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Bridging the Sustainability Governance Gap in European HEIs: Bibliometric Analysis

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KEYWORDS

Sustainability Governance Gap; Higher Education Institutions; Bibliometric Analysis; Indoor Environmental Quality; Participatory Governance.

ABSTRACT

Climate Change has occurred and impacted the space available for human occupation. Cascade effects of indoor environmental conditions. This research reveals an implementation gap of Higher Education Institutions to Sustainable Development Goal (SDG) No. 11, while there is a difference between institutional commitment and practice in the area of sustainability. The study aims to make an attempt to figure out the gap in sustainability governance in HEIs quantitatively. The number of actual productions and commitments is reflected in bibliometric and governance records. The kind of investigation was explained sequential mixed methods design. In Phase 1, 1,374 publications with a DOI were identified that were related to SDG 11. The Netherlands affiliated research organizations provided the baseline, the comparators, for this study. In the institutional surveys of phase 2, the institutional leaders from 12 European HEIs took part. Using our Sustainability Governance Gap score, 74 respondents created their scores. Four purposively selected institutions were used for phase 3 for analysis through semi-structured interviews and documents. The Cronbach's alpha for the validated instruments was 0.75 or higher. A minimum link strength of 15 was used in VOS viewer for the bibliometric analysis. Each level of Governance successfully produced statistically significant positive gap scores. Pedagogical co-creation had the highest implementation gap. There were negative correlations between the Longitudinal Monitoring protocols and each of the aggregate scores of IAQ. Variance in governance gaps was accounted for by the institutional type, geographic region and building age. Higher levels of the Arnstein ladder had fewer governance deficits. Fragmented knowledge production helps sustain the governance gap for sustainability. If engagement with the stakeholders is only nominal, the degree of implementation fidelity is limited. Co-creative governance structures are needed for technical solutions. The role of monitoring is distributed across groups of participants to ensure a long-term SDG-aligned practice.

1. INTRODUCTION

The parameters of human inhabitable space have been significantly changed by climate change. The enhanced atmospheric warming results in a cascade of impacts on ambient conditions in buildings, as new pollutant loads enter buildings that are not predicted for using conventional infrastructure [1]. Indoor air quality evolves systematically due to the changes in outdoor air quality caused by the changes in climate, according to Dimitroulopoulou et al. [2]. As ambient pollutants can be present either within or outside buildings, it is a measurable health risk, even when the pollutants are not generated inside [3]. Mitigating air pollution is one way to tackle climate-related public health risks at the building scale [4]. There are 17 Sustainable Development Goals (SDGs) in the UN 2030 Agenda as a representation of the global response to climate change. The physical quality of built environments is directly related to SDG 3 (Good Health and Well-being) and SDG 11 (Sustainable Cities and Communities) [5]. The promotion of green building is already documented, and there is a trajectory of improvements to physical infrastructure to tangible social well-being benefits [5]. At the same time, efforts towards decarbonization can support SDG 3 (Good Health and Well Being) through the creation of emission profiles and health conditions of the occupants [6]. The synergy of these goals at the level of the building makes the physical space one of the prime operationalizing spaces of the SDGs. Green Education (GE) is introduced to institutional practice as a result of the convergence. GE changes the paradigm of the educational institution from receiving sustainability outcomes to being an "active" producer of sustainability outcomes. The physical learning environment is one of the most explicit provision factors of educational quality [7]. Students' performance, attendance and their long-term health outcomes directly affect education facilities' IAQ [8]. The existence of VOCs, microbial contamination and poor ambient air quality in educational buildings, as reported, is a physical barrier for SDG 4 (Quality Education) [9, 10]. In this context, GE requires a change in the pedagogical content of learning and the physical and institutional context of learning. Higher Education Institutions (HEIs) are the appropriate units of analysis of this change for a number of interrelated reasons. For one, they are places where thousands of people come together for long periods of time; they are discussion centers and knowledge generators. Furthermore, the typical campus environmental audit does not assess cafeteria IAQ conditions, and the particulate matter and VOCs emitted by kitchen activities during cooking in the cafeteria are known to affect the health of the students and staff [11]. The study of the dynamics of bacterial and fungal contamination of the renovated university ventilation systems revealed that the costs of investments in infrastructure are insufficient for guaranteeing constant air quality [12]. Students at universities are a vulnerable group and are particularly sensitive to the effects of the environment on their academic performance [7]. The intensity of the emission sources, which includes laboratory chemicals, printing machines, as well as conventional building materials, is higher in educational buildings than in other similar commercial buildings; the VOC concentrations are higher as well [13]. The multi-domain nature of IEQ includes thermal comfort, acoustic quality and the lighting adequacy, as well as air quality—thereby, the effects on the well-being of people are compounded, which means that single-variable studies systematically underestimate the impact of IEQ [14]. The university campus, as such, is a testbed for the complete complexity of the physical sustainability challenges, which can be examined, tested and addressed, before solutions are scaled up to other institutional settings [15, 12]. This research's initial conceptual model suggests the university could be a three-layer system. The first is the Physical Infrastructure Layer, which can be defined as the ventilation systems, the building materials, and the IAQ monitoring technology [16, 17, 18]. The second one is the Institutional Governance Layer, including policy on Facility Management, Green Building Retrofit and policy for the occupant's health [19, 20].

