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Evaluating the impact of green infrastructure on campus sustainability goals: A case study of universities in Bangkok

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Abstract: This study explores the impact of green infrastructure on the sustainability goals of universities in Bangkok by examining the roles of institutional support, environmental awareness, and sustainable behavior. The study involves a population comprising administrators, faculty, and students from government, autonomous, and private universities in Bangkok. Using Structural Equation Modeling (SEM), significant relationships among these variables were identified, alongside the moderating effect of stakeholders' perceived effectiveness of green infrastructure. Results reveal that institutional support strongly influences green infrastructure development, directly contributing to achieving campus sustainability goals. Environmental awareness significantly affects sustainable behavior, though an unexpected negative relationship was found between sustainable behavior and campus sustainability goals, highlighting a misalignment between individual practices and institutional metrics. Additionally, the perceived effectiveness of green infrastructure was found to have no significant moderating effect, suggesting that perceptions alone may not enhance sustainability outcomes. This research provides novel insights by addressing the contextual challenges of urban universities in Southeast Asia. It offers actionable recommendations for policymakers and administrators to align sustainable practices with measurable outcomes. Future research should explore alternative moderating variables, address the negative impact of sustainable behavior on sustainability goals, and conduct cross-regional studies for broader generalization.

Keywords: *Campus sustainability, Environmental awareness, Green infrastructure, Institutional support.*

1. Introduction

"Green campuses" have recently gained prominence as a vital part of sustainability efforts in higher education. Universities are key in promoting environmental sustainability by implementing green infrastructure and fostering sustainable behaviors. Green infrastructure, encompassing natural and semi-natural features, delivers environmental, social, and economic benefits. These initiatives reduce carbon footprints, enhance biodiversity, improve resource efficiency, and promote the well-being of stakeholders [1]. As global challenges such as climate change, resource depletion, and pollution intensify, higher education institutions are increasingly adopting sustainable practices. These efforts include using renewable energy, water conservation systems, waste reduction programs, and green building certifications, aligning with the United Nations' Sustainable Development Goals (SDGs), particularly Goals 11 and 13 [2, 3]. The rise of green campus initiatives reflects a broader shift in societal priorities toward sustainability [4]. Universities are not only centers of learning but also hubs for fostering innovation and leading by example in sustainability practices [5]. They have the potential to influence their communities by demonstrating the feasibility and benefits of green initiatives [6]. However, implementing these initiatives often depends on various factors, including institutional

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policies, stakeholder engagement, and the perceived effectiveness of green infrastructure. These elements collectively determine the success of sustainability goals and how universities can fulfill their role as sustainability leaders.

This study investigates the impact of green infrastructure on campus sustainability in Bangkok, a rapidly urbanizing region with unique environmental and cultural characteristics. Structural Equation Modeling (SEM) explores the relationships [7] between institutional support, environmental awareness, sustainable behaviors, and sustainability outcomes. Additionally, the research examines the moderating role of stakeholders' perceived effectiveness of green initiatives, offering valuable insights for policymakers, administrators, and educators. By analyzing these factors, the study aims to comprehensively understand academic institutions' drivers and barriers to sustainability.

While existing studies underscore the importance of institutional policies and stakeholder engagement in fostering sustainable campus environments [8] there remains a lack of comprehensive research examining these factors in Bangkok. Furthermore, much of the existing literature focuses on Western settings, leaving a gap in understanding the specific dynamics of Asian urban environments, where cultural, economic, and environmental factors may differ significantly.

These findings are crucial as urban centers in Southeast Asia face mounting environmental challenges that require innovative and context-sensitive solutions. Understanding how green infrastructure initiatives interact with behavioral and institutional factors can inform the development of more effective sustainability strategies. This research not only enhances academic discourse but also provides practical recommendations for improving the sustainability of universities in Bangkok, potentially setting a benchmark for similar institutions across the region.

1.1. Research Objectives

To evaluate the level of factors that impact green infrastructure on the sustainability goals of universities in Bangkok.

To examine the structural model of the impact of green infrastructure on campus sustainability goals.

