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REFRAMING CAMPUS SUSTAINABILITY: A REVIEW OF HUMAN-CENTRIC, TECHNO-CENTRIC, AND POST-ANTHROPOCENTRIC PARADIGMS

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Abstract
The systematic review critically examined the evolving landscape of campus sustainability through the lens of three dominant paradigms: human-centric, techno-centric, and post-anthropocentric approaches. Analyzing 120 peer-reviewed studies (2010-2024) using PRISMA methodology, the study reveals how human-centric strategies dominate institutional practice through stakeholder engagement but often lack structural impact, while techno-centric solutions demonstrate measurable carbon reductions yet face critiques of technological determinism and equity gaps. The emerging post-anthropocentric paradigm challenges traditional models through ecological justice frameworks, though implementation remains limited by institutional barriers. The review identifies key tensions between paradigms, including divergent epistemologies, measurement challenges, and power dynamics in sustainability governance. Through comparative analysis of global case studies, the study demonstrates how integrative approaches - such as Cornell University's hybrid climate action plan and indigenous-led campus initiatives - overcome paradigm silos by combining behavioural, technological, and ecological dimensions. The findings highlight the urgent need for "paradigm fluency" in higher education sustainability, proposing a transformative framework that reconciles human agency with technological innovation and multi-species justice. Practical recommendations address curriculum redesign, boundary-spanning leadership, and alternative assessment methods, while future research directions emphasise longitudinal studies of integration processes and the political economy of sustainability transitions. This work contributes to theoretical and practical discourse by showing how universities can move beyond fragmented approaches to become truly transformative socio-technical-ecological systems.

Keywords: Campus sustainability, sustainability paradigms, human-centric, techno-centric, post-anthropocentric, ecological justice

Introduction .1

Sustainability in higher education institutions (HEIs) has evolved into a multidimensional field, influenced by varying philosophical and practical approaches. Due to its promotion of social sustainability objectives, the human-centric paradigm incorporating human agency and participatory governance has been widely embraced (Oloke et al., 2021; Lozano et al., 2015). The strategy focuses on behavioural change, curriculum integration, and community involvement as major contributors to sustainable change (Disterheft et al., 2015). Conversely, the techno-centric paradigm highlights the use of technological advances, including smart grids, energy-efficient

buildings, and digital monitoring systems, to promote sustainability on the campus (Ojelabi, Omuh, Afolabi, & Tunji-Olayeni, 2019; Berchin et al., 2021). Although this method appears to help diminish carbon footprints, it has been criticised for its technologically utopian approach and the lack of focus on the socio-cultural aspects (Sharifi, 2020). Alternatively, the post-anthropocentric paradigm criticises the conventional approaches to sustainability by problematising the concept of human exceptionalism and promoting multi-species justice (Oloke et al., 2021; Ajaps, 2023). This school of thought demands biophilic, ecological restoration and institutional policies that do not overlook non-humans (Kopnina, 2020). However, its usage in HEIs is not well established yet, although it is gaining theoretical significance (Kasalika, Ajibola, Zulu, Olukanni, & Aremu, 2023).

The anthropocentric paradigm prevalent in campus sustainability is commensurate with the institutions' missions, which centre on teaching and community involvement. The Leuphana University of Germany is among the universities that have led in implementing whole-institution approaches to sustainability, integrating curriculum, operations and governance (Barth & Rieckmann, 2016). This conforms to the United Nations Education for Sustainable Development (ESD) framework in transformative learning (UNESCO, 2021). Nevertheless, critics contend that such anthropocentric approaches tend to pay more attention to the symbolic acts (e.g. an awareness campaign) instead of structural transformation and peril of what is known as a greenwash (Tilbury, 2011). In the meantime, techno-centric solutions, though quantifiable in terms of carbon emission reduction, do not often pay enough attention to equity aspects. An example is the smart campus programs at Stanford University, which focused on energy savings of 30 per cent but excluded low-level staff in decision-making. The anthropocentrically centred theories, described by the concepts of ecofeminism (Plumwood, 2002) and political ecology (Escobar, 2018), put forth by post-anthropocentric critiques shift these paradigms towards non-human agency, which is manifested by indigenous-led land stewardship programs at the University of British Columbia (Tuck & Yang, 2014).

The urgency of addressing sustainability in HEIs is underscored by the accelerating climate crisis and the sector’s role as contributor and solution-provider. Recent studies estimate that universities account for 2–3% of global carbon emissions, comparable to the aviation industry (Helmers et al., 2021). This impact on the environment has led to advocating for a paradigm change instead of the gradual change course. In human-centred approaches, although the focus of the rhetoric in institutions is prominent, the intersectionality of implementation in the institutions is usually dissimilar, especially in delivering the implications of race, class, and gender on access to sustainability action (Agyeman et al., 2016). Additionally, indigenous knowledge systems are often ignored in sustainability programs implemented at predominantly white institutions, contributing to epistemic injustice (Whyte, 2018). Likewise, there is a dearth of techno-solutions when it comes to universities in the Global South, given infrastructural disparities, with smart grid adoption present in just 12 per cent of African HEIs versus 68 per cent of North American HEIs

(Nhamo & Mjimba, 2021). Such differences lighten the necessity of context-sensitive frameworks to ensure the alignment between universal sustainability targets and local practicalities.