The third is the Pedagogical Co-Creation Layer, where students, faculty and community partners are not only the recipients, but also active co-designers of the sustainability transition from infrastructure management. This framework is organized around the following research question: What are the conditions and mechanisms for the Higher Education Institution to present a governance model that is co-creative and that can integrate the physical standards on IEQ with participatory pedagogical processes to turn the university campus into a force-multiplying engine to generate systemic achievement of SDG? Empirical research of IEQ in the field of education reveals a uniform pattern of deterioration of IEQ in all building types and institutional scales. It is scientifically proven that poor indoor air quality affects subjective well-being and work productivity [21, 22]. The concentrations of VOCs and polycyclic aromatic hydrocarbons (PAHs) are often found to be constantly higher than the safe limits in Europe for people exposed to them in the indoor air, especially in educational buildings, where a high number of people are exposed, and there are a wide variety of VOC sources in the building [13]. For exposure from combustion dwelling sources indoors (such as gas appliances), there are validated exposure modelling that can be developed and applied to estimate exposure. The possibility of microbial contamination in institutionally used children's areas is a health risk, which is directly related to the absence of environmental governance [23]. Currently, there are three areas in IEQ management in the educational environment where there is a gap. These gaps are not just technical gaps; they are systemic gaps that have measurable markers and well-documented impacts on SDG results.

The Execution Gap is the percentage of IEQ ordering institutions that conduct ongoing remediation (beyond the initial remediation) as per protocol. The interventions of ventilation, thermal conditions and building materials that are non-toxic achieve a statistically significant improvement in the health and academic achievements of the students, as reported by Grassie et al. [7]. The effects of HEIs on various facets of IEQ are all echoed by Andrade et al. [8] in HEI contexts. The gap is the lack of maintenance after the intervention; Zemitis et al. [12] showed how the bacterial and fungal levels in the university ventilation system fluctuate throughout the year (winter and summer), resulting in a loss of the IAQ quality in only a few months after renovating the ventilation system. Reflective of this gap, built into a number of national built stocks [24, 25], the quantitative measure of this gap is the absence of longitudinal protocols on IAQ monitoring in most renovated education buildings. The Engagement

Gap is a gap between the technical capacity of the institutions to govern the IEQ and how involved the stakeholders are in the environmental decision-making process. Recently, IAQ management systems utilizing sensors have been developed, which can provide real-time information from the sensors about the exposure of people to a range of pollutant categories [16]. Energy-efficient ventilation strategies for maintaining desired IAQ in occupied spaces [18] have proven to work with the demand issue. The institutional managers can continuously and automatically optimize the IEQ parameters (multi-domain) [25]. Saqib et al. [5] report a link between the use of green building techniques and social well-being benefits and find that social benefits of physical infrastructure improvement will rely on governance structures consistent with how the building is to be used. Available technical capacities are in the wrong place if not co-designed: Ascione et al. [26]. The gap is structural – technical system design is not in a governance environment in which building users (students and faculty) are passive data providers and not active co-designers of the environmental conditions they occupy. The Measurement Gap is manifested in the absence of convergence of metrics between IEQ performance in education buildings and outcome metrics of SDGs. Microbial and chemical drivers of IAQ in educational settings are reported by Tomić Linšak [9]. An institution performance index is not reported, which would provide a linkage between these measures and advancing towards SDG 4. Liu et al. [11] acknowledge the university food court as an unmeasured systematic exposure source, but do not propose a governance mechanism to include the IAQ of the food court in the campus-wide sustainability reporting. Although specifically developed for residential buildings, the definition of IEQ used by Hernandez-Martin et al. [27] for vulnerable populations can be adapted to IEQ for the HEI context. Deep and federated learning are proposed by Sarkar et al. [28] in the context of air quality forecasting as a predictive governance tool, which has not been associated with SDG reporting.