To investigate the moderating role of stakeholders' perceived effectiveness in the relationship between green infrastructure and campus sustainability outcomes.

1.2. Research Hypotheses

$H_{1:}$ Institutional support directly affects green infrastructure development. H2: Institutional support directly affects sustainable behavior

$H_{3:}$ Environmental awareness directly affects sustainable behavior.

$H_{3:}$ Green infrastructure directly affects the campus sustainability goals. H4: Sustainable behavior directly affects the campus sustainability goals.

$H_{5:}$ Institutional support indirectly affects campus sustainability goals through green infrastructure.

$H_{6:}$ Environmental awareness indirectly affects campus sustainability goals through sustainable behavior.

$H_{7:}$ The perceived effectiveness of green infrastructure moderates the relationship between green infrastructure and campus sustainability goals.

2. Literature Review

Institutional Theory emphasizes the role of formal structures, rules, and norms in shaping organizational behaviors and practices [9]. This theory underpins the relationship between institutional support (IS) and green infrastructure (GI) development. Universities as institutions are influenced by external pressures, such as government policies and stakeholder expectations, which drive their adoption of sustainability initiatives [10].

The Resource-Based View (RBV) posits that organizations gain a competitive advantage by utilizing valuable, rare, and inimitable resources [11]. In this context, institutional support is critical for implementing green infrastructure, leading to improved sustainability outcomes. This theory supports the link between IS, GI, and campus sustainability goals (CSG) by emphasizing the strategic use of resources [12].

The theory of Planned Behavior (TPB) explains the relationship between environmental awareness (EA) and sustainable behavior (SB). According to this theory, attitudes, subjective norms, and perceived behavioral control influence individuals' behavioral intentions [13]. Universities fostering environmental awareness can positively influence stakeholders' intentions to adopt sustainable behaviors, thus contributing to broader sustainability goals.

Social Cognitive Theory (SCT) highlights the interaction between individual, behavioral, and environmental factors. This theory explains how sustainable behavior (SB) impacts campus sustainability goals (CSG). Through observational learning and reinforcement, university stakeholders can adopt eco-friendly behaviors that contribute to achieving sustainability objectives (Bandura, 1986).

Sustainability Transitions Theory focuses on systemic changes needed to achieve sustainability [14]. It provides a framework for understanding the transformation of campus systems through green infrastructure. This theory supports the relationship between GI and CSG, highlighting the need for multi-level collaboration and innovation to foster sustainable transitions [15].

The Technology Acceptance Model (TAM) explains the moderating role of the perceived effectiveness of green infrastructure (PEGI) in the relationship between GI and CSG. According to TAM, individuals are more likely to adopt and support new technologies if they perceive them as valuable and practical. PEGI enhances the impact of green infrastructure by reinforcing stakeholders' confidence in its ability to achieve sustainability goals [16-19]

3. Methodology

3.1. Research Design

The study employs a quantitative research design using Structural Equation Modeling (SEM) to analyze the direct and indirect relationships among Institutional Support (IS), Green Infrastructure (GI), Environmental Awareness (EA), Sustainable Behavior (SB), and Campus Sustainability Goals (CSG). The moderating effect of Perceived Effectiveness of Green Infrastructure (PEGI) is also examined.

3.2. Population and Sample Size

The target population includes administrators, faculty, and students from Bangkok's public, autonomous, and private universities. The sample size was determined using the G*Power software tool, which resulted in a recommended sample of 818 respondents. This calculation is based on the effect size = 0.3 Statistical power = 0.95 Degrees of freedom (df), which are calculated using the formula NI(NI+1)/2−NP, where NI represents the number of indicators (20). NP represents the number of parameters (26). By applying the formula: 20(20+1)/2−26, the calculation results in df = 184 [20]. This sample size ensured sufficient statistical power for SEM analysis, allowing detection of significant relationships between variables.

3.3. Multi-Stage Sampling Method

Stage 1: Stratification by University Type: Based on 68 universities in Bangkok are stratified into three main categories: government universities, autonomous universities, and private universities. This ensures proportional representation across these groups [21].

Government Universities include four, five Rajabhat, four Rajamangala, one Vocational Institute, five Military Institutes, and three Institutes.

