2018.05.010

Mangukiya, R. D., and Sklarew, D. M. (2023). Analyzing three pillars of sustainable development goals at sub-national scales within the USA. *World Dev. Sustain.* 2:100058. doi: 10.1016/j.wds.2023.100058

Mason, I. G., Brooking, A. K., Oberender, A., Harford, J. M., and Horsley, P. G. (2003). Implementation of a zero waste program at a university campus. *Resour. Conserv. Recycl.* 38, 257–269. doi: 10.1016/S0921-3449(02)00147-7

McDonald, B. C., De Gouw, J. A., Gilman, J. B., Jathar, S. H., Akherati, A., Cappa, C. D., et al. (2018). Volatile chemical products emerging as largest petrochemical source of urban organic emissions. *Science*, 359, 760–764.

Menon, S., and Suresh, M. (2020). Synergizing education, research, campus operations, and community engagements towards sustainability in higher education: a literature review. *Int. J. Sustain. High. Educ.* 21, 1015–1051. doi: 10.1108/IJSHE-03-2020-0089

MOEP. (2021). Green campus. GOV.IL. Available online at: https://www.gov.il/he/Departments/Guides/green_campus

Mohammadalizadehkorde, M., and Weaver, R. (2018). Universities as models of sustainable energy-consuming communities? Review of selected literature. *Sustain. For.* 10:3250. doi: 10.3390/su10093250

Mokski, E., Leal Filho, W., Sehnem, S., and de Andrade Guerra, J. B. S. O. (2022). Education for sustainable development in higher education institutions: an approach for effective interdisciplinarity. *Int. J. Sustain. High. Educ.* 24, 96–117. doi: 10.1108/ijshe-07-2021-0306

Moreira, A. M. M., Günther, W. M. R., and Ribeiro, H. (2018). "School of Public Health, University of Sao Paulo—Marching towards socioeconomic and environmental sustainability." World Sustainability Series, 701–713.

Mujal, G. N., Taylor, M. E., Fry, J. L., Gochez-Kerr, T. H., and Weaver, N. L. (2019). A systematic review of bystander interventions for the prevention of sexual violence. *Trauma Violence Abuse* 22, 381–396. doi: 10.1177/1524838019849587

Mulà, I., Tilbury, D., Ryan, A., Mader, M., Dlouhá, J., Mader, C., et al. (2017). Catalysing change in higher education for sustainable development: a review of professional development initiatives for university educators. *Int. J. Sustain. High. Educ.* 18, 798–820. doi: 10.1108/IJSHE-03-2017-0043

Murray, S., Peterson, C., Primo, C., Elliott, C., Otlowski, M., Auckland, S., et al. (2021). Prevalence of food insecurity and satisfaction with on-campus food choices among Australian university students. *Int. J. Sustain. High. Educ.* 22, 731–746. doi: 10.1108/IJSHE-09-2020-0348

Mylonas, G., Amaxilatis, D., Tsampas, S., Pocero, L., and Gunneriusson, J. (2019). "A methodology for saving energy in educational buildings using an IoT infrastructure." in 2019 10th international conference on information, intelligence, systems and applications (IISA).

Németh, P., Torma, A., Lukács, E., and Filep, B. (2023). Sustainability opportunities and barriers at universities, development of a sustainable university environment. *Chem. Eng. Trans.* 107, 505–510. doi: 10.3303/CET23107085

Niza, I. L., de Souza, M. P., da Luz, I. M., and Broday, E. E. (2023). Sick building syndrome and its impacts on health, well-being and productivity: a systematic literature review. *Indoor Built Environ.* 33, 218–236. doi: 10.1177/1420326X231191079

Norshahidi, N. D., Sadiah Ismail, N. H., Zainal Abidin, S., and Abd Razak, N. F. (2021). Profile identification of students' attitude towards statistics course: a case study in UiTM Pahang branch (Raub campus). *Math. Sci. Inform. J.* 2, 63–69. doi: 10.24191/mij.v2i1.13006

Obrecht, M., Feodorova, Z., and Rosi, M. (2022). Assessment of environmental sustainability integration into higher education for future experts and leaders. *J. Environ. Manag.* 316:115223. doi: 10.1016/j.jenvman.2022.115223

