Volume 6 (2) July 2026, Pages: 215-229

Environmental Pollution Journal

https://doi.org/10.58954/epj.v6i2.452

Strategic Green Ergonomics Design to Enhance Eco-Campus Effectiveness in Higher Education Institutions for Sustainability Outcomes

Ida Kusnawati Tjahjani[1✉], Yunia Dwie Nurcahyanie[1], Sri Widyastuti[2], Manik Ayu Titisari[1], Sabrina Nur Saraswati[1], and Alexander Indra Putra Hartawan[2]

[1] Prodi Teknik Industri Universitas PGRI Adi Buana, Surabaya, Indonesia

[2] Prodi Teknik Lingkungan Universitas PGRI Adi Buana, Surabaya, Indonesia

Keywords

Eco-campus; Green Ergonomics; Effectiveness; Strategy; Sustainability

Abstract

The effectiveness of the eco-campus program remains suboptimal due to weak integration among environmental, behavioral, and ergonomic aspects of campus users. This research aims to design strategies to enhance the effectiveness of the eco-campus program at Universitas PGRI Adi Buana Surabaya through a green ergonomics approach. Data were collected through observation, questionnaire distribution, and interviews involving all members of the academic community. The data were identified using a Fishbone Diagram and analyzed using the SWOT method to determine internal and external factors, followed by the formulation of improvement strategies using the QSPM method.The results of the study produced four strategies, namely S1, S2, S3, and S4. The prioritized strategy is S, an Integrated Green Ergonomics Model with the highest total score of 3.60. Therefore, it is necessary to increase the total attractiveness scores of the following factors: dependence on expensive technology (T3), lack of national Green Ergonomics standards (T4), changes in internal leadership policies (T2), resistance to organizational cultural change (T1), low awareness of the academic community regarding Green Ergonomics (W2), limited budget and management priorities (W4), support for sustainable research grants (O3), and the lack of cross-unit integration in eco-campus implementation (W1).

INTRODUCTION

The eco-campus concept translates the principles of sustainable development into practice within higher education institutions by integrating resource efficiency, environmental stewardship, effective institutional governance, and the well-being of the campus community (UNESCO, 2017). Universities are therefore expected not only to deliver education and research, but also to act as living laboratories in which sustainability principles are demonstrated through campus operations, organizational culture, and stakeholder participation (Filho et al., 2019; Findler et al., 2019). Recent studies show that sustainability performance improves when education, research, operations, and community engagement are managed as an integrated institutional system rather than as isolated environmental programs (Inga & Pereira, 2021; Menon & Suresh, 2020).

Universitas PGRI Adi Buana Surabaya has implemented several environmental sustainability initiatives, including the Tree Planting Guest Program, rare plant conservation, ecoenzyme workshops, and waste reduction campaigns (Universitas PGRI Adi Buana Surabaya. Press, 2020), campus greening, wastewater treatment, and energy conservation programs (Universitas PGRI Adi Buana Surabaya. Press, 2022). Despite these initiatives, the presence of individual sustainability programs alone is insufficient to foster sustained pro-environmental behavior or achieve measurable improvements in institutional sustainability performance. Evidence from green and non-green universities indicates that students' perceptions, daily routines, infrastructure availability, and visible institutional commitment jointly shape environmental behavior (Dagili et al., 2018; Roy, 2023). This implies that an eco-campus strategy

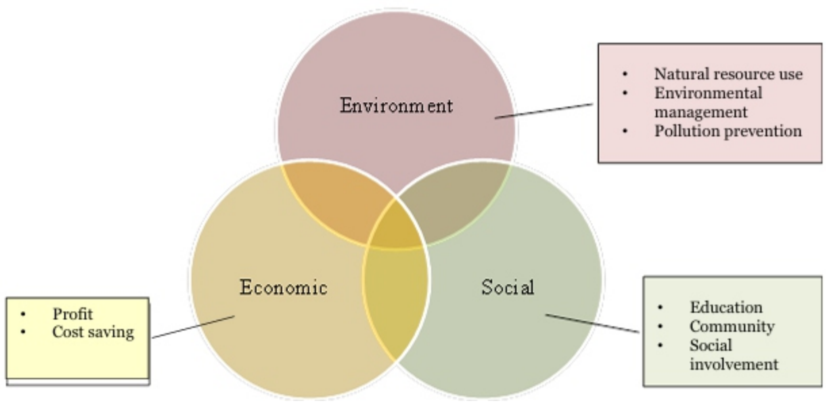
✉ ida.tjahjani@unipasby.ac.id, Surabaya, East Java

must address the interaction between people, technology, work systems, spatial design, and environmental objectives. This commitment has been exemplified by Universitas PGRI Adi Buana Surabaya in its efforts toward becoming an eco campus (Universitas PGRI Adi Buana Surabaya. Press, 2024). However, these initiatives have not yet achieved optimal outcomes (Ekawati & Fitri, 2024). However, the effectiveness of these initiatives continues to face several challenges, including limited user participation, suboptimal campus environmental design for promoting sustainable behavior, and insufficient integration of environmental, behavioral, and ergonomic dimensions within the campus environment (Buana, 2018). Therefore, this study aims to develop a strategy for improving the effectiveness of the eco-campus program at Universitas PGRI Adi Buana Surabaya (UNIPA) through a green ergonomics approach. This objective is particularly relevant because UNIPA has not yet met the assessment criteria required to obtain Eco-Campus recognition under the UI GreenMetric World University Rankings, a prominent sustainability-ranking framework that supports institutional internationalization in Indonesia and globally.