Autonomous Universities: 11 Universities, four Institutes, and one College.

Private Universities: 19 Universities, three Institutes, and eight Colleges.

Stage 2: Stratification by Institution Level: Further stratification is performed within each category based on the institution level (e.g., universities, institutes, colleges). This ensures that various institutional types are represented proportionally.

Stage 3: Cluster Sampling within Institutions: Institutions are divided into clusters based on faculties or departments. Clusters are randomly selected to capture diversity in academic disciplines and ensure comprehensive representation. (68 institutions × 3 clusters = 204 clusters)

Stage 4: Random Sampling of Participants: Participants will be randomly selected from the 204 clusters to ensure a balanced representation of key stakeholders, including administrators, faculty, and students. Each cluster will contribute one administrator, one faculty member, and two students, resulting in 818 participants (204 administrators, 204 faculty members, and 408 students).

4. Result

The sample consisted of 818 participants, with 45% male and 55% female respondents. Regarding age, 35% were 18-24, 40% were 25-34, 15% were 35-44, and 10% were 45 years and above. Regarding their roles, the sample included 25% administrators, 25% faculty members, and 50% students. Educational background varied, with 50% holding undergraduate degrees, 30% master's, and 20% doctoral degrees. The participants were also distributed across university types, with 30% from government universities, 25% from autonomous universities, and 45% from private universities.

Table 1.
Mean, standard deviation, and coefficient of variables.

Items	$\bar{x}$	**S.D.**	**C.V.**
Institutional Support (IS)			
Availability of policies promoting sustainability (IS1)	4.313	.172	3.988%
Financial resources allocated for green infrastructure projects (IS2)	4.372	.212	4.849%
Leadership commitment to sustainability goals (IS3)	4.316	.166	3.846%
Green Infrastructure (GI)			
The proportion of green spaces on campus (GI1)	4.296	.182	4.236%
Implementation of renewable energy systems (GI2)	4.280	.193	4.509%
Use of sustainable construction materials in buildings (GI3)	4.268	.200	4.686%
Waste management and recycling facilities (GI4)	4.243	.210	4.949%
Environmental Awareness (EA)			
Awareness of campus environmental policies (EA1)	4.323	.180	4.164%
Participation in sustainability-related events and workshops (EA2)	4.311	.213	4.941%
Knowledge of global environmental challenges (EA3)	4.300	.156	3.628%
Sustainable Behavior (SB)			
Consistent recycling practices (SB1)	4.262	.214	5.021%
Use of energy-efficient appliances and systems (SB2)	4.270	.197	4.614%
Participation in carpooling or use of public transport (SB3)	4.237	.193	4.555%
Campus Sustainability Goals (CSG)			
Reduction in overall carbon footprint (CSG1)	4.187	.221	5.278%
Improvement in water and energy efficiency (CSG2)	4.326	.196	4.531%
Increase in biodiversity on campus (CSG3)	4.346	.194	4.464%
Reduction in non-recyclable waste (CSG4)	4.311	.171	3.967%
Perceived Effectiveness of Green Infrastructure (PEGI)			
Perceived improvement in campus air quality (PEGI1)	4.311	.178	4.129%
Perceived reduction in operational costs due to green initiatives (PEGI2)	4.211	.234	5.557%
Perceived enhancement in campus aesthetics and comfort (PEGI3)	4.268	.200	4.686%

Table 1 revealed generally high mean scores across all constructs, indicating strong institutional support, well-developed green infrastructure, and a high level of environmental awareness among respondents. Institutional Support (IS) showed the highest mean for financial resource allocation (4.372) with a low coefficient of variation (C.V.) of 4.849%, suggesting consistent stakeholder perceptions. Green Infrastructure (GI) exhibited slightly more variability, particularly in waste management and recycling facilities (C.V. = 4.949%). Environmental Awareness (EA) scored consistently high, with the lowest variability in knowledge of global environmental challenges (C.V. = 3.628%). Sustainable Behavior (SB) demonstrated more significant variability, especially in recycling practices (C.V. =

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5.021%). For Campus Sustainability Goals (CSG), carbon footprint reduction showed the highest variability (C.V. = 5.278%), while water and energy efficiency improvements were more consistent. Finally, the Perceived Effectiveness of Green Infrastructure (PEGI) had the highest variability in the perceived reduction of operational costs (C.V. = 5.557%). These results highlight areas of consistency and opportunities for targeted improvement in sustainability practices across universities.