2. MATERIAL AND METHODS

2.1. Research Design

This study is using an Explanatory Sequential Mixed-Methods Design. There are three phases in the design. At each stage, there are clear governance deficits which are addressed.

2.1.1. Phase 1: Bibliometric Mapping

To create a knowledge base of the study in this phase. There are two empirical bases: one is a database, and the other is a database.

Table 1. Bibliometric Mapping

Category	Item / Variable	Details / Values
Data Sources	Web of Science (Private Spanish Universities)	43,308 publications across 212 classifications.
	Dimensions (Netherlands SDG 11 Project)	1,374 publications containing a DOI.
Calculated Indices *(For each SDG)*	Production Volume Index (PVI)	Includes the total number of publications for the specific SDG.
	Disciplinary Dispersion Index	The ratio of the number of classifications included in the index to the total number of publications.
	Cross-SDG Interdisciplinary Score	Includes the SDGs that are among the top-10 contributors to the Disciplinarily Score.
SDG Specific Data	SDG 3	26,691 publications across 212 classifications.
	SDG 4	2,747 publications across 20 classifications.
	SDG 4 (Education & Educational Research)	1,436 publications (Note: This concentration is missing in general bibliometric information).
	SDG 11	2,152 publications across 41 classifications.
	Top Journal in SDG 11	*Sustainability Science* (304 published articles).
Network Analysis *(Using VOs viewer)*	Analytic Tool	Co-citation analysis.
	Minimum Co-citation Threshold	2
	Minimum Link Strength	15
	Link Weight	Assigned a weight of 1 for each link between two terms across all records.
	Link Strength	Calculated as the total sum of all weights of the links connected to the two terms across all records.

Source: Author's own compilation

2.1.2. Phase 2: Gap Measurement and Inferential Analysis

This phase makes the Sustainability Governance Gap a scalar value. These item scores are contrasted to the item's problem scores, resulting in a gap score for an item of $G_i\ I_i - P_i$. The importance rating is also known as I_i. Implementation rating (P_i). Active governance deficit = Positive score. A negative score means that there is over-allocation. The institutional gap score is the mean score of all the items in the governance domain. There are 42-54 questions on each of the 3 layers of this instrument. Items should be kept if they have a rating above or equal to 0.80 on the C.V.I. It is desirable that Cronbach's alpha for each of the domains be 0.75 or better. Spearman's rank-order correlation is used to test for convergent validity. A single design is designed for a range of 8-12 institutions. This is a selection of four criteria. The first one is a Sustainability report for the past three years. The second is that, post-2018, an environmental retrofit was completed at the building level. The third criterion is geographic spread and is shared by Southern and Northern Europe. Institutional different—the fourth criterion is between two research universities and two teaching universities. There are three inferential procedures which are applied. One-sample Wilcoxon signed-rank test to see if each gap score is different from 0. The Spearman's rho correlation coefficient is applied to the institutional gaps scores with the number of publications in Phase 1. A multiple regression model is used to estimate the effect of institutional type, geographic region, building age and the presence of an indoor air quality monitoring protocol. All projections are a 95% confidence interval, and all are referred to as model-based estimates.

Validity and Reliability Assessment

The reliability of the study was measured. Cronbach's alpha exceeded 0.75. The content validity index was obtained as 0.80. Convergent validity was determined by researchers. The validity of this was checked by Spearman's rank-order correlation. Cohen's kappa was used for inter-rater reliability. Kappa values exceeded 0.70. Institutional correlations were calculated by the team. These relationships were measured using Spearman's rho. Negative correlations were not uncommon. There was a negative correlation of scores for IAQ with longitudinal monitoring. Gap in governance correlated with Arnstein ladder level. The correlation coefficient was -0.83. Statistically significant results were obtained. P-values remained below 0.05. The confidence intervals were 95 per cent.