Green ergonomics is a suitable perspective for this integration because it expands conventional ergonomics beyond its traditional focus on safety and productivity to simultaneously optimize human well-being and institutional sustainability performance. Within the campus context, it integrates ergonomic design with energy-efficient practices, sustainable material use, sustainable mobility, digital monitoring systems, and participatory governance. Despite the availability of sustainability assessment frameworks and university ranking systems as performance benchmarks, many higher education institutions continue to face challenges in translating broad sustainability commitments into coordinated practices and meaningful organizational change (Amaral et al., 2020; Omazic & Zunk, 2021; Sonetti et al., 2016). Accordingly, the research gap addressed in this study is the absence of a prioritized institutional strategy that explicitly links eco-campus performance with green ergonomics principles. The study therefore aims to identify root causes, formulate strategic alternatives, and determine the priority strategy for enhancing eco-campus effectiveness at Universitas PGRI Adi Buana Surabaya.

The UI GreenMetric applies a sustainability framework encompassing environmental, economic, and social dimensions, which are operationalized through six main categories, as presented in Figure 1 and Table 1 (Universitas Indonesia, 2019).

Although there have been



Source: Univeritas Indonesia, (2019)

Figure 1

Three Components of *UI GreenMetric*

Table 1
UI GreenMetric Assessment

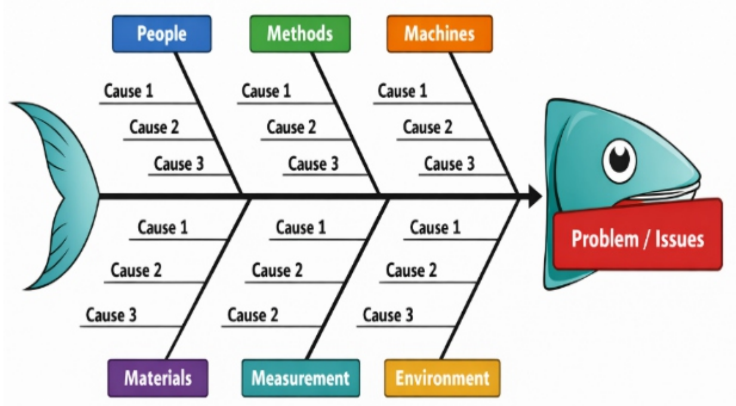
No.	Assessment Category	% Point	Number of Indicators						Changes	
			2019	2020	2021	2022	2023	2025	% Point	2024
1.	Setting and Infrastucture - SI	15	6	6	6	11	11	11	16	14
2.	Energy and Cli mate Change - EC	21	8	8	8	10	10	11	19	15
3.	(Waste - WS)	18	6	6	6	6	6	7	19	15
4.	Penggunaan Air (Water - WR)	10	4	4	4	5	5	6	15	11
5.	Transportation - TR	18	8	8	8	8	8	9	16	10
6.	Education and Research - ER	18	7	7	7	11	11	14	15	13
Total		100	39	39	39	51	51	58	100	78

Source: Universitas Indonesia, 2019

adjustments in the number of indicators, from 2019 to 2025, the framework consistently includes six core categories: (1) Setting and Infrastructure (SI), which covers open spaces, vegetation, green areas, and sustainability budgeting; (2) Energy and Climate Change (EC), including energy efficiency, renewable energy use, and emission management; (3) Waste (WS), encompassing waste management, recycling, and waste reduction; (4) Water (WR), including water conservation, efficiency, and quality; (5) Transportation (TR), covering green transportation policies, public transport, cycling, and pedestrian systems; and (6) Education and Research (ER), which includes sustainability-related curricula, publications, research activities, student organizations, and sustainability reporting. Building upon this comprehensive framework, this research aims to develop strategies to enhance the effectiveness of the eco-campus program at Universitas PGRI Adi Buana Surabaya through the application of a green ergonomics approach.

RESEARCH METHOD

This research was conducted at UNIPA using a sequential strategic-analysis design. The design combined qualitative problem identification with quantitative prioritization in six stages, that is (1) Observation and interviews; (2) Fishbone analysis is organized the causes into People, Methods, Machines, Materials, Measurement, and Environment; (3) Questionnaire administration. The questionnaire involved 40 respondents representing lecturers, students, and administrative staff. Responses were used to validate the causes identified through observation and interviews and to support the assignment of weights and ratings in the internal and external factor matrices; (4) the construction of the Internal Factor Analysis Summary (IFAS) matrix and the External Factor Analysis Summary (EFAS) matrix to assign weights and ratings to each factor; (5) SWOT strategy to formulate alternative strategies—SO, WO, ST, and WT—based on the institution's strengths, weaknesses, opportunities, and threats. SWOT transformed those causes into strategic alternatives; and (6) Quantitative Strategic Planning Matrix (QSPM) then compared the alternatives through weighted attractiveness scores. This sequence strengthens analytical traceability because each priority strategy can be cross-referenced to the root causes and strategic factors from which it was derived. This combination was selected because campus sustainability challenges are socio-technical, involving interactions among human behavior, procedures, technology, resources, measurement



Source: Created by Author (2026)
Figure 2
Fishbone Diagram

systems, and the physical environment; therefore, a multi-method approach is better suited than a single-indicator assessment to translate these complex issues into implementable institutional strategies.