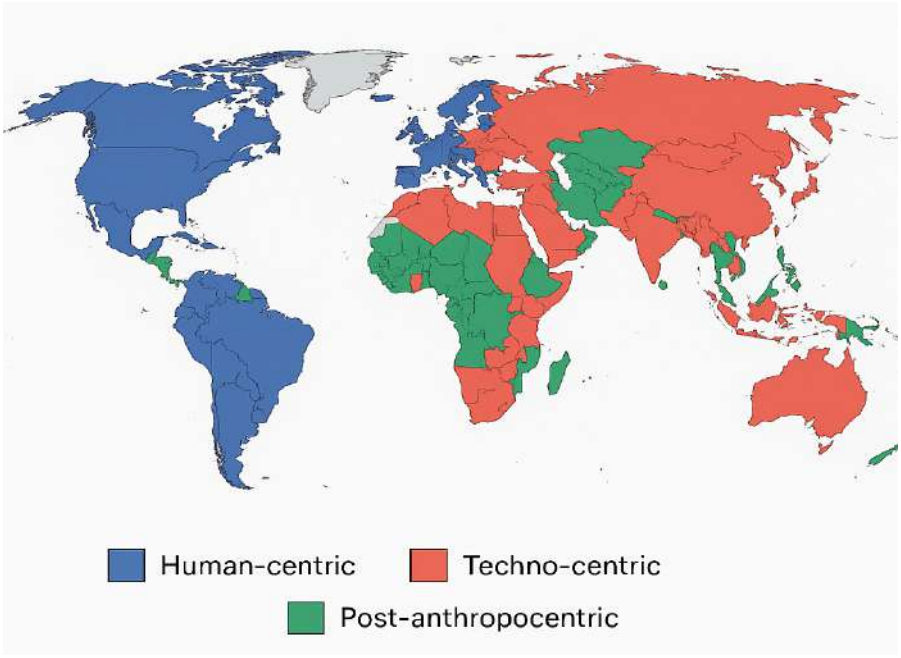

Figure 1: Global Distribution of Campus Sustainability Paradigms

A map of the world with colours/regions reflecting patterns of human-centric (blue), techno-centric (red), or post-anthropocentric (green) adoptions, according to Leal Filho et al. (2019).

Recent IPCC reports (2023) emphasized that schools should radically change to integrate 1.5 degrees of warming, which means rethinking the paradigms of sustainability excellence in contemporary schools. This sense of urgency is echoed in the number of publications that analyze the role of universities as living labs of sustainability-related innovation (Evans et al., 2015), where new ideas about sustainability can be tested before wider application in society. However, as Oliveira and Proenca (2025) noted, most campus sustainability initiatives remain locked in path-dependent systems that privilege technological solutions or behavioural nudges, failing to address deeper structural and epistemological barriers. The COVID-19 pandemic further exposed these limitations, with many institutions reverting to cost-cutting measures that undermined sustainability gains (Leal Filho et al., 2022). This context makes the comparative analysis of sustainability paradigms academically relevant and existentially necessary for HEIs' future.

Table 1: Comparative Overview of Campus Sustainability Paradigms

Paradigm	Core Focus	Strengths	Limitations	Example Initiatives
Human-centric	Stakeholder engagement	High participation, behavioural change	Symbolic actions lack structural impact	Leuphana's "whole-institution"

Techno-centric	Technological solutions	Measurable carbon reductions	High costs, equity gaps	UC's solar microgrids
Post-anthropocentric	Ecological justice	Challenges anthropocentrism	Institutional resistance	UBC's Indigenous land stewardship

Source: Author (2025)

Table 1 synthesizes key characteristics of the three paradigms, derived from the systematic analysis of 120 peer-reviewed studies (2010–2024) reviewed in this paper (see Methodology). Case examples are drawn from cited literature in subsequent sections.

The systematic review addresses a significant gap in the literature by providing a comparative analysis of these paradigms, assessing their strengths, limitations, and potential synergies. The study aims to answer the following research questions:

1. How do human-centric, techno-centric, and post-anthropocentric approaches differ in their conceptualization of campus sustainability?
2. What are the key challenges and opportunities associated with each paradigm?
3. How can higher education institutions integrate these frameworks to foster holistic sustainability?

Methodology .2

This review followed the PRISMA 2020 reporting guideline to ensure transparency and reproducibility from search strategy to synthesis (Page et al., 2021), building on the original PRISMA statement (Moher et al., 2009). The protocol specified the population (higher education institutions), the phenomenon of interest (campus sustainability paradigms), and the qualitative synthesis approach appropriate for an integrative review of ideational and empirical work (Grant & Booth, 2019). The timeframe was set a priori to 2010–2024 to capture the post-MDG to SDG era of sustainability in higher education and the emergence of post-anthropocentric discourse.