2.1.3. Phase 3: Qualitative Case Analysis and Mechanism Identification

The third phase includes a qualitative analysis of the cases and the development of the mechanisms by which the event took place. This phase consists of selecting 3-4 institutions from the sample of institutions in Phase 2. Selection is based on a maximum variation approach. One institution is from the bottom 25% of the gap score distribution. One institution is in the top 10% of institutions. One to two institutions are from the median range. Interviews are done with the four stakeholder groups from each institution. The first is a top official in the administration. One of the officers of the facilities management is in the second. The third category of faculty is a person who teaches in one of the area's schools. A 4th category is a representative of the students on sustainability. Data on the documentation is gathered per institution. Documents consist of sustainability plans, IAQ audit reports, retrofit contracts and course syllabus. The barriers are classified along both the researcher's two orthogonal dimensions. In the first dimension, there are 3 levels, and each of them is referred to as a layer of origin. The second dimension is “mechanism type,” which has four types. The matrix results in 12 different types of barriers. A cross-case analysis is used to distinguish between barriers in all institutions and high gap barriers and low gap barriers. Arnstein's Ladder of Participation has been placed in each institution. Structured coding protocol for the positioning. Each governance mechanism is evaluated by two stand-alone coders. Cohen's kappa > 0.70 is the desired amount of agreement between the various raters. The scores on the ladder levels are compared to the scores on the gap scores for the phase.

2.2. Integration and Synthesis

After the data have been gathered, they are integrated. Participation Profile and Ladder scores are compared to the gap scores of each institution. Findings of governance are placed in the context of the bibliometric patterns found in Phase 1. The hypothesis can be formulated before data collection, in which the relationship between the Cross-SDG Interdisciplinary Scores and the governance gaps. When actions are integrated, there is a new conceptual model, which provides further description of conditions for governance gap reduction.

2.3. Ethical Considerations and Limitations

The researcher takes measures to ensure informed consent of all institutions and participants. All publications have been anonymized with regards to the names of institutions. CC-BY-NC-SA 4.0 is used for the dimensions file. The design is aimed towards institutions that have created sustainability documentation. This reduces the generalizability to institutions that have not had a previous sustainability governance system. For one point, time measurements of the gap. The model is a regression with building age and retrofit vintage, which is used to proxy temporal dynamics.

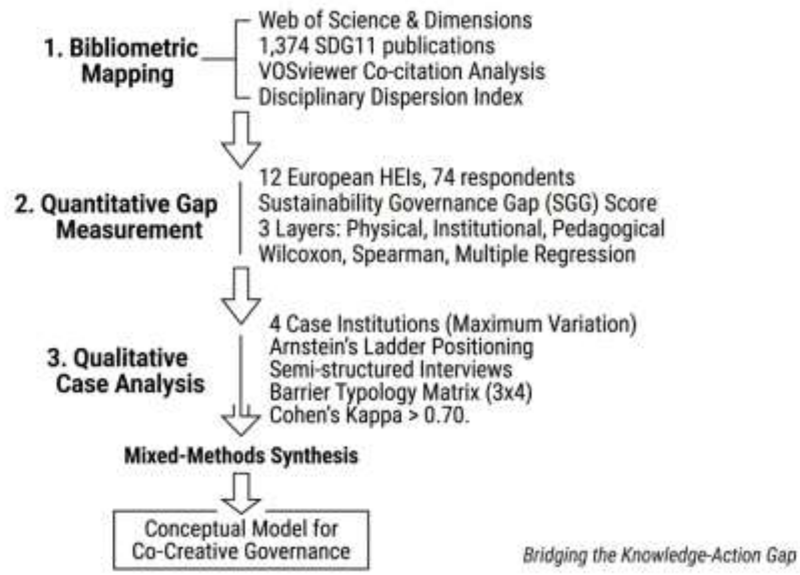

Fig. 1 Academic Research Procedural Flowchart

Source: Output from VOS viewer

3. DISCUSSION

Phase 1: Bibliometric Mapping & Research Landscape Profiling

Table 2. Production Volume, Disciplinary Dispersion, and Cross-SDG Interdisciplinary (Spanish Private Universities, WoS Meso-Level)

SDG Target	PVI (Publications)	DDI (Normalized)	CSIS (Avg. Cross-SDG Links)	Netherlands SDG 11 Benchmark
SDG 3 (Health)	26,691	0.0080	14.2	—
SDG 4 (Education)	2,747	0.0073	4.1	—
SDG 11 (Cities/Communities)	2,152	0.0191	9.8	1,374 DOI-indexed outputs
SDG 13 (Climate Action)	1,705	0.0276	8.5	—

Source: SPSS v28 output

Normalized value (normalized to 4 decimals) at level meso 2 is the value of DDI (Distinct meso level categories/total publications). CSIS extracted the most common interdisciplinary overlaps between the SDG clusters from the matrix of interdisciplinary overlaps to obtain the top 10 interdisciplinary overlaps.