Table 2.
The Pearson's correlation coefficients for the relationships between the observed variables.

Pearson's correlation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SI1	(.875)																			
SI2	.756**	(.874)																		
SI3	.699**	.805**	(.868)																	
GI1	.545**	.521**	.770**	(.868)																
GI2	.463**	.633**	.721**	.741**	(.867)															
GI3	.365**	.449**	.692**	.793**	.641**	(.867)														
GI4	.559**	.631**	.761**	.731**	.873**	.724**	(.888)													
EA1	-.345**	-.347**	-.140**	-.087*	-.013	-.062	-.063	(.888)												
EA2	-.409**	-.462**	-.239**	.049	-.025	.127**	.019	.677**	(.880)											
EA4	-.313**	-.256**	-.015	-.035	.083*	.124**	.096**	.690**	.704**	(.882)										
SB1	-.166**	-.257**	-.026	.061	-.081*	.328**	.187**	.307**	.657**	.630**	(.882)									
SB2	-.220*	-.121**	-.024	-.003	.132**	.190**	.146**	.470**	.400**	.635**	.615**	(.882)								
SB3	-.044**	.009	.209**	.123**	.090**	.137**	.173**	.223**	.392**	.557**	.566**	.381**	(.880)							
CSG1	-.126**	-.178**	.056	.230**	.208**	.162**	.336**	.425**	.644**	.609**	.595**	.530**	.662**	(.879)						
CSG1	.841**	.755**	.509**	.227**	.330**	.212**	.396**	-.342**	-.494**	-.263**	-.195**	-.094**	-.124**	-.306**	(.873)					
CSG1	.859**	.904*	.756**	.585**	.560**	.394**	.582**	-.342**	-.394**	-.305**	-.251**	-.230**	.040	-.081*	.797**	(.838)				
CSG1	.677*	.790**	.841**	.681**	.583**	.607**	.674**	-.138**	-.188**	-.021	.013	-.033	.189**	.081*	.656**	.849**	(.873)			
PEGI1	.494**	.578**	.672**	.562**	.674**	.599**	.556**	-.155**	-.254**	-.020	-.096**	.164**	-.038	-.189**	.541**	.489**	.504**	(.873)		
PEGI2	.354**	.147**	.293**	.507**	.510**	.244**	.416**	-.022	.127**	.013	-.125**	-.134**	.087*	.283**	.264**	.407**	.402**	.415**	(.879)	
PEGI3	.365**	.449**	.582**	.594**	.546**	.908**	.637**	-.062	.043	.124**	.328**	.283**	.045	.001	.419**	.394**	.607**	.702**	.244**	(.869)
Min	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.67	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.67	4.00
Max	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.75	4.67	4.67	4.67	4.67	4.67	4.67	4.67

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Table 2 shows that Pearson's correlation analysis reveals significant positive relationships among most observed variables, confirming strong internal consistency within constructs (Cronbach's alpha > 0.7). For instance, Institutional Support (IS) indicators, such as financial resources and leadership commitment, show high correlations (e.g., IS2 and IS3, r = 0.805**). Similarly, Green Infrastructure (GI) variables exhibit strong interrelations (e.g., GI3 and GI4, r = 0.724**). Cross-construct correlations, such as between Environmental Awareness (EA) and Sustainable Behavior (SB) (e.g., EA2 and SB1, r = 0.657**), indicate that awareness initiatives positively influence sustainable practices. Negative correlations, such as EA1 and IS1 (r = - 0.345**), suggest potential areas for improvement in aligning policies with environmental awareness. Overall, the observed variables scored highly, with values ranging from 4.00 to 4.67, reflecting strong stakeholder agreement on the importance of sustainability initiatives and supporting the model's validity.

Table 3.
Outer model evaluation results.