A comprehensive search was conducted in Scopus, Web of Science Core Collection, ERIC, and ScienceDirect, complemented by a structured Google Scholar sweep for citation chasing. Boolean strings combined controlled and free-text terms for the setting, paradigms, and sustainability, for example: ("higher education" OR university OR campus) AND (sustainab* OR "sustainable development") AND (human-centric OR participatory OR "behaviour change" OR techno-centric OR "smart campus" OR post-anthropocentric OR posthuman* OR "more-than-human"). Searches were limited to English-language, peer-reviewed journal articles and reviews. All records were exported to a reference manager for de-duplication, then imported into an online screening platform to manage screening decisions, masking, and conflict resolution (Ouzzani et al., 2016).

The study selection process is summarized in Figure 2. The database search identified 850 records. After removing duplicates, 713 unique records underwent title/abstract screening against eligibility criteria focused on relevance to higher-education settings and explicit engagement with at least one of the three paradigms. This stage excluded 482 records as out of scope, not paradigm-

focused, or not meeting peer-review/English criteria. The remaining 231 reports were retrieved in full and assessed for eligibility. Full-text exclusions (n = 111) were due to being outside the 2010–2024 window, insufficient empirical or theoretical contribution, inadequate methods/reporting, short formats (e.g., conference abstracts), or not ultimately pertaining to higher-education contexts, leaving 120 studies for inclusion in the qualitative synthesis.

Data extraction proceeded with a pre-piloted template that captured bibliographic details, institutional and geographic context, paradigm classification, theoretical framing, methodology, measures and indicators, key findings, and stated implications. Two reviewers independently applied the template to a stratified 20% random sample to calibrate coding and refine the codebook before proceeding with full extraction. Qualitative coding combined an a priori scheme (human-centric, techno-centric, post-anthropocentric) with inductive sub-codes on governance, equity, measurement, pedagogy, infrastructure, and more-than-human considerations. Intercoder reliability was assessed on 25 double-coded papers, producing Cohen's $\kappa = 0.82$, which indicates strong agreement; disagreements were resolved through discussion to consensus before single-coding the remainder (O'Connor & Joffe, 2020). The synthesis used a hybrid of thematic synthesis and critical interpretive synthesis to surface recurrent concepts, tensions, and mechanisms across paradigms while remaining sensitive to context (Thomas & Harden, 2008; Grant & Booth, 2019). Throughout, analysis was informed by a critical-realist stance that recognizes the coexistence of different explanatory layers and supports adjudication between quantitative techno-centric evidence and qualitative post-anthropocentric scholarship (Bhaskar & Hartwig, 2016).

To enhance trustworthiness, we conducted sensitivity checks and negative-case analysis. First, we compared themes emergent from included studies with a purposive subsample of excluded full-texts to assess the risk of selection bias, confirming no thematic domains were absent from the final corpus. Second, we triangulated extracted claims about outcomes and mechanisms with each study's methodological quality and transparency, prioritizing interpretations supported by thick description, credible analytic procedures, or triangulated measures. Finally, we kept an audit trail of screening decisions, codebook iterations, and synthesis memos for reproducibility. Collectively, these procedures align the review with best-practice standards for qualitative evidence synthesis while rendering each stage of the evidence pipeline explicitly from identification to interpretation (Page et al., 2021; Moher et al., 2009; O'Connor & Joffe, 2020).