RESULTS AND DISCUSSION

The observations and interviews conducted with Mr. Candra and Mr. Salimin in the vicinity of the Waste Management Laboratory at Universitas PGRI Adi Buana Surabaya (UNIPA), with the assistance of two students from the Environmental Engineering & Industrial Engineering programs, resulted in a series of photographs documenting the site conditions, as presented in Figure 3.

Based on questionnaire responses from 40 participants, comprising lecturers, students, and administrative staff, the causes of the identified problems, their impacts on the eco-campus initiative, and proposed solutions were determined, as summarized in several tables 2-7.

Table 2 translates the Fishbone categories into a socio-technical diagnosis of eco-campus performance. The People category identifies low awareness, inconsistent practice, resistance to change, and limited role modelling. These findings explain why environmental programs may exist without becoming routine behavior. This interpretation is consistent with Dagiliūtė et al. (2018) and Roy (2023), who found that pro-environmental

Source: Created by Author (2025)
Figure 3
Waste Management at Universitas PGRI Adi Buana Surabaya

Table 2
Problem Identification Based on the Man (People) Category

	Main Causes Internal and External	Impact on Eco-Campus	Proposed Problem-Solving Strategies
Internal	• Low awareness among the academic community regarding green behavior (energy saving, waste sorting, green transportation) • Inconsistent behavior (awareness exists but is not practiced regularly) • Resistance to change toward new environmentally friendly policies • Limited role modeling by leaders/lecturers in implementing eco-friendly habits • Insufficient knowledge of green ergonomics and sustainability practices	Green programs are not implemented consistently	Redesign the environmental education system and green behavior campaigns through training programs and the promotion of role models
External	○ Surrounding community culture is not fully environmentally oriented ○ Dependence on conventional habits (private vehicles, single-use plastics)		

Source : Processed Primary Data, 2025

behavior on campus depends not only on knowledge but also on institutional cues, perceived organizational support, and social norms. Consequently, the education and role-model strategies proposed in Table 2 should not be treated as stand-alone initiatives but rather integrated with policies, supporting facilities, feedback mechanisms, and performance indicators across the other Fishbone categories.

Table 3
Problem Identification Based on the Methods Category

	Main Causes Internal and External	Impact on Eco-Campus	Proposed Problem-Solving Strategies
Internal	• Environmental management SOPs are insufficiently detailed or not well disseminated • Absence of ergonomic standards for spatial design, work practices, and campus systems • Inconsistent monitoring and evaluation (M&E) of policy implementation • Limited integration across units (academic, administration, laboratories, student affairs) • Ineffective feedback systems → complaints are not addressed, innovation is hindered	Environmental strategies lack clear direction	• Develop sustainability Standard Operating Procedures (SOPs) and Key Performance Indicators (KPIs), accompanied by regular audits • Strengthen policy integration across institutional units
External	○ Annual changes in UI GreenMetric World University Rankings assessment criteria requiring continuous institutional adaptation ○ Dynamic regulatory pressures from government (ESG, zero waste, carbon reporting)		

Source : Processed Primary Data, 2025

Table 4
Problem Identification Based on the Machines Category

	Main Causes Internal and External	Impact on Eco-Campus	Proposed Problem-Solving Strategies
Internal	• Buildings and facilities are not energy-efficient (lighting, air conditioning, pumps, internal transportation) • Laboratory equipment is energy-intensive and not ergonomically designed • Limited digital systems → activities remain paper-based and manual • Lack of energy-efficient IoT infrastructure (lighting sensors, energy metering systems)	High energy consumption and inefficiency	• Implement phased investments in energy-efficient technologies and digital systems • Introduce Internet of Things (IoT)-based interventions
External	○ Environmentally friendly technologies are costly and require high initial investment ○ Limited availability of local vendors providing green/renewable solutions		

Source : Processed Primary Data, 2025

Table 3 shows that insufficient procedures and fragmented governance reduce the effectiveness of environmental programs. Incomplete SOPs, the lack of ergonomic standards, inconsistent monitoring, limited cross-unit coordination, and inadequate feedback mechanisms contribute to unclear responsibilities and inconsistent implementation. Consequently, the implementation of energy conservation, waste management, water efficiency, and sustainability reporting varies across university units.

These findings also relate to the people-related problems in Table 2 because unclear procedures can weaken motivation and accountability. External pressures, including changes in UI GreenMetric indicators and growing requirements for ESG, zero waste, and carbon reporting, require an adaptive management system. Therefore, sustainability SOPs, measurable KPIs, regular audits, corrective-action mechanisms, and integrated coordination should be developed. Procedures must also consider usability, accessibility, safety, comfort, and workload. Table 3 confirms that effective eco-campus implementation requires standardized, integrated, and ergonomically designed governance rather than isolated initiatives by individual units.

Table 4 identifies inefficient facilities and limited green technology as major causes of high energy consumption. Inefficient lighting, air-conditioning, pumps, laboratory equipment, paper-based processes, and the absence of IoT monitoring systems indicate that existing infrastructure does not adequately support sustainability goals.

