

Measurements of Sustainability in Higher Education Institutions: A Scoping Review and Framework for Assessment

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Abstract: *Sustainability has become a strategic priority for HEIs (higher education institutions) worldwide, with growing efforts to integrate environmental, social, economic, and governance dimensions into institutional operations and academic missions. Yet, considerable variation remains in how sustainability is measured and reported across HEIs. This scoping review maps and synthesizes major sustainability measurement frameworks and identifies trends, challenges, and implementation gaps. These frameworks include STARS (Sustainability Tracking, Assessment & Rating System), UI GreenMetric (UI GreenMetric World University Ranking), GASU (Graphical Assessment of Sustainability in Universities), SAQ (Sustainability Assessment Questionnaire), and ISO 14001. Guided by Arksey and O'Malley's framework and PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) protocols, peer-reviewed studies from 2014 to 2024 were systematically reviewed. The findings reveal that while some tools offer multidimensional metrics, most lack contextual adaptability, standardization, and sufficient coverage of social and educational outcomes. A conceptual framework is proposed to support the integration of sustainability assessments into institutional planning and policy. The study provides practical insights for policymakers, administrators, and researchers working toward more holistic and context-sensitive sustainability measurement in higher education.*

Keywords: Sustainability Assessment, Higher Education Institutions, Scoping Review, STARS, UI GreenMetric

1. Introduction

Sustainability has become a strategic priority for HEIs worldwide, particularly following the adoption of the United Nations' 2030 Agenda for Sustainable Development in 2015. The 17 SDGs (Sustainable Development Goals) emphasize the role of education not only in quality education, but also as a cross-cutting driver of all other goals (UNESCO, 2022). As centers of knowledge creation, HEIs are uniquely positioned to address global challenges—such as climate change, social inequality, and environmental degradation—through education, research, innovation, and community engagement (Lozano et al., 2015; Leal Filho et al., 2020). The integration of sustainability within higher education extends beyond environmental management to encompass social equity, economic responsibility, and institutional governance, aligning with the Triple Bottom Line framework (Elkington, 1998). Increasingly, universities embed sustainability in curricula, campus operations, strategic planning, and

partnerships, thereby cultivating graduates equipped with the knowledge and skills necessary to promote sustainable development (Sterling, 2015).

Global initiatives, including the Higher Education Sustainability Initiative and the Times Higher Education Impact Rankings, have reinforced the commitment of HEIs to the SDGs by evaluating contributions across research, outreach, and institutional operations (Times Higher Education, 2023). However, studies reveal that despite widespread awareness, the adoption of a whole-institution sustainability approach remains limited. For instance, a survey by the International Association of Universities (IAU) reported that only 45% of HEIs have strategic plans explicitly addressing sustainability (IAU, 2020). Moreover, challenges persist in measuring and comparing sustainability performance, as there is no universal set of standardized metrics. Tools like STARS and UI GreenMetric offer assessment criteria, but their implementation varies widely across regions and institutional contexts (Alonso-Almeida et al., 2020; Yarime & Tanaka, 2015). Therefore, developing robust, context-sensitive yet standardized assessment frameworks is crucial for enhancing transparency, accountability, and global benchmarking of HEI sustainability performance.

Although the integration of sustainability principles into higher education has gained momentum, measuring and assessing sustainability performance in HEIs remains inconsistent and fragmented. There is no universally accepted assessment framework that captures the holistic dimensions of sustainability—environmental, social, economic, and governance—within the context of higher education. Existing tools such as STARS and UI GreenMetric differ significantly in indicators, weightings, and scoring approaches, which limits comparability and benchmarking across institutions (Alonso-Almeida et al., 2020; Yarime & Tanaka, 2015).

Most sustainability assessments focus primarily on operational aspects (e.g., energy, waste, infrastructure) while overlooking the educational mission, such as curriculum transformation, research, and community engagement (Leal Filho et al., 2020). This creates a gap between institutional sustainability goals and their academic and societal impact.

Reliable data on sustainability indicators are often difficult to obtain due to fragmented data systems, lack of staff training, and inconsistent reporting standards. Smaller or resource-constrained HEIs face greater challenges in implementing comprehensive assessments (Bantanur & Patil, 2018).

Conducting sustainability assessments requires financial, technical, and human resources. Many institutions, particularly in developing regions, lack dedicated sustainability offices or staff, leading to superficial or one-off evaluations (Christou et al., 2024).