Opp, S. M. (2016). The forgotten pillar: a definition for the measurement of social sustainability in American cities. *Local Environ.* 22, 286–305. doi: 10.1080/13549839.2016.1195800

Owens, T. L. (2017). Higher education in the sustainable development goals framework. *Eur. J. Educ.* 52, 414–420. doi: 10.1111/ejed.12237

Ozili, P. K. (2022). Sustainability and sustainable development research around the world. *Manag. Glob. Transit.* 20:293. doi: 10.26493/1854-6935.20.259-293

Pareja-Eastaway, M. (2012). Social sustainability. *Int. Encyclop. Housing Home*, 502–505. doi: 10.1016/b978-0-08-047163-1.00571-3

Park, J., Lee, L., Byun, H., Ham, S., Lee, I., Park, J., et al. (2014). A study of the volatile organic compound emissions at the stacks of laboratory fume hoods in a university campus. *J. Clean. Prod.* 66, 10–18. doi: 10.1016/j.jclepro.2013.11.024

Pompeii, B., Chiu, Y. W., Neill, D., Braun, D., Fiegel, G., Oulton, R., et al. (2019). Identifying and overcoming barriers to integrating sustainability across the curriculum at a teaching-oriented university. *Sustain. For.* 11:2652. doi: 10.3390/su11092652

Posner, S. M., and Stuart, R. (2013). Understanding and advancing campus sustainability using a systems framework. *Int. J. Sustain. High. Educ.* 14, 264–277. doi: 10.1108/IJSHE-08-2011-0055

Purcell, W. M., Henriksen, H., and Spengler, J. D. (2019). Universities as the engine of transformational sustainability toward delivering the sustainable development goals. *Int. J. Sustain. High. Educ.* 20, 1343–1357. doi: 10.1108/IJSHE-02-2019-0103

Ramirez, O., Hernandez-Cuellar, D., and de la Rosa, J. D. (2023). Air quality monitoring on university campuses as an essential element to move towards sustainable campuses: an overview. *Urban Clim.* 52:101694. doi: 10.1016/j.uclim.2023.101694

Razzaq, I., Amjad, M., and Qamar, A. (2023a). 2023 UI GreenMetric participants. Google My Maps. Available online at: https://www.google.com/maps/d/viewer?mid=1 4ugCOy5tuLEcewYazXsKmQ47ClXU41U

Razzaq, I., Amjad, M., Qamar, A., Asim, M., Ishfaq, K., Razzaq, A., et al. (2023b). Reduction in energy consumption and CO2 emissions by retrofitting an existing building to a net zero energy building for the implementation of SDGs 7 and 13. *Front. Environ. Sci.* 10:1028793. doi: 10.3389/fenvs.2022.1028793

Ribeiro, J. M. P., Hoeckesfeld, L., BocaSanta, S. L., Araujo, G. G. M., Jonck, A. V., Berchin, I. I., et al. (2019). "Students' opinion about green campus initiatives: a South American University case study" In: Sustainability on University Campuses: Learning, Skills Building and Best Practices. World Sustainability Series Eds. W. Leal Filho and U. Bardi (Springer, Cham).

Ribeiro, J. M. P., Hoeckesfeld, L., Dal Magro, C. B., Favretto, J., Barichello, R., Lenzi, F. C., et al. (2021). Green Campus Initiatives as sustainable development dissemination at higher education institutions: Students' perceptions. *Journal of Cleaner Production*, 312:127671.

Rosales, C. M. F., Jiang, J., Lahib, A., Bottorff, B. P., Reidy, E. K., Kumar, V., et al. (2022). Chemistry and human exposure implications of secondary organic aerosol production from indoor terpene ozonolysis. Science *Advances*, 8:eabj9156.