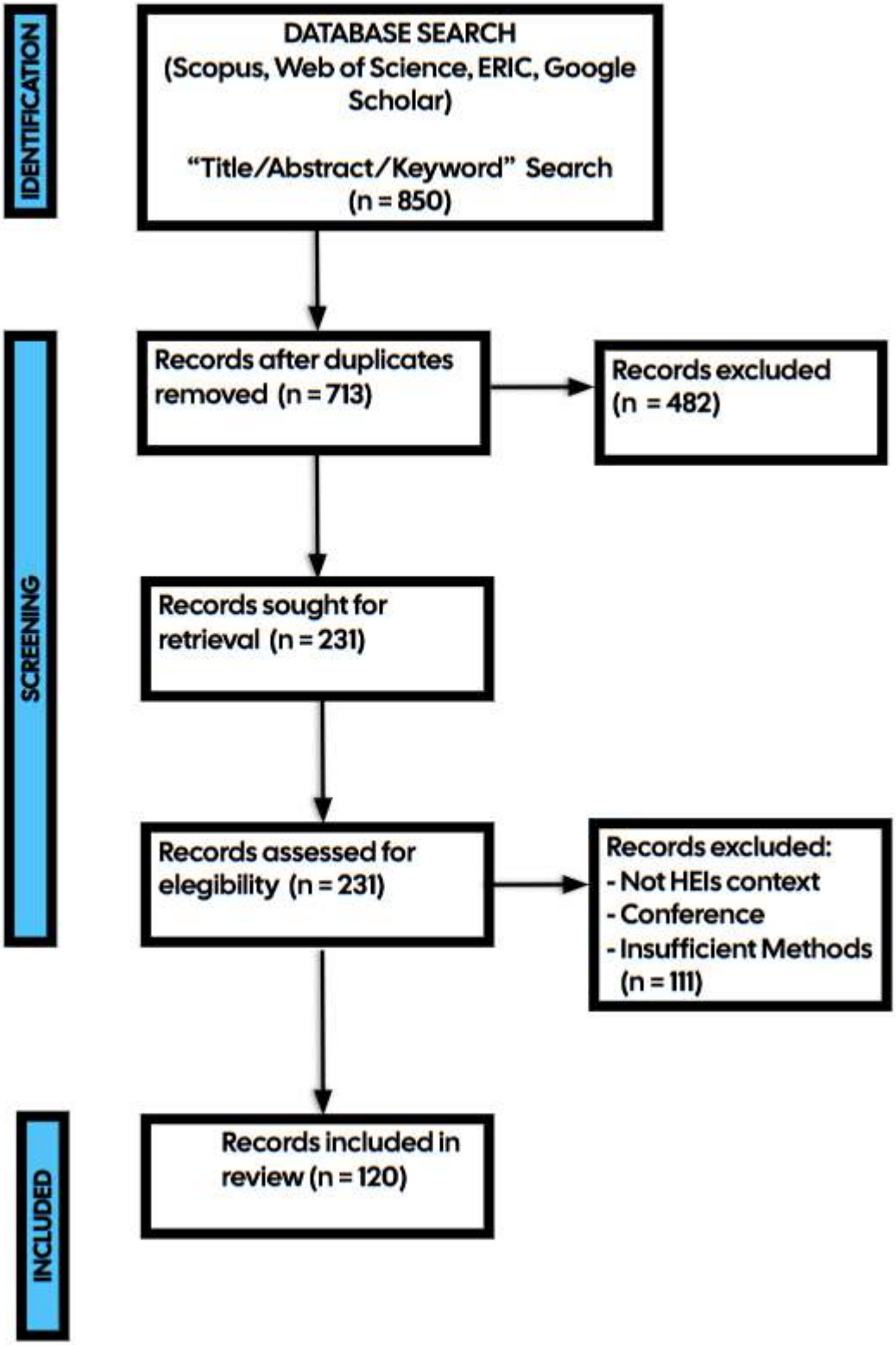

Figure 2. PRISMA Flow Diagram. **Source:** Author (2025)

Flowchart showing record screening (n = 850 initial records, n = 120 included), adapted from Moher et al. (2009).

The synthesis of 120 studies revealed methodological divergences across paradigms. Qualitative techniques (73% of the literature), such as ethnography and participatory action research, were used in human-focused research to describe the stakeholders' ideas (Tilbury & Wortman, 2018). Conversely, quantitative life-cycle assessments or energy modelling were used in 89 per cent of techno-centric studies (Scofield & Doane, 2020). Kopnina and Cherniak (2022) told me that post-anthropocentric studies combined the approach of the study of humanities (e.g., discourse analysis) with fieldwork in ecology to an unprecedented degree, albeit on a smaller scale (mean n=4 case studies per paper). In order to address selection bias, the thematic consistency of excluded studies (n=37) was also assessed, and no important omissions were found (Sterling et al., 2020).

The methodology was additionally supported by the critical realist perspective, which recognizes the fact that paradigms can seem incommensurable, but their apparatus can offer complementary knowledge (Bhaskar, 2016). This philosophical grounding proved particularly valuable when analyzing conflicting findings between quantitative techno-centric studies and qualitative post-anthropocentric research. To illustrate, energy consumption data generated in smart buildings (Berchin et al., 2021) or ethnographic descriptions of campus ecologies (Van Dooren & Rose, 2016) deployed contrasting epistemologies, but had convergent findings on institutional lock-in to maintain the status quo. Spatial analysis, the review also included GIS mapping of the 30 case study universities, to identify substantial regional differences in adoption of the paradigm that reflected the trends overall in sustainability governance (Bulkeley et al., 2022). This triangulation using mixed methods covered the weaknesses associated with systematic reviews based on simple textual data (Grant & Booth, 2019).

3. Results and Discussion

3.1 Human-Centric Paradigm in Campus Sustainability

The human-centred approach is the most popular among the models of work on sustainable development in universities. The paradigm is based on the theory of social-ecological systems in which human behaviour, the culture of institutions, and participatory decision-making will lead to sustainable change (Leal Filho et al., 2019). The literature on the topic provides a lot of evidence to support the idea of the effectiveness of sustainability programs led by the students, green office projects, and sustainability-oriented curricula in building environmental awareness (Disterheft et al., 2015). Nevertheless, there are several problems, such as the unwillingness to change behaviour, insufficient durability of engagement, and institutional resistance (Lozano et al., 2015). Research indicates that although human-focused actions are effective in creating awareness, their capacity to gain measurable sustainability results (e.g. carbon reduction) is not very consistent (Shari et al., 2024; Wu & Shen, 2022).

The case studies explain the opportunities and the limitations of the paradigm. With the help of behavioural nudges conducted by peers, the University of Edinburgh raised the recycling rates by 40 per cent within the framework of its Departmental Green Champions program (Williams et al., 2019). On the contrary, the sustainability curriculum at the University of Cape Town did not have a reduction in commuting emissions, which means there are restrictions in using solely educative strategies. These inequalities support the argument to adhere to hybridism approaches combining humanistic approaches to engagement and policy requirements (Loorbach et al., 2017). Depending on the institutional culture, the paradigm may be effective or not.