Institutional culture plays a critical role in the adoption of sustainability practices. Resistance to change, siloed departmental structures, and insufficient leadership commitment hinder the institutionalization of robust sustainability measurement (Alshuwaikhat & Abubakar, 2018).

In light of the increasing global emphasis on sustainability and the pivotal role of HEIs in advancing the SDGs, this study aims to explore the current state, effectiveness, and challenges of sustainability measurement practices in HEIs. The research focuses on identifying the frameworks adopted, the dimensions being measured, and the institutional and contextual factors influencing measurement practices.

2. Literature Review

2.1 Conceptualizing Sustainability in Higher Education

The concept of sustainability in higher education has evolved significantly, shaped by the UN's 2030 Agenda and Sustainable Development Goals. The Brundtland Report's foundational definition—development that meets the needs of the present without compromising the ability of future generations to meet their own needs—remains central (WCED, 1987). When applied to HEIs, it implies not only reducing environmental impact but also cultivating ethical leadership and inclusive learning environments (Sterling, 2004).

Lozano et al. (2013) conceptualize sustainability in HEIs across four interconnected dimensions: (1) curriculum and teaching, (2) research, (3) campus operations, and (4) community outreach. AASHE (2019) similarly defines it as “a dynamic process that enables all people to realize their potential and improve their quality of life in ways that simultaneously protect and enhance the Earth's life-support systems.” Despite these frameworks, no universally accepted conceptualization exists, leading to implementation variability across institutions (Yarime & Tanaka, 2015).

2.2 Major Assessment Frameworks

In response to global sustainability emphasis, multiple measurement frameworks have been developed. Table 1 provides a comparative overview.

Table 1: Comparative Overview of Major Sustainability Assessment Frameworks

Framework	Originator	Scope	Key Features	Adoption	Limitations
STARS	AASHE (2010)	Comprehensive	5 categories; transparent scoring; annual self-reporting	1,000+ HEIs (primarily N. America/Europe)	Resource-intensive
UI GreenMetric	Universitas Indonesia (2010)	Environmental focus	6 indicators (energy, waste, Water, transport, infrastructure, education)	1,200+ HEIs (Asia, Latin America, Middle East)	Limited social/governance coverage; per-capita bias
GASU	Gómez et al. (2015)	Multidimensional	Radar graph visualization; customizable weights	Limited adoption	Lacks international benchmarks
SAQ	ULSF (2002)	Qualitative self-assessment	Institutional mission, operations, curriculum, research, outreach	Declining usage	Outdated; lacks quantifiable metrics
ISO 14001/EMAS	International standards	Environmental management only	Standardized certification; third-party audits	Selected universities (Europe)	Detached from academic mission

While each framework offers distinct strengths, critical gaps remain evident across multiple dimensions. In terms of scope and integration, STARS provides the broadest coverage across institutional sustainability dimensions, whereas UI GreenMetric emphasizes environmental performance with comparatively limited attention to curriculum development or governance

structures. Empirical studies indicate that most assessment tools tend to underrepresent social and educational outcomes relative to operational metrics (Alonso-Almeida et al., 2020). This imbalance reflects a systemic bias toward measurable environmental indicators over transformative educational outcomes.

Regarding comparability, STARS and UI GreenMetric enable institutional benchmarking through standardized metrics; however, regional variations in institutional contexts and self-reporting bias substantially limit meaningful comparability across diverse geographical and organizational settings. Conversely, GASU and SAQ, while offering institutional flexibility, lack universal structural frameworks, thereby reducing cross-institutional comparison and global benchmarking capacity. ISO 14001 offers internationally standardized certification mechanisms but rarely contextualizes sustainability requirements to educational settings, consequently omitting curriculum transformation and pedagogical innovation—critical components of institutional sustainability.

Resource requirements present another significant barrier to framework implementation. STARS and ISO 14001 are notably resource-intensive, demanding extensive documentation systems and third-party verification processes that often function as barriers for smaller institutions or those with constrained financial resources. In contrast, UI GreenMetric and SAQ, though more accessible in terms of implementation costs, frequently sacrifice assessment depth and measurement accuracy in the process (Leal Filho et al., 2022). This trade-off between accessibility and rigor remains a persistent challenge in framework selection.