Saldaña-Durán, C. E., and Messina-Fernández, S. R. (2020). E-waste recycling assessment at university campus: a strategy toward sustainability. *Environ. Dev. Sustain.* 23, 2493–2502. doi: 10.1007/s10668-020-00683-4

Seblos, K., Tabañag, D., Sangcap, C., Ocampo, C. N., Tapdasan, F. D., and Paño, J. (2023). Challenges and initiatives on single-use plastics in universities. *J. Soc. Sci.* 4, 2360–2379. doi: 10.46799/jss.v4i6.604

Sertyeşilişık, B., Giritli, H., Tezel, E., and Sertyeşilişık, E. (2018). An investigation into university students' perceptions of sustainability. In *Proceedings of 3rd International Sustainable Buildings Symposium (ISBS 2017)* Volume 2. Springer International Publishing. pp. 338–346.

Sharma, S. K., Mohapatra, S., Sharma, R. C., Alturjman, S., Altrjman, C., Mostarda, L., et al. (2022). Retrofitting existing buildings to improve energy performance. *Sustain. For.* 14:666. doi: 10.3390/su14020666

Shaw, A., Capetola, T., Lawson, J. T., Henderson-Wilson, C., and Murphy, B. (2018). The cost of sustainability in higher education: staff and student views of a campus food culture. *Int. J. Sustain. High. Educ.* 19, 376–392. doi: 10.1108/IJSHE-12-2016-0225

Shawe, R., Horan, W., Moles, R., and O'Regan, B. (2019). Mapping of sustainability policies and initiatives in higher education institutes. *Environ. Sci. Pol.* 99, 80–88. doi: 10.1016/j.envsci.2019.04.015

Shih, Y. H., Hsu, M. C., and Chang, C. L. (2025). Sustainability transformations in higher education: global perspectives on the challenges and solutions. *Int. J. Educ. Humanit.* 5, 126–139. doi: 10.58557/(ijeh).v5i1.290

Sholihin, M. Y. M., Prasetyani, R., and Mukti, B. C. (2020). Analysis of the impacts of motor vehicle exhaust emissions at Pancasila university on health in order to create a green campus. *IOP Conf. Ser. Mater. Sci. Eng.* 847:012042. doi: 10.1088/1757-899X/847/1/012042

Sippel, M. (2023). Key insights from climate communication – and how they can inspire sustainability in higher education. *Int. J. Sustain. High. Educ.* 24, 1594–1609. doi: 10.1108/IJSHE-07-2022-0208

Soares, N., Dias Pereira, L., Ferreira, J., Conceição, P., and Pereira da Silva, P. (2015). Energy efficiency of higher education buildings: a case study. *Int. J. Sustain. High. Educ.* 16, 669–691. doi: 10.1108/IJSHE-11-2013-0147

Sonetti, G., Lombardi, P., and Chelleri, L. (2016). True green and sustainable university campuses? Toward a clusters approach. *Sustain. For.* 8:83. doi: 10.3390/su8010083

STARS. (2024). The sustainability tracking, Assessment & Rating System—Technical Manual. Available online at: https://stars.aashe.org/resources-support/technical-manual/

Sugiarto, A., Lee, C.-W., and Huruta, A. D. (2022). A systematic review of the sustainable campus concept. *Behav. Sci.* 12:130 PubMed. doi: 10.3390/bs12050130

Swearingen White, S. (2014). Campus sustainability plans in the United States: where, what, and how to evaluate? *Int. J. Sustain. High. Educ.* 15, 228–241. doi: 10.1108/IJSHE-08-2012-0075

Taghizadeh-Hesary, F., and Yoshino, N. (2020). Sustainable solutions for green financing and investment in renewable energy projects. *Energies* 13:788. doi: 10.3390/en13040788

Temkin, A. M., Geller, S. L., Swanson, S. A., Leiba, N. S., Naidenko, O. V., and Andrews, D. Q. (2023). Volatile organic compounds emitted by conventional and "green" cleaning products in the us market. *Chemosphere* 341:139570. doi: 10.1016/j.chemosphere.2023.139570

The 17 Goals. (2015). Sustainable development. Available online at: https://sdgs.un.org/goals

Thompson, C. A., Pownall, M., Harris, R., and Blundell-Birtill, P. (2023). Is the grass always greener? Access to campus green spaces can boost students' sense of belonging. *Int. J. Sustain. High. Educ.* 24, 1841–1857. doi: 10.1108/IJSHE-11-2022-0349

Tifferet, S., and Teman, E. (2021). In-service learning: What can be learned from the lecturers.