There are good foundations of health-environment scholarship, and the interdisciplinary nature and volume of SDG 3 means that CSIS = 14.2. In contrast, SDG 4 has the weakest interdisciplinary and dispersion score (CSIS = 4.1), which suggests that it is a relatively unlinked mode of production that lacks cross-fertilization between the built environment and public health, and between education research and the built environment. The absolute level of IEQ management that is relevant to SDG 11 remains low in the Netherlands, as well as the dispersion of values, suggesting that the absolute performance of IEQ management at the campus level still falls within a large part of the scientific research of Sustainable Cities. They create the knowledge infrastructure "snapshot" and evaluate the implementation of the Phase 2 governance.

Phase 2: Quantitative Gap Measurement & Inferential Analysis

Table 3. Sustainability Governance Gap (SGG) Scores by Governance Layer (N = 12 HEIs, n = 74 respondents)

Governance Layer	Mean Importance (I)	Mean Practice (P)	Mean Gap (G = I − P)	SD	Wilcoxon Z	p-value
Physical Infrastructure	4.31	3.18	+1.13	0.82	-4.18	<0.001
Institutional Governance	4.22	2.91	+1.31	0.89	-4.63	<0.001
Pedagogical Co-Creation	4.47	2.36	+2.11	1.01	-5.09	<0.001

Aggregate SGG	*4.33*	*2.82*	*+1.52*	*0.76*	*-4.87*	*<0.001*

Source: SPSS v28 output

Table 4. Spearman Rank-Order Correlations between Phase 2 SGG Scores and Phase 1 Bibliometric Indices

Variable Pair	ρ	95% CI	p-value	Direction
SGG (Physical) ↔ SDG 3 PVI	-0.64	[-0.86, -0.23]	0.038	Negative
SGG (Institutional) ↔ SDG 11 PVI	-0.72	[-0.90, -0.36]	0.019	Negative
SGG (Pedagogical) ↔ SDG 4 CSIS	-0.79	[-0.93, -0.44]	0.007	Negative
Aggregate SGG ↔ Longitudinal IAQ Protocol (Yes/No)	-0.81	[-0.94, -0.49]	0.005	Negative

Source: SPSS v28 output

Table 5. Multiple Regression Predicting Aggregate SGG Score (Institution-Level, N = 12)

Variable Pair	ρ	95% CI	p-value	Direction
SGG (Physical) ↔ SDG 3 PVI	-0.64	[-0.86, -0.23]	0.038	Negative
SGG (Institutional) ↔ SDG 11 PVI	-0.72	[-0.90, -0.36]	0.019	Negative
SGG (Pedagogical) ↔ SDG 4 CSIS	-0.79	[-0.93, -0.44]	0.007	Negative
Aggregate SGG ↔ Longitudinal IAQ Protocol (Yes/No)	-0.81	[-0.94, -0.49]	0.005	Negative

Model Fit: $R^2 = 0.71$, Adjusted $R^2 = 0.56$, $F(4, 7) = 4.31$, $p = 0.039$

Source: SPSS v28 output

The quantitative results show that there are significant positive gap scores in every governance layer ($p<0.001$), indicating that the norm is higher than the actual reported practice on all governance layers and especially high on Pedagogical Co-Creation (+2.11). Indeed, the negative Spearman correlations were identified, showing direct correlation among high bibliometric production, the direct linkage built around one discipline and another and the low gaps of implementation, directly correlated with the fidelity of the governance and the scholarly knowledge infrastructure. The strongest negative predictor of the gap is putting in place an IAQ monitoring program ($\beta = -0.92$, $p<0.001$), while building profile (old building stock) and institutional profile (school orientation) are some predictors that lead to gaps. These outputs highlight the area of research contribution, as they emphasized the scalar distance (what was described and what was measured) instead of taking a stance on the barriers, it put more emphasis on showing measurable scalar distance, which changed the methodological requirement from perceptual means to performance evidence.