Green ergonomics emphasizes that technological improvements should balance energy efficiency with user comfort, health, and productivity. Reducing air-conditioning use without considering thermal comfort, for instance, may negatively affect user performance. Digitalization can also reduce paper consumption, simplify administrative work, and decrease repetitive tasks. The lack of smart meters, occupancy sensors, and automated controls limits the institution's ability to detect excessive energy use and evaluate improvements.

The high initial investment required for environmentally friendly technologies, together with the limited availability of suitable vendors, supports the adoption of a phased implementation approach. Priority should be given to low-cost, high-impact technologies with short payback periods. Pilot projects can first be introduced in buildings or laboratories with the highest energy consumption, supported by user training and

Table 5
Problem Identification Based on the Materials Category

	Main Causes Internal and External	Impact on Eco-Campus	Proposed Problem-Solving Strategies
Internal	• Use of non-environmentally friendly mate rials (single-use plastics, ink, bottled water) • Absence of waste sorting or reduction systems at the source • Limited implementation of reuse–reduce–recycle programs across units • Resource constraints (stationery, compos - ting facilities, categorized waste bins)	High levels of waste generation	Prioritize the implementation of the 3R principles (reduce, reuse, recycle) and improve facility management
External	○ Recycling supply chain circulation is not yet optimal at the local/regional level ○ Universities depend on vendor policies		

Source : Processed Primary Data, 2025

performance monitoring.

Table 5 shows that high waste generation results from both consumption practices and weak waste-management systems. The use of bottled water, single-use plastics, ink, insufficient waste sorting, limited 3R implementation, and inadequate facilities indicate that waste problems begin at the procurement stage, not only at disposal.

Sustainable material management should prioritize waste prevention, followed by reuse and recycling, in line with the waste hierarchy. Procurement policies should support the use of refill systems, reusable products, reduced packaging, and environmentally responsible suppliers to minimize waste generation at its source. Effective source segregation is equally critical because the mixing of waste streams diminishes the quality, recyclability, and economic value of recoverable materials. In addition, waste collection infrastructure should be strategically distributed, clearly labeled, readily accessible, and ergonomically designed to encourage correct disposal behavior and maximize material recovery.

Table 6 reveals that the institution faces challenges in evaluating eco-campus performance due to incomplete and unsystematically collected environmental data. The lack of real-time measurements, eco-dashboards, unit level KPIs, and

Table 6
Problem Identification Based on the Measurement Category

	Main Causes Internal and External	Impact on Eco-Campus	Proposed Problem-Solving Strategies
Internal	• Energy, water, and waste consumption data are not measured in real time • Absence of dashboards or data-processing systems based on green ergonomics • Lack of sustainability Key Performance Indicators (KPIs) at the unit level • Data on student and lecturer activities (transportation, campus engagement) are not systematically recorded	The institution faces difficulties in evaluating performance	• Establish comprehensive measurement and reporting systems • Integrate data (energy, waste, and mobility) into a campus eco-dashboard
External	○ Variations in sustainability assessment methodologies (UI GreenMetric, THE Impact, ESG) ○ Measurement technologies require specialized expertise and investment		

Source : Processed Primary Data, 2025

Table 7
Problem Identification Based on the Environment Category

	Main Causes Internal and External	**Impact on Eco-Campus**	**Proposed Problem-Solving Strategies**
Internal	• The campus was not originally designed as an eco-campus (limited green spatial planning) • Non-ergonomic spatial design (circulation, ventilation, lighting) • High campus activity density increases emissions and waste generation • Work culture does not yet integrate green ergonomics principles	Increasing energy demand and waste burden	• Redesign spatial layouts • Apply ergonomics-based interventions to create healthy workspaces and improve resource efficiency
External	○ Tropical climate conditions → high cooling demand ○ Campus location near main roads → high reliance on private vehicles ○ Surrounding community habits do not fully support green practices		

Source : Processed Primary Data, 2025

consistent transportation or participation data means that decisions may rely on assumptions rather than evidence.

The absence of baseline data prevents the institution from objectively evaluating the effectiveness of energy conservation, water conservation, and waste reduction initiatives. Furthermore, aggregated data may obscure variations in performance across faculties, laboratories, offices, and buildings. Therefore, key performance indicators (KPIs) should be disaggregated by organizational unit, activity, and location to enable more accurate performance evaluation and targeted interventions.

An integrated eco-dashboard could combine energy, water, waste, transportation, emissions, participation, and research data. However, data definitions, collection responsibilities, verification procedures, reporting frequency, and access rights must first be standardized. Although different sustainability frameworks use varying indicators, an integrated database can support multiple reporting systems. Table 6 emphasizes that valid, timely, and accessible measurement is essential for continuous improvement, accountability, investment planning, and strategic decision-making.

Table 7 identifies spatial, climatic, cultural, and locational conditions that increase energy demand and waste generation. The campus was not originally designed as an eco-campus, while limitations in circulation, ventilation, lighting, green space, and work culture reduce both environmental efficiency and user comfort.

Spatial design within a green ergonomics framework should integrate people, activities, technology, and the physical environment to simultaneously enhance environmental and human performance. nefficient circulation layouts increase unnecessary movement, while inadequate ventilation and insufficient daylight contribute to higher cooling and lighting energy demands, respectively. Similarly, high activity density requires coordinated scheduling, efficient space allocation, and sustainable transportation management to improve resource efficiency while maintaining user comfort and productivity.