Too, L., and Bajracharya, B. (2015). Sustainable campus: engaging the community in sustainability. *Int. J. Sustain. High. Educ.* 16, 57–71. doi: 10.1108/IJSHE-07-2013-0080

Tsunekawa, K., Matsuuoka, T., and Taniguchi, G. (2009). A study on bench marking survey of faculty operational expense on universities. *AIJ J. Technol. Design* 15, 295–300. doi: 10.3130/aijt.15.295

United Nations. (2015). World Public Sector Report chapter 4: Transforming governance for the 2030 agenda for sustainable development. pp 73–87. doi: 10.18356/e5a72957-en

U.S. Green Building Council. (2024). Leed rating system. Available online at: https://www.usgbc.org/leed (Accessed March 15, 2024).

UK Parliament (2003). Select Committee on Office of the Deputy Prime Minister. Housing, planning, local government and the regions eighth report. Available online at: https://publications.parliament.uk/pa/cm200203/cmselect/cmodpm/77/7704.htm (Accessed March 15, 2024).

ULSF—University Leaders for a Sustainable Future. (2015). Sustainability assessment questionnaire. Available online at: http://ulsf.org/sustainability-assessment-questionnaire/ (Accessed March 2, 2024).

Umar, S. B., Ahmad, J., Bukhori, M. A. B. M., Mohd Ali, K. A., and Wan Hussain, W. M. H. (2024). A decade in review: bibliometric analysis of sustainable performance trends in higher education institutes. *Front. Educ.* 9:1433525. doi: 10.3389/feduc.2024.1433525

UN Environment (2017). Green university networks. UNEP - UN Environment Programme. Available online at: http://www.unep.org/explore-topics/education-environment/why-does-education-and-environment-matter/green-university

UN Environment. (2019). Global environment outlook – GEO-6: healthy planet, healthy people. Nairobi.

UNEP (2014) Greening Universities Toolkit v2.0. Available online at: https://wedocs.unep.org/bitstream/handle/20.500.11822/11964/Greening%20University%20Toolkit%20V2.0.pdf

United Nations Conference on Environment and Development (1992). Rio declaration on environment and development. *Int. Leg. Mater.* 31, 874–880. doi: 10.1017/S0020782900014765

University of Utah (2024). Integrating sustainability into courses Available online at: https://sustainability.utah.edu/sustainability-across-the-curriculum/integrating-sustainability-into-courses/?utm_source=chatgpt.com

Velazquez, L., Munguia, N., Platt, A., and Taddei, J. (2006). Sustainable university: what can be the matter? *J. Clean. Prod.* 14, 810–819. doi: 10.1016/j.jclepro.2005.12.008

Versal, N., and Sholoiko, A. (2022). Green bonds of supranational financial institutions: on the road to sustainable development. *Invest. Manag. Financ. Innov.* 19, 91–105. doi: 10.21511/imfi.19(1).2022.07

Wang, Y., and Qian, H. (2021). Phthalates and their impacts on human health. *Healthcare* 9:603. doi: 10.3390/healthcare9050603

Widiastuti, H., Arifin, N. L., and Mutiarani (2019). "Waste sorting campaign toward green campus: case study in Politeknik Negeri Batam." in AIP Conference Proceedings.

Wiek, A., Withycombe, L., and Redman, C. L. (2011). Key competencies in sustainability: a reference framework for academic program development. *Sustain. Sci.* 6, 203–218. doi: 10.1007/s11625-011-0132-6

Wolff, L. A., and Ehrström, P. (2020). Social sustainability and transformation in higher educational settings: a utopia or possibility? *Sustain. For.* 12:4176. doi: 10.3390/su12104176

Woolliams, J., Lloyd, M., and Spengler, J. D. (2005). The case for sustainable laboratories: first steps at Harvard University. *Int. J. Sustain. High. Educ.* 6, 363–382. doi: 10.1108/14676370510623856

Žalėnienė, I., and Pereira, P. (2021). Higher education for sustainability: a global perspective. *Geogr. Sustain.* 2, 99–106. doi: 10.1016/j.geosus.2021.05.001