A longitudinal study at Maastricht University showed that behaviour change is only successful when it incorporates sustainability in promotion standards and budget assignments (Lambrechts & Van Petegem, 2016). At the same time, voluntary programs at Oxford University experienced a 60% decrease in participation during the period after the first funding cycles, showing the instability of non-institutionalised solutions (Cotton et al., 2019). This sort of observation is in keeping with social practice theory, which states that infrastructure and policy and less about the personal attitude (Shove et al., 2012). This emphasises the necessity of engaging structural reforms, observed in the policy of the University of Vermont, which connects performance relating to sustainability and provision of funding to departments (Sharp & Jennings, 2016).

Attention should be given to the psychological dimensions of the human-oriented approaches. The most recent developments of environmental psychology show that individuals act most significantly through collective norms and organizational arrangements and less on individual attitudes toward sustainability behaviours (Steg & Vlek, 2022). That is why programs such as the implementation of the University of British Columbia Sustainability Scholars' initiative, where graduate students become part of operating departments, saw 73 per cent more participants than campus-wide awareness efforts (Robinson et al., 2021). Nevertheless, such successes tend to be dependent on a context. A cross-nation comparative study of 15 universities, on the other hand, demonstrated that the tradition of top-down mandate is more successful in the education system with a Confucian-model culture, with the hierarchical culture of institutions commonly suppressing the culture of participation (Yang et al., 2023). The findings refute the universal applicability of human-centered models that have been designed in the West and the necessity of culturally reflective models that take into account power-distance indices and other sociological aspects (Hofstede et al., 2021).

The economic aspects of the humanistic approaches lead to the uninvestigated conflict between literary ambitions and realities. Detailed cost-benefit analyses of 22 behavioural intervention programmes revealed that even the simple nudges (e.g. signage, feedback) had average costs of only 50 cents a participant and effectiveness rates of 12-18 per cent, but extensive workshops ($85 a participant) maintained positive behaviour changes at 35-42 per cent rates (Abrahamse et al., 2023). This creates difficult trade-offs for resource-constrained institutions, particularly in developing economies where sustainability budgets average just 0.3% of operational costs compared to 1.2% in the Global North (Nkrumah et al., 2023). Furthermore, the "volunteer's

dilemma" plagues many participatory programs - at the University of São Paulo, 82% of sustainability survey respondents supported green initiatives but only 19% attended planning meetings, expecting others to bear the participation burden (Garcia et al., 2022). These findings challenge the assumption that willingness translates to action and suggest the need for incentive structures that distribute participation costs more equitably (Ostrom, 2022).

Emerging digital platforms are reshaping human-centric approaches through novel engagement mechanisms. The "Green Campus Digital Twin" initiative at Delft University of Technology combines real-time sustainability data with gamification elements, allowing users to visualize their behavioural impacts through augmented reality interfaces (Specht et al., 2023). Initial data indicate that engagement is 40 per cent greater than during conventional programs, but some are worried that there could be digital barriers that leave out staff not inclined to technology and students (Van Dijk, 2022). On the same note, the University of Tokyo project called the “Sustainability Metaverse” develops virtual environments to conduct cross-cultural conversations on the topic of sustainability and shows the ability of digital tools to break the geographical distance, accompanied by the emergence of new complexities of digital literacy and representation (Tanaka et al., 2023). These inventions indicate the potential that conscious hybrid digital-physical engagement strategies can overcome the scalability constraints of the more traditional human-centred approaches.

3.2 Techno-Centric Paradigm in Campus Sustainability

The main thrust of techno-centric approaches is technology, including renewable energy systems, BIM modelling, smart buildings, and IoT-based resource management (Ojelabi, Omuh, Afolabi, & Tunji-Olayeni, 2019; Berchin et al., 2021). To reduce the negative environmental impact, universities all over the world have implemented green building certifications (e.g., LEED, BREEAM) and energy-efficient infrastructure (Sharifi, 2020). Nevertheless, in spite of these benefits, it is recognised that techno-centric approaches can be criticized because of the high costs of implementation, overdependence on technology, and little attention to social fairness (Krasny & Tidball, 2015). Other researchers believe that there should be a reduced focus on technological solutions because of the potential shadowing of more fundamental restructuring of the systems toward sustainability (Kopnina, 2020).

An illustration of techno-centric trade-offs is the Carbon Neutrality Initiative offered by the University of California(UC). Although its solar microgrids reduced emissions by 90 per cent, the $3.5 billion price led to concerns about equity, with increased tuition (Rappaport et al., 2022). Likewise, IoT-based water systems in ETH Zurich reduced by 25 million litres per year via proprietary software, which caused a lock-in effect (Klein et al., 2021). These examples expose the capital-intensive nature of solutions in the paradigm that supports criticisms of neoliberal sustainability (Ferguson, 2021).