External conditions such as tropical climate, proximity to main roads, and dependence on private vehicles cannot be eliminated, but their effects can be reduced through passive cooling, shading, vegetation, efficient air-conditioning, pedestrian routes, bicycle facilities, shuttle services, and public transport incentives. Table 7 confirms that eco-campus development should be treated as a socio-technical system in which environmental design, organizational culture, user behavior, and external conditions interact.

The Methods and Measurement categories reveal a second critical issue: the institution lacks comprehensive and consistently disseminated standard operating procedures (SOPs), unit-level sustainability key performance indicators (KPIs), real-time resource monitoring, and an integrated feedback mechanism. These deficiencies correspond directly to W1 and W3 in Table 8, namely weak cross-unit integration and inadequate greenhouse gas documentation. Consequently, the eco-campus initiatives described in the Introduction have not yet translated into a coherent institutional sustainability performance profile. This finding is consistent with previous studies showing that fragmented governance, limited cross-unit coordination, and inadequate monitoring systems impede the effective implementation of sustainability initiatives and continuous institutional improvement (Findler et al., 2019; Menon & Suresh, 2020). Thus, the eco-dashboard and periodic audit proposed in Table 2 are governance instruments, not merely technical additions.

The progression from Tables 2–7 to Tables 8 and 9 illustrates how the operational findings identified through the Fishbone analysis were systematically synthesized into strategic factors within the SWOT framework. Multidisciplinary expertise and alignment with the UI GreenMetric framework and the Sustainable Development Goals (SDGs) were classified as strengths (S1–S2), whereas fragmented implementation, low environmental awareness, incomplete greenhouse gas emissions data, and budget constraints were identified as weaknesses (W1–W4).

Table 8
SWOT Matrix

	Strengths (S)		***Weakness (W)***
S1.	The Green Ergonomics concept is multidisciplinary (Industrial Engineering – Environmental Engineering – Mechanical Engineering)	W1.	Eco-campus implementation is not yet integrated across units
S2.	Supports indicators of the U I GreenMetric World University Rankings and the Sustainable Development Goals	W2.	Low awareness among the academic community regarding Green Ergonomics
S3.	Potential for emission reduction through energy efficiency and work behavior	W3.	Campus greenhouse gas (GHG) emission data are not well documented
S4.	Capable of generating strategic models and campus policy recommendations	W4.	Limited budget and management priorities
	Opportunities (O)		***Threats (T)***
O1.	Green Campus and Net Zero Emission policies	T1.	Resistance to organizational cultural change
O2.	Global trends in sustainability and green universities	T2.	Changes in internal leadership policies
O3.	Availability of sustainable research grant support	T3.	Dependence on costly technologies
O4.	Institutional reputation enhancement through UI GreenMetric	T4.	Lack of national Green Ergonomics standards

Source : Processed Primary Data, 2025

Likewise, supportive policy developments and research funding opportunities were categorized as opportunities (O1–O4), while cultural resistance, leadership discontinuity, high technology investment costs, and the absence of national green ergonomics standards were recognized as threats (T1–T4). This systematic transformation demonstrates that the SWOT factors were derived directly from the empirical findings of the Fishbone analysis rather than from subjective judgment, thereby strengthening the methodological rigor, transparency, and credibility of the strategic assessment.

Table 8 summarizes the internal and external conditions influencing the implementation of Green Ergonomics within the eco-campus program. The main strengths are the multidisciplinary nature of Green Ergonomics, its alignment with UI GreenMetric and Sustainable Development Goals, its potential to reduce emissions, and its ability to support strategic policy development. These strengths indicate that the institution already possesses a strong conceptual foundation for integrating environmental performance with human well-being and operational efficiency.

However, several weaknesses remain, particularly limited cross-unit integration, low awareness among the academic community, incomplete greenhouse gas emission data, and constrained budgets. These weaknesses may hinder consistent implementation and evidence-based decision-making.

The identified opportunities include supportive national and global sustainability policies, expanding research funding, and opportunities to enhance institutional reputation through participation in the UI GreenMetric ranking. Conversely, resistance to organizational change, leadership turnover, high technology investment costs, and the absence of national Green Ergonomics standards constitute significant strategic threats. Overall, the SWOT matrix suggests leveraging multidisciplinary expertise and external opportunities to overcome internal fragmentation, strengthen environmental data management, and reduce reliance on costly technologies.

The Machines, Materials, and Environment categories further demonstrate that behavioral change alone cannot resolve the problem. Energy-intensive equipment, limited digital monitoring, single-use materials, insufficient source separation, non-ergonomic circulation, and high cooling demand create structural constraints on sustainable behavior. These findings support the fundamental premise of green ergonomics that human behavior is shaped by the design of technology and the physical environment. Similarly, previous studies on campus sustainability have consistently demonstrated that effective interventions require the integration of operational efficiency, infrastructure redesign, resource management, and active stakeholder participation (Amaral et al., 2020; Ribeiro et al., 2021. The Fishbone results therefore provide the causal basis for the four strategic alternatives later presented in Table 9.