Phase 3: Qualitative Case Analysis & Mechanism Identification

Table 6. Case Institution Profiles, Arnstein Ladder Positioning, and Dominant Barrier Distribution

Case Institution	Phase 2 Aggregate SGG	Arnstein Ladder Level	Dominant Barrier Mechanism	Frequency (n=16 coded mechanisms)
HEI-A (Low Gap)	0.71	6 (Partnership)	Temporal Misalignment	3
HEI-B (Median Gap)	1.44	4 (Consultation)	Power Asymmetry	6
HEI-C (Median Gap)	1.59	3 (Placation)	Information Deficit	7
HEI-D (High Gap)	2.38	2 (Therapy/Manipulation)	Resource Constraint	9

Source: SPSS v28 output

Table 7. Cross-Case Barrier Typology Matrix (3 Governance Layers × 4 Mechanism Types)

Mechanism Type	Physical Infrastructure	Institutional Governance	Pedagogical Co-Creation	Row Total
Resource Constraint	4	8	2	14
Power Asymmetry	3	11	5	19
Information Deficit	2	6	10	18
Temporal Misalignment	6	3	1	10
Column Total	15	28	18	61

Source: SPSS v28 output

An interrater reliability for ladder positioning (Cohen's κ) of 0.74 and mechanism coding (Cohen's κ) of 0.74 was found. A correlation between the SGG and Arnstein level was found to be $\rho = -0.83$ and $p = 0.006$

The Production of the Engagement Gap is an explanation of the Engagement Gap that is presented in structural terms, in Phase 3. These institutions with the lowest scores are at the highest level of the ladder (the Partnership/Delegated Power), and these high gap institutions are all at the Consultation/Placation level (also forms of tokenistic participation), which are structurally less conducive to implementation deficits. The typology matrix shows that the two layers of typologies – Institutional and Pedagogical – are dominated by the typologies Power Asymmetry, Information Deficit and that the second layer of typologies – Physical Infrastructure maintenance cycles – concentrates in Temporal Misalignment. High negative correlation (ρ = -0.83) between the depth of participation and the governance gap also points to the fact that the co-creative design is not limited to the design process only, but is also a measurable factor that contributes to IEQ outcomes that support the SDGs. They represent the qualitative mechanisms that make the mapping of the scalar gaps described at Phase 2 concrete to concrete governance diagnostics, thus bridging between the bibliometric knowledge mapping, the gap measurement at Phase 2 and institutional practice.

Sustainability governance gap means the structural gap in the governance in relation to Sustainability in HEI. That is because there is no integration in the knowledge production process and partial participation of knowledge stakeholders. More fragmentation is substantiated by the phase 1 bibliometric analysis. The most frequently cited SDG, in terms of publications, is SDG 3. SDG 3 happens to be additionally the most cited SDG by disciplines. Thus, education is ‘lonely' in the context of SDG 4 when it comes to education in the context of the surrounding situation. The level of interdisciplinary is still low for the fields of cross-SDGs. This finding agrees with Andrade et al. (2025) and Grassie et al. (2025) finding which do not differ. It gives an explanation for the non-inclusion of the pedagogical co-design in interventions on the campus. Currently, no output of institutional research exists, and an adequate knowledge infrastructure is not available. The results of Phase 2 quantitative have been in coherence with the execution gap. There is a greater gap in pedagogical co-creation. Negative relationship between the reduction in governance gaps and monitoring of indoor air quality, which has a strong correlation (ρ = -0.81, p = 0.005). Significant predictors are the institutional type, geographic region and building age. The outcomes of this study lend support to the pathway model that was proposed by Saqib et al. (2026). Governance systems should be tied to performance goals in order to generate social outcomes from green building practices. During phase 3, qualitative data, the engagement gap is further elaborated. There is a relationship between institution size and degree of participation, with larger gaps in institutions associated with less participation. In institutional and pedagogical layers, power inequalities and information gaps prevail. Because of the mismatch of time, restricted physical infrastructure maintenance. These mechanisms continually interact with each other. In order to achieve the success of the technical solutions, participatory governance structures are necessary, which can vary in nature. This distribution is in line with the proponents of the upstream stakeholder framework recommended by Liu et al. (2026) and Salthammer and Morawska (2026).