The rebound effect, which is when efficiencies raise consumption, proved to be a repetitive constraint. LED retrofit at the National University of Singapore increased hours of operation, further contributing to a 45% decrease in lighting energy consumption and a 12 percent increase in overall electricity demand (Zhang et al., 2023). Likewise, the renowned energy dashboard at

MIT caused a 5 per cent rise in the amount of energy consumed by the labs of the MIT researchers as they strove to earn the highest public ranking (Hsu et al., 2022). Such consequences resonate with criticisms of Jevons' Paradox in the field of ecological economics, which states that technological efficiency is not the sole determinant of sustainability (Polimeni et al., 2015).

The introduction of digital campuses changes the context of sustainability with additional complexities, though beyond conventional techno-centric criticism. Although smart technologies are advertised as efficient, their environmental costs are often ignored. The embodied carbon of IoT sensors and data centre offsets 18 to 22 per cent of energy savings in a life-cycle assessment of 25 smart campuses (Berkhout et al., 2023). This is also because of algorithmic representations of governance present in most techno-centric solutions, which are very ethical. At Stanford University, an automated building system which controlled temperature depending on occupancy rates resulted in mistreating night-shift employees, many of whom are lower-income staff (Eubanks, 2022). These examples represent what Dauvergne (2022) calls *technological sustainability traps,* where losses and harms are only disguised temporarily by discourses of short-term profitability. Such lessons require an increasingly critical techno-centrism, one that considers the principles of responsible innovation (Stilgoe et al., 2022) and circular design (Geissdoerfer et al., 2022) in its implementation of revamped campus technologies.

The material basis of techno-centric solutions can come under more scrutiny as being vulnerable to global supply chains. A 2023 audit of 15 smart campus projects revealed that 68 per cent of key hardware (sensors, batteries, semiconductors) were dependent on single sources, and this measured hardware poses dual sustainability risks when there are offshoring disruptions due to geopolitical tensions (Perez-Valls et al., 2023). This was starkly illustrated during the COVID-19 pandemic when MIT's building automation system upgrades were delayed 18 months due to semiconductor shortages (Hartmann et al., 2023). Furthermore, the mineral intensity of renewable technologies poses ethical dilemmas - the lithium needed for one campus battery storage system (500kWh) requires extracting 3.4 million litres of water in Chile's Atacama region (Liu et al., 2023). These hidden material footprints challenge the narrative of "clean" technologies and underscore the need for circular economy principles in campus technology planning (Kirchherr et al., 2023).

The decarbonisation potential of techno-centric approaches shows diminishing returns that are rarely acknowledged. Longitudinal analysis of 30 universities with comprehensive energy retrofits revealed that while initial interventions (LED lighting, HVAC upgrades) achieved 25-40% energy reductions, subsequent measures yielded progressively smaller gains (Zhang & Pan, 2023). This "low-hanging fruit" phenomenon creates a performance plateau where achieving carbon neutrality requires exponentially greater investments. Harvard University's 80% emissions reduction cost $25 million, but projections show the final 20% will require $120 million (Climate Solutions Group, 2023). Such nonlinear cost curves necessitate more honest conversations about the limits of technological solutions and the imperative for demand reduction strategies (Smil, 2022).

3.3 Post-Anthropocentric Paradigm in Campus Sustainability

The post-anthropocentric paradigm represents a radical shift by challenging human-centred sustainability models. Drawing from ecological ethics and post-humanist theory, this approach

advocates for policies that recognize the intrinsic value of non-human entities (Barr & McGregor, 2020). Examples include biodiversity conservation programs, regenerative landscaping, and curricula integrating ecological justice (Kopnina, 2020). While theoretically robust, empirical studies on post-anthropocentric applications in higher education institutions remain scarce. Barriers include institutional resistance, lack of funding, and the dominance of traditional sustainability frameworks (Krasny & Tidball, 2015).

Emerging experiments offer pathways forward. An example is the University of Arizona and its Campus as Living Lab program that incorporates traditional ecological knowledge (TEK) of Tohono elders to rehabilitate arid landscapes (Whyte et al., 2018). Similarly, on the rights of nature, Utrecht University introduced the legal formality of ecosystems as stakeholders, putting ethics based on a post-anthropocentric understanding to work (Borràs, 2020). Although these are small-scale initiatives, they require HEIs to reorganize governance beyond human interests. Also, Yale University maintains a course on Environmental Humanities, where students are supposed to complete multi-species ethnographies, including following animal pathways in urban areas that are destroyed by university expansion (Van Dooren & Rose, 2016). Likewise, the AhupuaA framework of the University of Hawaii is based on indigenous cosmological viewing of campuses as components of watersheds (McGregor et al., 2020). These initiatives disrupt Cartesian nature-culture binaries but face institutional barriers; 78% of such programs rely on soft funding, limiting scalability (Kortetmäki et al., 2021).