Each framework offers distinct strengths, yet critical gaps persist across multiple dimensions. Regarding scope and integration, STARS provides the broadest coverage across environmental, social, and academic dimensions. In contrast, UI GreenMetric emphasizes environmental performance with limited attention to curriculum development or governance structures. Empirical studies confirm that most tools underrepresent social and educational outcomes relative to operational metrics (Alonso-Almeida et al., 2020), reflecting a systemic bias toward easily measurable environmental indicators over transformative educational impacts.

Concerning comparability, STARS and UI GreenMetric enable institutional benchmarking through standardized metrics. However, regional variations in institutional contexts and self-reporting bias substantially limit meaningful cross-institutional comparison (Yarime & Tanaka, 2012). GASU and SAQ offer flexibility for institutional customization but lack the structural standardization required for global benchmarking. ISO 14001 provides internationally recognized certification yet focuses exclusively on environmental management, omitting curriculum transformation and pedagogical innovation—critical components of institutional sustainability.

2.3 Measurement Challenges

Despite the proliferation of assessment frameworks, significant systemic barriers continue to impede effective implementation across higher education institutions. Standardization deficits pose a fundamental challenge, as divergent indicators, weighting schemes, and scoring logics across frameworks impair cross-institutional benchmarking and introduce comparability problems (Alonso-Almeida et al., 2020; Yarime & Tanaka, 2012). Data infrastructure limitations further undermine measurement quality, with many HEIs lacking centralized systems for sustainability data. This necessitates manual collection across functionally siloed

departments, resulting in incomplete temporal datasets and inconsistent units of measurement (Bantanur & Patil, 2018).

A persistent academic integration gap characterizes current practice, wherein assessments predominantly prioritize operational dimensions—energy consumption, waste management, and infrastructure—while inadequately addressing curriculum transformation, research alignment with Sustainable Development Goals, and governance integration. These latter elements constitute critical drivers of transformative institutional impact (Leal Filho et al., 2019). Finally, organizational and cultural barriers including entrenched departmental silos, insufficient leadership commitment, and limited stakeholder participation constrain the institution-wide embedding of sustainability measurement (Alshuwaikhat & Abubakar, 2008). No single framework fully satisfies the multifaceted and context-specific nature of sustainability in HEIs. STARS offers depth and standardization, UI GreenMetric provides accessibility and visibility, while tools like GASU and SAQ offer internal reflection and flexibility. ISO 14001 excels in environmental compliance but falls short on educational integration. A hybrid or context-sensitive model may thus be more effective in capturing the complex dynamics of sustainability in higher education.

3. Methodology

3.1 Research Design: Scoping Review Approach

To comprehensively map and analyze the existing literature on sustainability measurement in HEIs, this study adopts a scoping review methodology. A scoping review is particularly suitable for topics characterized by conceptual ambiguity, diverse methodologies, and rapidly evolving bodies of literature (Munn et al., 2018; Peters et al., 2015). Unlike systematic reviews, which typically aim to answer narrow questions and assess the quality of studies, scoping reviews are exploratory in nature and aim to map key concepts, gaps, and evidence within a broad topic area. This method aligns with the objective of this paper: to explore how sustainability is measured in HEIs, compare existing frameworks, identify challenges, and highlight gaps in knowledge.

A scoping review is considered the most appropriate design for the following reasons: The literature on sustainability in HEIs spans multiple disciplines (e.g., education, environmental science, management). Various measurement tools and conceptual models have been proposed, but lack standardization. There is a need to clarify definitions, indicators, and domains used in sustainability assessments. The aim is not to assess the effectiveness of interventions, but to explore and synthesize the breadth and diversity of existing approaches. This approach follows the methodological framework proposed by Arksey and O'Malley (2005) and further refined by the Joanna Briggs Institute (JBI) (Peters et al., 2015; Tricco et al., 2018).

3.2 Study Selection

Inclusion criteria: Peer-reviewed journal articles, English language, published from 2014 to 2024, focusing on sustainability measurement or frameworks in higher education. The study selection process followed the PRISMA-ScR guidelines (Tricco et al., 2018). Figure 1 illustrates the screening and inclusion process for eligible studies. A total of 1,465 records were identified, and after removing duplicates and assessing eligibility, 270 studies were included in the final scoping review. The source is from Scopus (2014-2024).