Construct	**Indicator**	**Loading**	**Indicator Reliability (Loading²)**	**Average Variance Extracted (AVE)**	**Cronbach's Alpha**	**Composite Reliability (CR)**	
						Dijkstra-Henseler's rho (ρA)	**Joreskog's rho (ρc)**
Institutional Support (IS)	IS1	0.875	0.766	0.834	0.902	0.935	0.938
	IS2	0.932	0.869				
	IS3	0.932	0.869				
Environmental Awareness (EA)	EA1	0.847	0.717	0.789	0.870	0.929	0.918
	EA1	0.893	0.797				
	EA1	0.923	0.852				
Green Infrastructure (GI)	GI1	0.904	0.817	0.813	0.923	0.931	0.946
	GI2	0.909	0.826				
	GI3	0.863	0.745				
	GI4	0.929	0.863				
Sustainable Behavior (SB)	SB1	0.898	0.806	0.682	0.765	0.784	0.865
	SB2	0.820	0.672				
	SB3	0.753	0.567				
Campus Sustainability Goals (CSG)	CSG1	-0.172	0.030	0.639	0.712	0.913	0.821
	CSG2	0.886	0.785				
	CSG3	0.959	0.920				
	CSG4	0.905	0.819				
Perceived Effectiveness of Green Infrastructure (PEGI)	PEGI1	0.914	0.835	0.645	0.714	0.763	0.842
	PEGI2	0.618	0.382				
	PEGI3	0.848	0.719				
Moderating	PEGI x GI	1.000					

Table 3 indicates that the outer model evaluation demonstrates the analysis's reliability, validity, and strong measurement properties across constructs. Institutional Support (IS), Environmental Awareness (EA), and Green Infrastructure (GI) exhibit high factor loadings (ranging from 0.847 to 0.932), strong indicator reliability (Loading² > 0.7), and excellent internal consistency with Cronbach's Alpha and Composite Reliability (CR) values exceeding 0.9. Sustainable Behavior (SB) and Perceived Effectiveness of Green Infrastructure (PEGI) also show acceptable reliability, with AVE values above the threshold of 0.5, though PEGI2 (loading = 0.618) suggests room for refinement. Campus Sustainability Goals (CSG) showed a negative loading for CSG1 (-0.172), which was excluded to enhance construct validity. The remaining indicators for CSG have strong loadings (0.886 to 0.959) and reliability. Overall, the model exhibits robust measurement properties suitable for SEM analysis.

Table 4.
Inner model path coefficients and effect sizes.

Path	Path Coefficient	t-value	p-value	f^2 Effect Size
IS → GI (Direct effect)	0.742	47.069	0.000	1.222
IS → SB (Direct effect)	0.140	7.169	0.000	0.034
EA → SB (Direct effect)	0.726	27.943	0.000	0.919
GI → CSG (Direct effect)	0.378	7.013	0.000	0.100
SB → CSG (Direct effect)	-0.194	11.883	0.000	0.067
PEGI x GI → CSG (Moderating effect)	-0.003	0.212	0.832	0.000
EA → CSG (Indirect effect)	-0.141	29.148	0.000	-
IS → CSG (Indirect effect)	0.253	17.537	0.000	-

Table 4 demonstrates that the path analysis results indicate that Institutional Support (IS) has a substantial direct effect on Green Infrastructure (GI) (path coefficient = 0.742, t-value = 47.069, $p < 0.001$), with a large effect size ($f^2 = 1.222$). IS also has a more minor but significant direct effect on Sustainable Behavior (SB) (path coefficient = 0.140, t-value = 7.169, $p < 0.001$, $f^2 = 0.034$). Environmental Awareness (EA) significantly impacts SB (path coefficient = 0.726, t- value = 27.943, $p < 0.001$, $f^2 = 0.919$). In terms of Campus Sustainability Goals (CSG), GI has a moderate direct effect (path coefficient = 0.378, t-value = 7.013, $p < 0.001$, $f^2 = 0.100$), while SB shows a negative direct effect (path coefficient = -0.194, t-value = 11.883, $p < 0.001$, $f^2 = 0.067$). The moderating effect of the Perceived Effectiveness of Green Infrastructure (PEGI) on the GI → CSG relationship is negligible and non-significant (path coefficient = -0.003, t-value = 0.212, $p = 0.832$, $f^2 = 0.000$). Additionally, EA has an indirect negative effect on CSG through SB (path coefficient = -0.141, t-value = 29.148, $p < 0.001$), whereas IS indirectly impacts CSG positively via GI (path coefficient = 0.253, t-value = 17.537, $p < 0.001$). These results highlight the critical roles of IS, GI, and EA in achieving sustainability goals, with limited influence from the moderating variable PEGI.