Table 9
SO, WO, ST, and WT Strategy Matrix

Strategy	Strategy Formulation
SO	Integration of Green Ergonomics to improve eco -campus performance and reduce greenhouse gas emissions
WO	Strength ening management systems and Green Ergonomics education based on emission data
ST	Development of adaptive and low -cost Green Ergonomics models
WT	Formulation of an eco -campus policy roadmap based on sustainable ergonomics

Source : Processed Primary Data, 2025

The SO strategy in Table 9 uses the institution's multidisciplinary capability to integrate green ergonomics with eco-campus and emissions-reduction objectives. The WO strategy responds to W1-W3 by strengthening management systems, education, and data-based decision making. The ST strategy leverages internal expertise and low-cost adaptive solutions to reduce dependence on expensive technologies, whereas the WT strategy strengthens implementation resilience through a formal policy roadmap. This collection reflects recommendations in the higher-education sustainability literature that institutional transformation requires coordinated governance, curriculum and awareness, operational experimentation, and long-term policy continuity (Aleixo et al., 2016; Filho et al., 2019; Inga & Pereira, 2021).

Among these alternatives, the Integrated Green Ergonomics Model is conceptually broader because it can function as an umbrella architecture for the remaining strategies. Policy and SOP development provide governance controls; behavioral change supplies the human component; and green technology provides operational support. The strategies should therefore be interpreted as complementary layers rather than mutually exclusive projects. This interpretation also explains why an integrated model can receive the highest priority even when several individual weakness and threat factors still require improvement.

Furthermore, the weighting values of both factors are derived from SWOT analysis calculations, based on the identification of key factors within the internal environment (strengths and weaknesses) and external environment (opportunities and threats). These results are presented in Table 10.

Table 10 quantifies the relative attractiveness of the four alternatives. The internal-factor subtotal for S1 is 2.21, higher than S2 (1.93), S3 (1.95), and S4 (1.37), indicating that the integrated model makes the strongest use of institutional strengths while addressing the identified weaknesses. Its external-factor subtotal is also the highest at 1.39, compared with 1.26, 1.21, and 1.03. Thus, S1's overall advantage is not produced by a single high score; it results from consistently strong alignment across both internal and external dimensions.

A closer reading of Table 5 also reveals the limits of the preferred strategy. The relatively low TAS values associated with costly technology (T3), the absence of national standards (T4), leadership changes (T2), and cultural resistance (T1) indicate that integration alone will not remove implementation risk. These challenges require phased investment, internal standardization, policy institutionalization, and effective change management. In contrast, the strong contributions of strengths S1–S4 and opportunities O1, O2, and O4 indicate that the proposed strategy is well supported by multidisciplinary expertise, favorable global sustainability trends, and reputational incentives. This pattern is consistent with studies that identify leadership commitment, organizational learning, funding continuity, and measurable targets as key enablers of sustainable university transformation (Aleixo et al., 2016; Bauer et al., 2018; Purcell et al., 2019).

The lower score of S4, Ergonomic Green Technology Implementation (2.40), should not be interpreted as evidence that technology is unimportant. Rather, it indicates that technology-driven implementation is less effective when introduced without adequate governance, user participation, data management systems, and budgetary preparedness. This finding reinforces the socio-technical logic of green ergonomics: technology should be selected after work processes, user needs, environmental targets, and institutional capabilities have been aligned.

The QSPM analysis constitutes the final stage in selecting the most appropriate strategy for an institution. It is derived from the SWOT analysis,

Table 10
QSPM Matrix Calculation

1. QSPM – Internal Factor

Internal Factor	Weight	AS S1	TAS S1	AS S2	TAS S2	AS S3	TAS S3	AS S4	TAS S4
S1	0,10	4	0,40	3	0,30	3	0,30	2	0,20
S2	0,08	4	0,32	3	0,24	3	0,24	2	0,16
S3	0,09	4	0,36	3	0,27	4	0,36	3	0,27
S4	0,08	4	0,32	3	0,24	3	0,24	3	0,24
W1	0,07	3	0,21	4	0,28	3	0,21	2	0,14
W2	0,06	3	0,18	3	0,18	4	0,24	2	0,12
W3	0,06	4	0,24	4	0,24	3	0,18	2	0,12
W4	0,06	3	0,18	3	0,18	3	0,18	2	0,12
Subtotal	**0,60**		**2,21**		**1,93**		**1,95**		**1,37**

2. QSPM – External Factor

External Factor	Weight	AS S1	TAS S1	AS S2	TAS S2	AS S3	TAS S3	AS S4	TAS S4
O1	0,08	4	0,32	4	0,32	3	0,24	3	0,24
O2	0,07	4	0,28	3	0,21	3	0,21	3	0,21
O3	0,06	3	0,18	3	0,18	3	0,18	2	0,12
O4	0,06	4	0,24	3	0,18	3	0,18	3	0,18
T1	0,05	3	0,15	3	0,15	4	0,20	2	0,10
T2	0,04	3	0,12	3	0,12	3	0,12	2	0,08
T3	0,02	2	0,04	2	0,04	2	0,04	3	0,06
T4	0,02	3	0,06	3	0,06	2	0,04	2	0,04
Subtotal	**0,40**		**1,39**		**1,26**		**1,21**		**1,03**
Total	**1,00**		**3,60**		**3,19**		**3,16**		**2,40**

Source : Processed Primary Data, 2025

Notes:

AS = (Attractiveness Score) refers to the value indicating how attractive a given strategy is in responding to internal and external factors identified from the SWOT, IFE, and EFE matrices. The commonly used rating scale is: 1 = Not attractive, 2 = Less attractive, 3 = Moderately attractive, and 4 = Highly attractive.