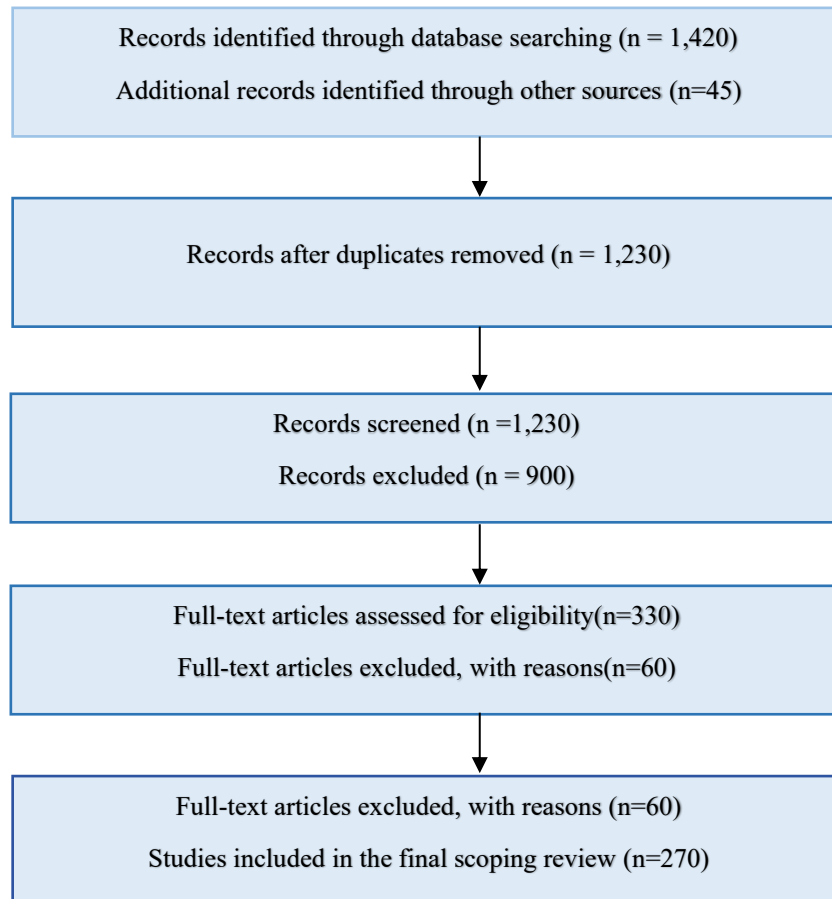


Figure 1: PRISMA flow diagram of the study selection process

3.3 Comparative Analysis of Assessment Frameworks

STARS developed by the Association for the Advancement of Sustainability in Higher Education (AASHE), is a comprehensive self-reporting framework designed for colleges and universities worldwide. It assesses institutional sustainability across five core categories: Academics, Engagement, Operations, Planning/Administration, and Innovation. The framework comprises 64 main indicators and approximately 90 sub-indicators, yielding a performance rating ranging from Bronze to Platinum. Although STARS offers a robust and transparent assessment mechanism, its implementation is data-intensive, requiring detailed documentation and inputs. Limitations include a predominant focus on operational efficiency metrics (without incorporating absolute indicators), potential double-counting of credits (e.g., energy consumption and emissions), and the inapplicability of certain credits to all institutional contexts.

UI GreenMetric, initiated by Universitas Indonesia, is a global university ranking system that emphasizes environmental sustainability, with a particular focus on campus physical setting and infrastructure. It evaluates participating institutions across six weighted categories: Setting and Infrastructure, Energy and Climate Change, Waste, Water, Transportation, and Education and Research, with operational aspects accounting for approximately 82% of the total score. The tool relies on an online questionnaire, offering a relatively low entry barrier for universities. However, its heavy reliance on intensity metrics (e.g., per capita or per area measures) introduces bias, often favoring institutions with large green spaces or campus forests. Additionally, UI GreenMetric has faced criticism for including potentially misleading

criteria—such as classifying combined heat and power as renewable energy—and for disadvantaging urban campuses with limited physical footprint.