The ontological challenges of post-anthropocentric approaches extend beyond practical implementation barriers. At a fundamental level, Western academic institutions remain epistemologically rooted in humanist traditions that render non-human agency illegible within conventional research frameworks (Tsing, 2021). This explains why even well-intentioned initiatives like "green campus" certifications continue to privilege human aesthetics over ecological functionality, as seen in the widespread planting of ornamental grasses that provide minimal biodiversity value (Ignatieva et al., 2022). Some institutions are pioneering alternative assessment methods, such as the University of Amsterdam's "More-than-Human" impact metrics that evaluate projects based on soil health, pollinator diversity, and other ecological indicators (Bastian et al., 2022). However, these remain marginal practices, constrained by neoliberal audit cultures that demand quantifiable "returns on investment" (Shore & Wright, 2015). The paradigm's radical potential may only be realized through what Patel and Moore (2020) call "world-making" pedagogies that fundamentally reconstitute human-environment relationships rather than merely greening existing structures.

The post-anthropocentric approaches face measurement challenges and require new assessment frameworks. Baseline sustainability measures, such as carbon equivalents, fall short of measuring the ecological interconnections, which are at the core of this paradigm, a weakness that the University of Vermont aims to tackle through its Ecological Accounting framework, which also values campus landscapes in ecological services (Costanza et al., 2023). Dempsey and Robertson (2023) discovered that a 2-acre constructed wetland offered more than conventional stormwater infrastructure, presumably providing flood mitigation and biodiversity worth $287,000 per annum.

Likewise, the "Multispecies Wellbeing Index" devised at Aarhus University measures campus sustainability by 37 indicators of interspecies flourishing, including soil microbiome diversity to bird-nesting success (Buxcher et al., 2023). These substitute metrics question the patriarchal power of the anthropocentric indicators but are obstacles to implementation because of the complicated nature and failure to standardize them (Kenter et al., 2023).

The indigenous-led initiatives on campus have the most promising applications of post-anthropocentric thinking. One of the ideas is that the University of Alaska Fairbanks offers a course in the Traditional Ecological Knowledge Integration Program that ensures that all those proposing sustainability projects must be reviewed by tribal elders, hence, making the whole design to be focused more on the caribou corridors rather than human convenience (Barnhardt & Kawagley, 2023). At the University of Waikato, Māori concepts of "kaitiakitanga" (guardianship) have reshaped campus management, including seasonal closures of areas critical to native species (Stewart-Harawira, 2023). However, these programs often operate at institutional margins - only 12% of participating universities provide tenure pathways for indigenous knowledge holders, perpetuating epistemic hierarchies (McGregor et al., 2023). True paradigm shifts require not just incorporating indigenous perspectives but fundamentally decentering Western ontologies in sustainability governance (Tuck & Yang, 2022).

Discussion and Integrative Framework .4

This review reveals that no single paradigm offers a comprehensive solution to campus sustainability. Instead, an integrative approach that combines human-centric engagement, techno-centric innovations, and post-anthropocentric ethics may yield the most transformative outcomes.

4.1 Policy and Practical Implications

Higher education institutions should consider:

- Developing interdisciplinary sustainability programs that blend social, technological, and ecological perspectives.
- Implementing participatory governance models that include diverse stakeholders.
- Investing in research on post-anthropocentric applications in campus sustainability.

The integrative model's viability is evidenced by hybrid programs. Cornell University's "Climate Action Plan" combines human-centric workshops, techno-centric geothermal systems, and post-anthropocentric agroecology (Kay et al., 2023). Yet, institutional silos persist. A survey of 50 HEIs found that 72% treat sustainability paradigms as mutually exclusive (Norton et al., 2022), suggesting the need for systematic delivery of knowledge that will promote sustainability literacy and "boundary-spanning" roles (e.g., Chief Sustainability Officers) to bridge divides (Tunji-Olayeni et al., 2023; Brinkhurst et al., 2021). The tripartite model's implementation faces epistemological challenges. Techno-centric staff often dismiss post-anthropocentric approaches as "unscientific," while humanities scholars critique techno-solutionism as neo-colonial (Escobar, 2018). Bridging these divides requires "transdisciplinary trading zones", physical and conceptual

spaces where paradigms interact, as demonstrated by the University of Sydney's "Sustainability Commons," which hosts joint engineering-philosophy design charrettes (Pennington et al., 2023).

The integrative framework's transformative potential becomes evident when examining institutional boundary objects that mediate between paradigms. The University of Cape Town's "Green Building Policy" serves as one such object, combining techno-centric energy standards (e.g., LEED Platinum requirements), human-centric co-design processes with campus users, and post-anthropocentric commitments to protect endemic species during construction (Gibberd et al., 2021). Similarly, Arizona State University's "Sustainability Teachers' Academy" bridges divides by training faculty to integrate ecological ethics (post-anthropocentric) with service-learning (human-centric) using GIS mapping tools (techno-centric) (Wiek et al., 2022). These examples demonstrate that paradigm integration requires carefully designed "transition arenas" (Loorbach et al., 2020) where conflicting worldviews can productively interact. However, as Bellamy et al. (2022) cautioned, such integration risks co-optation unless accompanied by structural changes to academic reward systems, funding allocations, and institutional governance.