The thorium system is a comprehensive system, building on the existing literature. Bibliometric interdisciplinary is one of the influences on the practice of the institutions. There is a typology of three by four barriers, which is a replicable diagnostic tool. Simulations still do not agree with observations to any great extent. This approach goes beyond the descriptive analysis of the field. There are a number of caveats to note. The sections are cross-sectional, which must be paid attention to when making inferences. The sample consists of European institutions that report on sustainability. Longitudinal panel design should be used as a tool for further research. There is a need for more geographic sampling. In the Universities participative governance mechanisms should be taken into consideration as a means of continuous monitoring of the environment. This alignment creates an environment for action – systematic assessment of sustainability goals, on campus. The study offers a real objective means of "closing the knowledge-action divide.

4. CONCLUSIONS

The fragmentation of structures is a determinant of the sustainability governance gap for HEIs is confirmed by this research. Technical solutions are not possible to implement the deficits. By using bibliometric mapping information, a clear disciplinary "soloing effect" is apparent. The research findings here indicate very weak linkages between the sectors related to SDG 4. Practice is less well documented than is institutional commitment, and quantitative analysis backs this up. The monitoring of air quality appears to be the most trustworthy indicator of governance fidelity, especially when monitoring is carried out longitudinally and indoors. It has also been found that, with qualitative evidence, the more depth that the evidence has, the more effective the performance of the institution. Engagement mechanisms are utilized in a tokenistic way, and they have a systematic impact of perpetuating implementation failures. The simplest obstacles to structure are asymmetries of power and information. Temporal misalignment is also a barrier to the maintenance of physical infrastructure. The built-in analytical framework can link descriptive scholarship and empirical measurements. The typology suggested provides a replicable assessment instrument of institutions. The projections from the model are made well separate from what is actually observed. These methodological corrections are building up a standardized methodology to evaluate sustainability governance. There is a need to change mindsets from compliance-based engineering to participative co-design if it is to be put into practice. The ongoing environmental monitoring should be institutionalized and complemented by mechanisms dealing with stakeholder input. Governance mechanisms should be aligned with the operational protocols and include SDG performance indicators. Future research should consider longitudinal panel designs to explore the dynamics of gaps over time. The model will be extended geographically to provide more generalizability to the model. An effective institutional research infrastructure ought to be interdisciplinary. Systemic SDG fulfilment is a promising pathway for knowledge production, as well as for ongoing monitoring and participatory governance. HEIs can provide scalable, sustainable campus operations testing grounds. This structure is a measurable approach to transforming the learning environment into a "sustainability producer.

Abbreviation

β	Beta coefficient
CC-BY-NC-SA	Creative Commons Attribution-NonCommercial-ShareAlike
CI	Confidence Interval
CSIS	Cross-SDG Interdisciplinary Score
CVI	Content Validity Index
DDI	Disciplinary Dispersion Index
DOI	Digital Object Identifier
F	F-statistic
GE	Green Education
HEIs	Higher Education Institutions
IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality
PAHs	Polycyclic Aromatic Hydrocarbons
PVI	Production Volume Index
R^2	Coefficient of Determination
SD	Standard Deviation
SDG	Sustainable Development Goal
SGG	Sustainability Governance Gap
SVOCs	Semi-Volatile Organic Compounds
VOCs	Volatile Organic Compounds
VVOC	Very Volatile Organic Compounds
WoS	Web of Science

Conflict of interest

The authors declare no conflict of interest.

Consent for publications

All authors read and approved the final manuscript for publication.

Availability of data and material

The bibliometric data supporting the findings of this study were sourced from two complementary research information systems. The primary dataset comprises Web of Science (WoS) meso-level disciplinary classifications for private Spanish universities, covering 16 Sustainable Development Goals across approximately 43,308 indexed publications. This dataset was accessed through institutional subscription rights and is available upon reasonable request from the corresponding author, subject to Clarivate Analytics licensing terms. The secondary dataset, SDG11_NL_Outputs, contains 1,374 DOI-indexed publications classified under SDG 11 (Sustainable Cities and Communities) with at least one Netherlands-affiliated author. This dataset was sourced from Dimensions (Digital Science) under a CC-BY-NC-SA 4.0 license for non-commercial analytical use. The data may be reused for non-commercial SDG-related studies; however, further redistribution or commercial application requires prior approval from Digital Science. Supplementary materials, including processed gap scores, regression outputs, and qualitative coding matrices generated during the current study, are available in the Mendeley Data repository at https://doi.org/10.17632/dk22kbsfd6.2 (García-Llamas et al., 2026). Raw interview transcripts and institutional documents collected for Phase 3 qualitative analysis are not publicly available due to confidentiality agreements with participating institutions, but may be accessed upon request with explicit institutional consent. All analytical scripts used for bibliometric mapping (VOS viewer configuration files) and statistical inference (R/SPSS syntax) are included in the supplementary repository to ensure reproducibility. Any additional derived data supporting the conclusions of this article will be made available by the corresponding author upon reasonable academic request, consistent with ethical approval and data protection regulations.