GASU (Graphical Assessment of Sustainability in Universities), developed by Gómez et al. (2015), is a visual, multi-dimensional assessment tool designed to evaluate sustainability performance in higher education institutions. It adapts the Global Reporting Initiative framework to the university context, encompassing four core dimensions: ecological, economic, social, and educational. The tool presents results through nine radar charts—one for each sub-dimension—providing a visual representation of institutional performance levels. GASU is characterized by its user-friendly graphical interface and flexibility, allowing for customization to diverse institutional contexts. However, its reliance on qualitative scoring using a 0–4 scale limits standardization and cross-institutional comparability. Additionally, the framework requires localized data inputs and has not achieved widespread adoption since its introduction, constraining its utility for global benchmarking.

SAQ developed by the University Leaders for a Sustainable Future in approximately 2002, is a qualitative self-evaluation instrument designed for colleges and universities. It assesses institutional sustainability across three core pillars—environmental management, social responsibility, and economic sustainability—through structured questions. The tool employs a simple survey format that can be implemented without specialized resources, making it accessible to a wide range of institutions. However, its purely qualitative nature precludes numeric scoring or rating, limiting its utility for performance benchmarking. Moreover, the framework is relatively outdated and has been largely superseded by more comprehensive assessment tools in recent years.

ISO 14001, part of the International Organization for Standardization's environmental management system series, establishes criteria for organizations to enhance their environmental performance through systematic management. While applicable to any organization, it is not specifically tailored to higher education institutions. The standard follows a Plan-Do-Check-Act (PDCA) cycle, requiring organizations to set environmental objectives, ensure legal compliance, and monitor performance. Implementation typically involves third-party audit and certification, demanding substantial organizational resources. Despite its international recognition, ISO 14001 focuses exclusively on environmental management aspects, omitting academic metrics, social dimensions, curriculum transformation, and community engagement—elements essential to a holistic assessment of institutional sustainability in higher education.

Scoping reviews do not typically assess the quality or risk of bias in the included studies, which may limit the strength of conclusions regarding effectiveness or causal inference. However, given the exploratory nature of this study, this approach remains methodologically sound and justified (Pham et al., 2014).

4. Result

This chapter presents the key findings of the scoping review on sustainability measurement in HEIs. The analysis addresses four key areas: (1) the distribution and characteristics of the reviewed studies; (2) the adoption of major sustainability measurement frameworks; (3) the coverage of sustainability dimensions, and (4) institutional challenges and barriers. A total of 270 peer-reviewed studies published between 2014 and 2024 were included, spanning Europe, Asia, North America, and the Middle East. The analysis reveals a growing emphasis on

sustainability assessments after 2018, largely driven by the UN 2030 Agenda and ranking systems such as STARS and UI GreenMetric.

STARS and UI GreenMetric dominate the landscape, but most frameworks overemphasize environmental indicators while underrepresenting social, educational, and governance dimensions. Key challenges include the lack of standardized metrics, inconsistent data collection, and limited institutional resources, especially in developing regions. The following sections provide detailed analyses of the reviewed studies and their implications.

4.1 Publication Trends and Research Distribution

This section analyzes the temporal and geographical distribution of the studies included in the scoping review, highlighting how interest in sustainability measurement in HEIs has evolved over the past decade. A total of 213 studies published between 2014 and 2024 were reviewed, reflecting a growing focus on sustainability frameworks and practices.

The number of publications on HEI sustainability assessments has grown steadily, particularly after 2018. This trend aligns with global initiatives such as the United Nations’ 2030 Agenda and the growing influence of sustainability ranking systems like UI GreenMetric. From 2014–2016, research was limited and mostly conceptual; between 2017–2019, studies expanded with empirical applications of frameworks like STARS; and from 2020–2024, there was a surge in publications driven by SDG commitments, particularly SDG 13 (climate action). As shown in Figure 2, the number of publications on HEI sustainability assessments has grown steadily, particularly after 2018.