TAS = (Total Attractiveness Score) = Weight × AS, represents the total value indicating the attractiveness level of a strategy toward specific strategic factors, taking into account the relative importance (weight) of each factor derived from the IFE/EFE matrices, with values ranging from 0.0 to 1.0 and a total weight equal to 1.00.

which generates several alternative strategies based on internal and external factors. These alternatives are then ranked to determine the priority strategy (Hatta & Tjahjani, 2024). The ranking of alternative strategies is presented in Table 11, which indicates that the selected strategy is the one with the highest total QSPM score, namely S1 – Integrated Green Ergonomics Model**.**

As summarized in Table 11, S1—Integrated Green Ergonomics Model—achieved the highest QSPM score of 3.60, followed by S2—Eco-Campus Policy and SOP Development (3.19), S3—Behavioral Change among the Academic Community (3.16), and S4—Ergonomic Green Technology Implementation (2.40). The narrow difference between S2 and S3 indicates that governance and behavior are almost equally important supporting priorities. Therefore, the practical implication is not to implement S1 as an abstract model, but to operationalize it through an integrated sequence: establish policy and KPIs, build participation and role modelling, create a resource and emissions dashboard, redesign priority workspaces and material flows, and introduce affordable technology in stages.

Table 11
Total QSPM Scores

Strategy	Strategy Formulation
SO	Integration of Green Ergonomics to improve eco-campus performance and reduce greenhouse gas emissions
WO	Strengthening management systems and Green Ergonomics education based on emission data
ST	Development of adaptive and low-cost Green Ergonomics models
WT	Formulation of an eco-campus policy roadmap based on sustainable ergonomics

Source : Processed Primary Data, 2025

The proposed model can be monitored through indicators that cross-reference the six UI GreenMetric categories: green-space and ergonomic accessibility under Setting and Infrastructure; energy intensity and emissions under Energy and Climate Change; source separation and material reduction under Waste; conservation and reuse under Water; low-emission mobility and walkability under Transportation; and sustainability curricula, research, training, and reporting under Education and Research. Linking these indicators to unit-level accountability would address W1 and W3 while mitigating the risks associated with T1 and T2. Such integration is aligned with the view of universities as living laboratories in which operational changes, education, and research mutually reinforce sustainability outcomes (Evans et al., 2015; Omazic & Zunk, 2021; Purcell et al., 2019).

This study contributes a strategic prioritization framework for eco-campus development through green ergonomics, but the findings should be interpreted within several limitations. The sample was limited to 40 respondents from one institution, and QSPM attractiveness scores remain dependent on stakeholder judgment. Future research should validate the model using larger samples, longitudinal performance data, direct measurements of energy, water, waste, mobility, emissions, and ergonomic conditions, and comparison with other higher education institutions. These extensions would allow the strategic model to be tested not only for perceived attractiveness but also for measurable environmental and human-performance outcomes.

CONCLUSIONS

The integrated analysis of Fishbone, SWOT, and QSPM indicates that the suboptimal effectiveness of the eco-campus program is a socio-technical problem involving fragmented governance, inconsistent behavior, insufficient measurement, resource-intensive facilities, material-management weaknesses, and non-ergonomic environmental conditions. The priority strategy is S1—Integrated Green Ergonomics Model—with a total attractiveness score of 3.60. Its selection reflects the strongest combined response to both internal and external factors and confirms that eco-campus improvement should integrate people, procedures, technology, data, materials, and spatial design rather than rely on isolated environmental activities. Implementation should begin with a formal cross-unit policy, unit-level KPIs, a campus sustainability dashboard, regular audits, leadership role modelling, and targeted education. Green technology should then be introduced in affordable phases based on verified resource and ergonomic priorities. Particular attention is required for eight factors with relatively low attractiveness contributions: dependence on costly technology (T3), lack of national green-ergonomics standards (T4), leadership-policy changes (T2), cultural resistance (T1), low awareness (W2), budget limitations (W4), continuity of research-grant support (O3), and weak cross-unit integration (W1). Future studies should validate the model longitudinally using objective sustainability, behavioral, and ergonomic indicators, including UI GreenMetric metrics.

ACKNOWLEDGEMENTS

The researchers would like to express their gratitude to the Research and Com - munity Service Institute (LPPM) of Universitas PGRI Adi Buana Surabaya for funding this research through the Risbuana Grant, as well as to all members of the academic community and all parties who actively contributed to this study.