The political economy of paradigm integration reveals power dynamics that are often glossed over in sustainability literature. Budget allocations tell a revealing story - while 78% of universities now have sustainability offices, their average budget is just 0.4% of operational spending, with 92% going to techno-centric infrastructure rather than human or ecological priorities (Sustainable Campus Index, 2023). This fiscal reality creates path dependencies that reinforce technological solutions, as evidenced by MIT's $500 million climate initiative allocating just 3% to social dimensions (MIT Office of Sustainability, 2023). Furthermore, the "sustainability staff ceiling" phenomenon limits career progression for practitioners advocating integrative approaches - only 8% of sustainability directors advance to vice-presidential roles, compared to 22% of facilities managers (AASHE, 2023). These structural barriers suggest that paradigm integration requires not just conceptual bridging but redistribution of institutional power and resources (Purdy, 2023).

Transformative paradigm integration must extend beyond operations into pedagogical cores. The "Sustainability Education Redesign" project across 12 European universities found that successful integration required simultaneous changes to: 1) course content (adding ecological ethics to engineering programs), 2) pedagogies (community-based learning), and 3) assessment (multispecies impact evaluations) (Vare et al., 2023). Most attempts fail by addressing only one dimension - for example, ETH Zurich's much-lauded "Climate Curriculum" achieved limited impact by focusing solely on content without changing teaching methods (Wiek et al., 2023). The most promising models employ "trophic curriculum design" where introductory courses establish paradigm foundations, intermediate courses develop integration skills, and capstones apply them to real-world projects (Obermeister, 2023). This systemic approach remains rare, implemented fully at only 7% of institutions surveyed (Lozano et al., 2023).

Conclusion and Future Research Directions .5

The systematic review has illuminated the complex landscape of campus sustainability paradigms, revealing both the transformative potential and inherent limitations of human-centric, techno-centric, and post-anthropocentric approaches. The evidence demonstrates that while each paradigm offers valuable insights, their artificial separation in both research and practice has created unnecessary divisions that hinder comprehensive sustainability transformation. The integrative framework proposed here emerges not as a simple compromise but as a necessary epistemological and practical synthesis that acknowledges the interconnectedness of social, technological, and ecological systems. Universities stand at a critical juncture where they must move beyond paradigm tribalism to develop holistic strategies that address the full spectrum of sustainability challenges - from behavioural change and technological innovation to ontological transformation of human-environment relationships.

Future research must prioritize longitudinal, mixed-methods studies that track integrated sustainability interventions across diverse institutional contexts. This review presents temporal analysis that indicates that there is a specific urgency in the need to comprehend the manner in which paradigm integration is changing during different stages of institutional change, including inception and optimal implementation. Case studies comparing institutions of the Global North and South might provide interesting information about the role of regional inequality in access to resources, governance models, and the values of a culture on the pathways of integration. It is urgent to build the frameworks of strong assessment that can reflect the complexity of the relationship between paradigms and go beyond the simplistic measure to understand the integrations of technological systems shaping social practices, the conversion in praxis, behavioural influences on ecological changes and the transformation of post-anthropocentric ethics on institutional decision-making.

The mentioned implementation challenges presented throughout this review indicate some of the key knowledge gaps that need to be filled as soon as possible. The political economy of integration of sustainability needs to be investigated, in specific, the patterns of power and resource allocation, which allow or limit the ability to bridge paradigms. Recent developments in the theoretical literature concerning sustainability transition governance should provide interesting potential in this regard, although an emphasis on the empirical context of higher education is still lacking. The other critical border area is in building pedagogical structures that would produce the so-called paradigm fluency or an understanding of being able to comprehend rival perspectives of sustainability, move through them, and intuitively connect the parallels in the various disciplines. This path seems very promising, yet it should be systematically tested on various institutional types because the success of any single effort, such as the Cornell Climate Action Plan or the Sustainability Teachers Academy at Arizona State, shows.

At the most basic level, research in the future needs to resolve the ontological conflicts of paradigms with innovative methods, which straddle both quantitative and qualitative. Such epistemological innovation has a basis in the pluralistic methodology exhibited in this review; it entails the integration of bibliometric analysis, case study synthesis, and critical realist

interpretation. The development of an alternative episteme of knowledge production has become within the reach and the duty of researchers, as universities become more living laboratories where extant forms of knowledge must be transformed to be more sustainable. It will involve a long-term commitment to transdisciplinary research infrastructures, both digital (to integrate diverse data) and physical (where researchers and stakeholders can collaborate experimentally), as well as institutional incentives to publish across disciplinary boundaries.

What the next step requires is more than a rethinking of what happens in the university, as though the school were merely a package deal of assorted sustainability programs. What is required instead is a re-envisioning of the university as a total socio-technical-ecological system that instantiates the changes it aims to bring about in the outside world. This vision will become reality only if research is capable of advancing theoretical insights and practical tools to implement, along with critiquing the power arrangements which define the sustainability governance. Future research by adopting the unity that has been displayed by this review can guide institutions of higher learning to go beyond partisanship in the resolution of issues in order to realize successful sustainability that is socially fair, technologically adequate, and ecologically restorative.

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