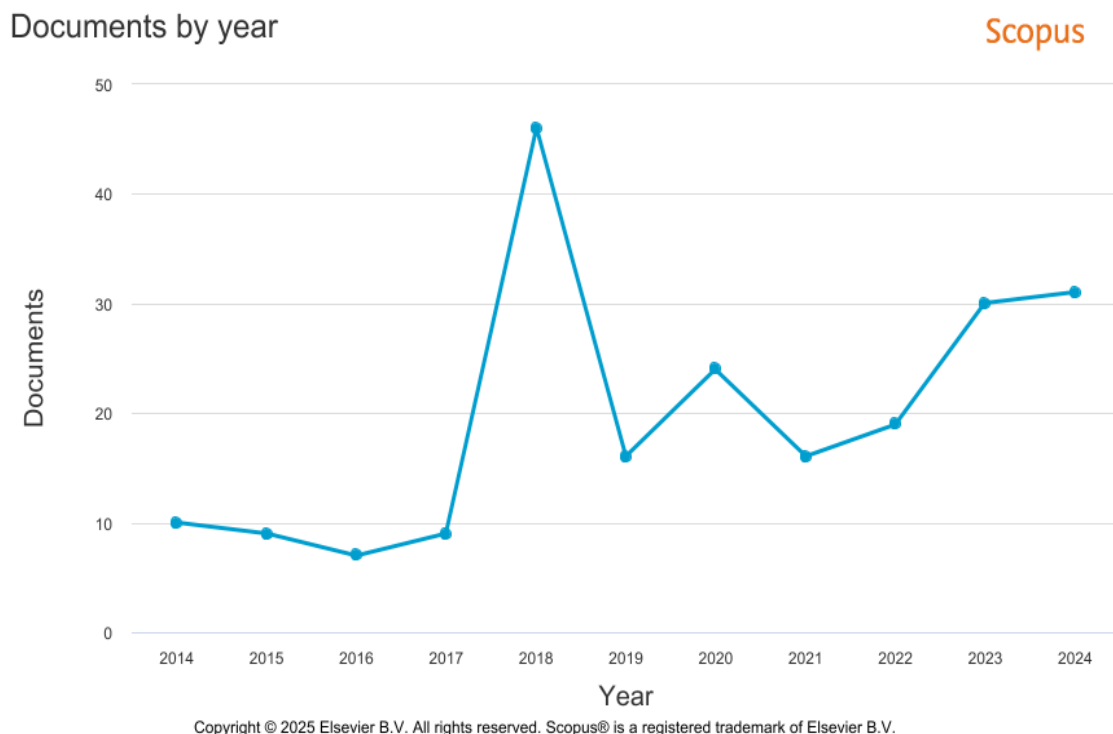


Figure 2: Publication Trends from 2014 to 2024

The reviewed studies represent diverse geographic contexts. Europe leads with strong contributions from Spain, the UK, and Nordic countries, partly due to the EU Green Deal. Asia and the Middle East, especially Malaysia, China, India and Indonesia, show rapid growth

driven by UI GreenMetric adoption. North America remains a key hub for STARS-related research, while a smaller share of global reviews (e.g., Singh et al., 2023) compare cross-regional practices. Figure 3 illustrates the distribution of subject areas covered in the reviewed studies.