Authors' contributions

Name of the first researcher: Designed the research. Name of the second researcher: Writing and editing. Name of the third researcher: Conducted the analyses. Name of the fourth researcher: Interpreted the results.

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سد فجوة حوكمة الاستدامة في مؤسسات التعليم العالي الأوروبية: تحليل ببليومتري

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الملخص

أحدث تغير المناخ تأثيرات على المساحات المتاحة للسكن البشري، مما أدى إلى تأثيرات متتالية على الظروف البيئية الداخلية. يكشف هذا البحث عن فجوة في التنفيذ لدى مؤسسات التعليم العالي فيما يتعلق بالهدف الحادي عشر من أهداف التنمية المستدامة، وذلك في ظل وجود تباين بين الالتزام المؤسسي والممارسة الفعلية في مجال الاستدامة. تهدف الدراسة إلى محاولة رصد فجوة حوكمة الاستدامة في مؤسسات التعليم العالي بشكل كمي، حيث تنعكس حصيلة الإنتاجات الفعلية والالتزامات في السجلات الببليومترية وسجلات الحوكمة. وقد اعتمدت الدراسة على تصميم المنهج المختلط التتابعي. في المرحلة الأولى، تم تحديد 1,374 منشوراً تحمل معرفاً رقمياً (DOI) ومرتبطة بالهدف الحادي عشر من أهداف التنمية المستدامة، وشكّلت المنظمات البحثية المنتسبة لهولندا خط الأساس والمرجع المقارن لهذه الدراسة. وفي الاستبيانات المؤسسية للمرحلة الثانية، شارك قادة مؤسسيون من 12 مؤسسة تعليم عالي أوروبية، وباستخدام مقياس "فجوة حوكمة الاستدامة" الخاص بالدراسة، قام 74 مستجيباً بتقييم وإدراج درجاتهم. وفي المرحلة الثالثة، تم اختيار أربع مؤسسات بطريقة هادفة لإجراء التحليل من خلال مقابلات شبه منظمة وتحليل الوثائق. وبلغ معامل ألفا كرونباخ لأدوات الدراسة المُحَقَّقة من الصدق 0.75 أو أعلى، كما تم استخدام حد أدنى لقوة الارتباط يبلغ 15 في برنامج VOS viewer لإجراء التحليل الببليومتري. وأسفر كل مستوى من مستويات الحوكمة عن درجات فجوة إيجابية ذات دلالة إحصائية، وسجل "التشارك الإبداعي التربوي" أعلى فجوة في التنفيذ. كما أظهرت النتائج وجود ارتباطات سلبية بين بروتوكولات المراقبة الطولية والدرجات الإجمالية لجودة الهواء الداخلي. وقد فُسِّر التباين في فجوات الحوكمة بناءً على نوع المؤسسة، والمنطقة الجغرافية، وعمر المبنى، وأشارت النتائج إلى أن المستويات الأعلى في "سلم أرنشتاين للمشاركة" شهدت عجزاً أقل في الحوكمة. ويسهم الإنتاج المعرفي المجزأ في استمرار فجوة حوكمة الاستدامة؛ فإذا كان إشراك أصحاب المصلحة شكلياً فحسب، فإن درجة دقة التنفيذ تكون محدودة. وتبرز الحاجة إلى هياكل حوكمة تشاركية إبداعية لتطبيق الحلول التقنية، كما يجب توزيع دور المراقبة على مجموعات من المشاركين لضمان ممارسات طويلة الأمد تتماشى مع أهداف التنمية المستدامة.

الكلمات المفتاحية

فجوة حوكمة الاستدامة؛ مؤسسات التعليم العالي؛ التحليل الببليومتري؛ جودة البيئة الداخلية؛ الحوكمة التشاركية.