Table 5.
Inner model evaluation R^2, Adjusted R^2, and Q^2 values.

Endogenous variable	R^2	Adjusted R^2	Q^2 (Predictive relevance)
Green Infrastructure (GI)	0.550	0.549	0.441
Sustainable behavior (SB)	0.483	0.482	0.327
Campus sustainability goals (CSG)	0.460	0.457	0.377

Table 5 demonstrates that the inner model evaluation shows strong explanatory and predictive power for all endogenous variables. Green Infrastructure (GI) has the highest explained variance, with an R^2 of 0.550 and strong predictive relevance ($Q^2 = 0.441$), driven primarily by Institutional Support (IS). Sustainable Behavior (SB) has an R^2 of 0.483 and moderate predictive relevance ($Q^2 = 0.327$), influenced by Environmental Awareness (EA) and IS. Campus Sustainability Goals (CSG), with an R^2 of 0.460 and a Q^2 of 0.377, shows that GI and SB significantly contribute to achieving sustainability goals. The minor differences between R^2 and Adjusted R^2 across constructs confirm the model's robustness and reliability for predicting campus sustainability outcomes.

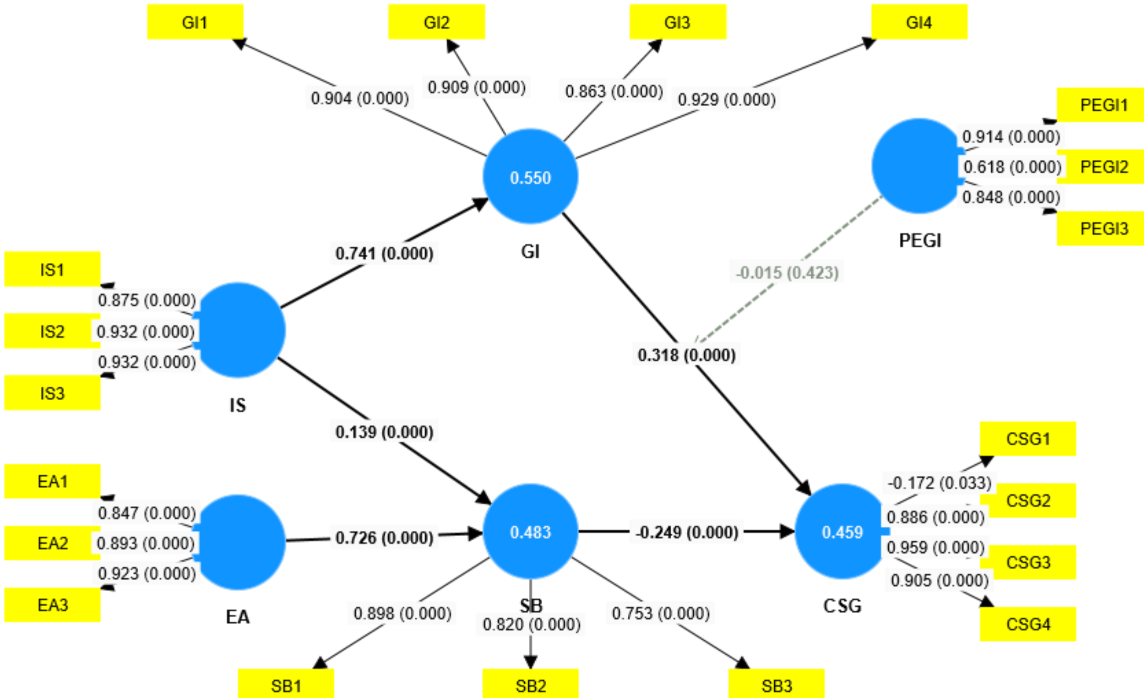

Figure 2.
Structural equation modelling of the impact of green infrastructure on campus sustainability goals.