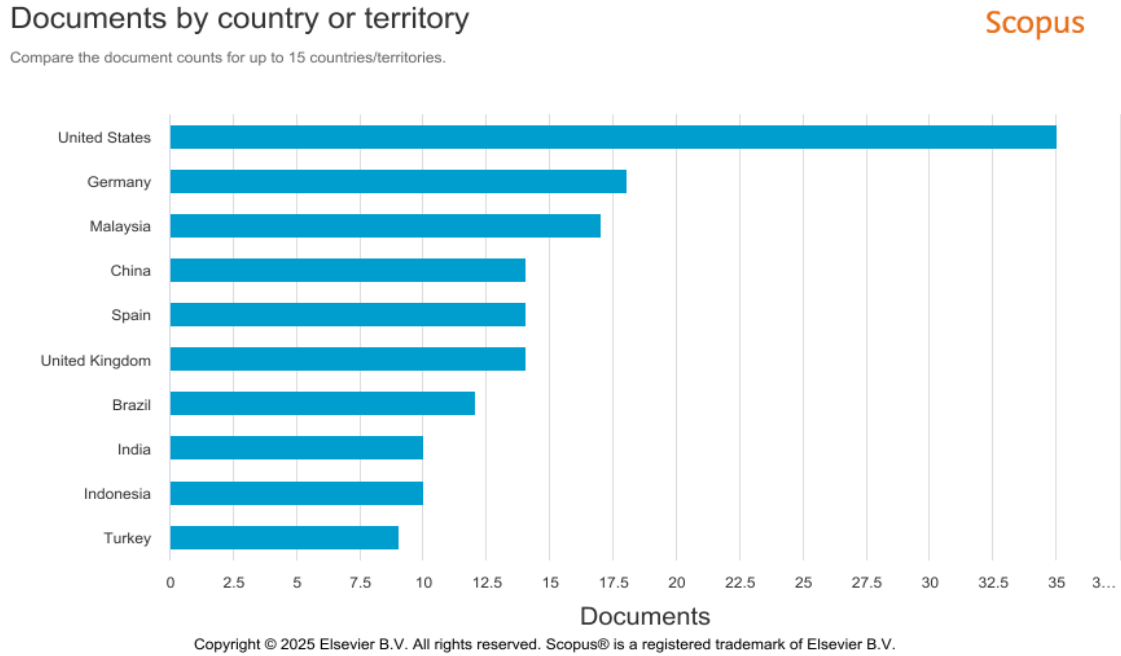


Figure 3: Subject Area from 2014 to 2024

4.2 Distribution by Research Methodology

The studies used diverse methodologies, including case studies, comparative analyses, surveys, interviews, and scoping/systematic reviews. Table 2 summarizes the research methods employed in the reviewed studies, along with representative references.

Table 2: An overview of the research methods and representative references

Research Type	Number of Studies	Example References
Case Studies	9	Berzosa et al. (2017)
Comparative Analyses	17	Horan & O'Regan (2021)
Surveys and Interviews	7	Adenle & Saghir (2016)
Scoping/Systematic Reviews	31	Singh et al. (2023)

5. Discussion

The review highlights the widespread adoption of frameworks such as STARS and UI GreenMetric, with notable regional differences. STARS, used by over 1,000 HEIs (primarily in North America and Europe), provides a comprehensive and transparent scoring system (AASHE, 2023). UI GreenMetric, involving over 1,200 universities across 85 countries, emphasizes infrastructure and operational sustainability (UI GreenMetric, 2023). SAQ and GASU are used for qualitative assessments, while ISO 14001 focuses on environmental compliance, particularly in Europe and Japan.

Sustainability assessment in HEIs commonly covers environmental, social, economic, and governance dimensions. However, most frameworks prioritize environmental metrics, with

limited attention to social and governance aspects. STARS is the most balanced, while UI GreenMetric and ISO 14001 are environment-heavy. Table 3 synthesizes key empirical studies that apply or compare the major assessment frameworks, revealing consistent findings regarding framework strengths and limitations.

Table 3: Comparison of Sustainability Assessment Frameworks in Higher Education

Authors (Year)	Country/Region	Framework(s)	Key Findings (cited)
Singh et al. (2023)	Global (review)	SAQ, STARS, UEMS, and others	Scoping review of 88 studies: SAQ is the dominant qualitative tool; mixed-method approaches (e.g., STARS + UEMS) are increasingly used. Calls for integrating multiple tools to capture institutional complexity.
Horan & O'Regan (2021)	Ireland	UI GreenMetric, STARS	Comparative analysis: UI GreenMetric heavily weights campus operations (~82%), while STARS distributes weight across academics (29%), engagement (20%), and planning (16%). UI uses intensity-based metrics, limiting comparability across institution sizes.
Berzosa et al. (2017)	Spain	Multiple SATs (case study)	Empirical application of four assessment tools on a Spanish campus. Coordinated use of multiple SATs can yield 20–40% medium-term improvement in overall sustainability performance.
Abubakar et al. (2016)	Saudi Arabia	Student survey	Survey at University of Damman: ~65% of students showed concern about environmental sustainability, but participation is low. 75% reported no student group focused on sustainability, highlighting engagement gaps.

Despite the rapid expansion of sustainability assessment initiatives across HEIs, implementation remains uneven due to a constellation of interrelated barriers. First, the absence of globally harmonized indicators and weighting schemes impairs benchmarking across regions and institutional types: leading tools such as STARS and UI GreenMetric operationalize different constructs, apply divergent scoring logics, and variably address external impacts, making like-for-like comparison problematic and potentially misleading (Alonso-Almeida et al., 2020; Veidemane, 2022; Yarime & Tanaka, 2012).

Second, data infrastructure gaps undermine measurement quality. Many HEIs lack centralized, quality-assured data on energy, waste, mobility, curriculum integration, or community engagement. Multi-source reporting often depends on manual collection across siloed units, resulting in incomplete time series and inconsistent units of measure (Bantanur & Patil, 2018; Sonetti et al., 2016).