REFERENCES

Aleixo, A. M., Leal, S., & Azeiteiro, U. M. (2016). Conceptualization of sustainable higher education institutions, roles, barriers, and challenges for sustainability: An exploratory study in Portugal. *Journal of Cleaner Production*, *172*, 1664–1673.https://doi.org/10.1016/j.jclepro.2016.11.010

Amaral, A. R., Rodrigues, E., Gaspar, A. R., & Gomes, Á. (2020). A review of empirical data of sustainability initiatives in university campus operations. *Journal of Cleaner Production*, *250*, 119558. https://doi.org/10.1016/j.jclepro.2019.119558

Bauer, M., Bormann, I., & Kummer, B. (2018). Sustainability Governance at Universities : Using a Governance Equalizer as a Research Heuristic. *Higher Education Policy*, *31*, 491 – 511. https://doi.org/10.1057/s41307-018-0104-x

Buana, R. P., Wimala, M., & Evelina, R. (2018). Pengembangan Indikator Peran Serta Pihak Manajemen Perguruan Tinggi dalam Penerapan Konsep Green Campus. (Hal. 82-93). *RekaRacana: Jurnal Teknil Sipil*, *4*(2), 82.https://doi.org/10.26760/rekaracana.v4i2.82

Dagili, R., Liobikiene, G., & Minelgaite, A. (2018). Sustainability at universities : Students ' perceptions from Green and Non-Green universities. *Journal of Cleaner Production*, *181*, 473–482. https://doi.org/10.1016/j.jclepro.2018.01.213

Ekawati, D., & Fitri, N. (2024). Analisis Pengaruh Program Eco-Campus Terhadap Perilaku Pro Lingkungan Mahasiswa. *Jurnal Koloboratif Sains*, *7*(2), 788–789. https://doi.org/10.56338/jks.v7i2.4863

Evans, J., Jones, R., Karvonen, A., Millard, L., & Wendler, J. (2015). Living labs and co-production : university campuses as platforms for sustainability science. *Current Opinion in Environmental Sustainability*, *16*, 1–6. https://doi.org/10.1016/j.cosust.2015.06.005

Filho, W. L., Shiel, C., Paço, A., Mifsud, M., Ávila, L. V., Brandli, L. L., Molthanhill, P., Pace, P., Azeiteiro, U. M., Vargas, R., & Caeiro, S. (2019). Sustainable Development Goals and Sustainability Teaching at Universities: Falling Behind or Getting Ahead of the Pack? *Journal of Cleaner Production*, *232*, 285–294. https://doi.org/10.1016/j.jclepro.2019.05.309

Findler, F., Schönherr, N., Lozano, R., Reider, D., & Martinuzzi, A. (2019). The Impacts of Higher Education Institutions on Sustainable Development A review and Conceptualization. *International Journal of Sustainability in Higher Education*, *20*(1), 23–38. https://doi.org/10.1108/IJSHE-07-2017-0114

Hatta, M., & Tjahjani, I. K. (2024). Strategi Pengembangan Produk Unggulan Daerah pada Usaha Tempe dengan Metode SWOT dan. *JUTIN : Jurnal Teknik Usaha Terintegrasi*, *7*(1), 166–175.

Inga, Ž., & Pereira, P. (2021). Higher Education For Sustainability : A Global Perspective. *Geography and Sustainability*, *2*, 99–106. https://doi.org/10.1016/j.geosus.2021.05.001

Menon, S., & Suresh, M. (2020). Synergizing education, research, campus operations , and community engagements towards sustainability in higher education : a literature review. *Synergizing Education*, *21*(5), 1015–1061.https://doi.org/10.1108/IJSHE-03-2020-0089

Omazic, A., & Zunk, B. M. (2021). Semi-Systematic Literature Review on Sustainability and Sustainable Development in Higher Education Institutions. *Sustainability*, *13*(7683), 1–45.

Purcell, W. M., Henriksen, H., & Spengler, J. D. (2019). Universities as the engine of transformational sustainability toward delivering the sustainable development goals " Living labs " for sustainability. *Sustainable Development Goals*, *20*(8), 1343–1357. https://doi.org/10.1108/IJSHE-02-2019-0103

Ribeiro, P., Hoeckesfeld, L., Baú, C., Magro, D., Favretto, J., Barichello, R., Cesar, F., Secchi, L., & Rog, C. (2021). Green Campus Initiatives as sustainable development dissemination at higher education institutions : Students ' perceptions e Baltazar Salgueirinho Os o. *Journal of Cleaner Production*, *312*(127671). https://doi.org/10.1016/j.jclepro.2021.127671

Roy, S. K. (2023). Green University Initiatives and Undergraduates' Reuse Intention for Environmental Sustainability: The Moderating Role of Environmental Values. *Environment Chalenge*, *13*(September), 100797. https://doi.org/10.1016/j.envc.2023.100797

Sonetti, G., Lombardi, P., & Chelleri, L. (2016). True Green and Sustainable University Campuses ? Toward a Clusters Approach. *Sustainability*, *8*(83), 1–23. https://doi.org/10.3390/su801008

UNESCO. (2017). *Education for Sustainable Development Goals: Learning Objectives*. https://doi.org/10.54675/cgba9153

Universitas Indonesia. (2019). *UI GreenMetric World University Rankings*.

Universitas PGRI Adi Buana Surabaya. Press. (2020). *Program dan Kegiatan Utama Penerapan Eco Campus di Universitas PGRI Adi Buana Surabaya*. Berita Kampus.

Universitas PGRI Adi Buana Surabaya. Press. (2022). *Penerapan Eco Campus di Universitas PGRI Adi Buana Surabaya*. Berita Kampus.

Universitas PGRI Adi Buana Surabaya. Press. (2024). *UNIPA MENUJU ECO CAMPUS.pdf*. Berita Kampus.