Third, resource intensity limits uptake—particularly in small, private, or resource-constrained universities—because comprehensive audits demand staffing, technical capacity, and recurrent funding that are frequently unavailable. Consequently, institutions tend to gravitate toward lower-barrier reporting schemes or partial implementations (Abo-Khalil, 2024; Lozano, 2006). Fourth, cultural and organizational frictions slow mainstreaming: entrenched departmental silos, weak incentives, limited leadership follow-through, and variable stakeholder participation have been repeatedly identified as obstacles to embedding sustainability institution-wide (Alshuwaikhat & Abubakar, 2008; Ávila et al., 2017). Finally, measurement remains poorly linked to the academic core—teaching, research, and civic partnerships—in many settings; operational “greening” dominates while curricular change, research alignment

with SDGs, and governance integration lag, constraining transformative impact and local relevance (Leal Filho et al., 2019; Hernandez-Diaz et al., 2021).

This scoping review is based on literature published between 2014 and 2024. Although this period captures the most active development of sustainability assessment frameworks, the authors acknowledge that developments in 2025–2026—such as potential updates to STARS or UI GreenMetric, emerging AI-based assessment tools, or new policy directives from UNESCO—are not reflected in the current analysis. Future research should build upon this foundation by incorporating post-2024 developments and examining whether the gaps identified here (e.g., underrepresentation of social and governance dimensions) have been addressed in more recent frameworks or practices.

6. Conclusion

This study aimed to explore the current state, effectiveness, and challenges of sustainability measurement in HEIs, with a specific focus on the frameworks adopted, the dimensions measured, and the institutional and contextual factors influencing measurement practices. In response to these objectives, this scoping review synthesized evidence from 270 peer-reviewed studies published between 2014 and 2024.

Regarding **the current state of sustainability measurement**, the review confirms that STARS and UI GreenMetric are the most widely adopted frameworks globally, with STARS offering a comprehensive, multidimensional approach covering academics, engagement, operations, and governance, while UI GreenMetric emphasizes environmental and infrastructural performance. Other tools such as SAQ, GASU, and ISO 14001 play complementary but limited roles due to their qualitative nature, narrow scope, or lack of standardization.

Concerning **the dimensions measured**, the findings reveal a persistent imbalance: most frameworks overemphasize environmental indicators (e.g., energy, waste, water) while underrepresenting social, economic, and governance dimensions. This limits the holistic assessment of institutional sustainability and neglects transformative educational outcomes such as curriculum integration, research alignment with SDGs, and community engagement.

In terms of **effectiveness**, the review indicates that while frameworks like STARS enable transparent benchmarking, their resource-intensive nature and reliance on self-reported data reduce comparability and accessibility, particularly for smaller or under-resourced institutions. UI GreenMetric offers a lower entry barrier but sacrifices depth and social coverage. Overall, no single framework fully captures the complexity of sustainability in HEIs, and effectiveness varies significantly across institutional contexts.

The study also identified **key challenges** impeding robust measurement: lack of standardized metrics and global harmonization, fragmented data infrastructure, insufficient financial and human resources, weak organizational commitment, and cultural resistance within institutions. These barriers are particularly acute in developing regions, where sustainability offices and dedicated staff are often absent.

Finally, regarding **institutional and contextual factors**, the findings highlight that measurement practices are deeply influenced by leadership commitment, departmental silos, stakeholder engagement, and the availability of external incentives such as rankings or national

policies. Contextual adaptability—rather than one-size-fits-all approaches—is essential for meaningful sustainability assessment.

To address these gaps, the study proposes the need for hybrid or context-sensitive frameworks that integrate environmental, social, economic, and governance dimensions while ensuring adaptability to diverse institutional contexts. As the field continues to evolve, ongoing monitoring of framework updates, emerging technologies, and policy shifts will be essential. Future studies should extend this review to include literature from 2025 onward, to assess whether the identified challenges are being progressively resolved. Future efforts should prioritize the development of standardized yet flexible indicators and strengthen the integration of sustainability assessment into strategic planning, curriculum design, and community engagement.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this study.

Author Contributions

Zhang Zhujuan: Conceptualization, Writing – original draft, Methodology; Rosli Mahmood: Supervision, Review & editing; Nur Shazwani Rosli: Methodology, Validation; Liu Shan: Data curation, Formal analysis; Feng Qian: Visualization, Investigation. All authors have read and approved the final version of the manuscript.

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