Figure 2 Illustrated the modified model demonstrates the significant roles of Institutional Support (IS) and Environmental Awareness (EA) in fostering Green Infrastructure (GI) and Sustainable Behavior (SB), which in turn drive Campus Sustainability Goals (CSG). Notably, CSG1 (reduction in overall carbon footprint) was removed due to a hostile and unreliable factor loading, improving the validity and reliability of the CSG construct. The model explains 55% of the variance in GI, 48.3% in SB, and 46% in CSG. While GI positively impacts CSG (path coefficient = 0.378, $p < 0.001$), SB has an unexpected adverse effect on CSG (path coefficient = -0.194, $p < 0.001$), suggesting that some sustainable behaviors may not directly translate into measurable sustainability outcomes. The moderating effect of Perceived Effectiveness of Green Infrastructure (PEGI) on the GI-CSG relationship is non-significant (path coefficient = -0.003, $p = 0.832$), indicating that stakeholders' perceptions of GI effectiveness do not significantly influence its impact on sustainability goals. This highlights the need to explore other potential moderating factors further to enhance model fit and explanatory power.

Table 6.
The result of hypotheses testing.

Hypothesis	Path	Path coefficient (β)	t-value	p-value	Result
H1: IS → GI	Institutional support directly affects green infrastructure development.	0.742	47.069	0.000	Supported
H2: IS → SB	Institutional support directly affects sustainable behavior.	0.140	7.169	0.000	Supported
H3: EA → SB	Environmental awareness directly affects sustainable behavior.	0.726	27.943	0.000	Supported
H4: GI → CSG	Green infrastructure directly affects the Campus Sustainability Goals.	0.381	7.013	0.000	Supported
H5: SB → CSG	Sustainable behavior directly affects the Campus Sustainability Goals.	-0.194	11.883	0.000	Supported

Table 6 shows that the hypothesis testing results confirm that Institutional Support (IS) significantly drives Green Infrastructure (GI) (β = 0.742) and Sustainable Behavior (SB) (β = 0.140), while Environmental Awareness (EA) strongly influences SB (β = 0.726). Both GI and SB directly affect Campus Sustainability Goals (CSG), with GI having a positive impact (β = 0.381) and SB showing an unexpected negative effect (β = -0.194). Indirect effects indicate that IS influences CSG through GI (β = 0.255), and EA impacts CSG through SB (β = -0.141). However, the moderating role of the Perceived Effectiveness of Green Infrastructure (PEGI) on the GI- CSG relationship is non-significant (β = -0.003).

5. Conclusion

This study evaluated the impact of green infrastructure on campus sustainability goals in Bangkok's universities, highlighting the roles of institutional support, environmental awareness, and sustainable behavior. The findings revealed that institutional support strongly influences green infrastructure, directly driving campus sustainability outcomes. Environmental awareness significantly impacts sustainable behavior, although sustainable behavior unexpectedly showed a negative relationship with campus sustainability goals. Furthermore, the perceived effectiveness of green infrastructure did not significantly moderate the relationship between green infrastructure and sustainability goals. These results emphasize the importance of institutional policies and awareness programs while identifying areas for improvement in aligning sustainable practices with measurable outcomes.

6. Discussion

The results align with prior research emphasizing the critical role of institutional support in fostering green infrastructure. Zabel and Häusler [22] noted that strong leadership commitment and dedicated resources are vital for successfully implementing sustainability initiatives. This study corroborates these findings, with institutional support showing a substantial effect on green infrastructure. Moreover, the direct impact of green infrastructure on campus sustainability goals reflects the importance of physical infrastructure in reducing environmental impact, as Zellner and Massey [23] supported. Environmental awareness also emerged as a significant driver of sustainable behavior, consistent with Khan [24] described Theory of Planned Behavior, which posits that awareness and attitudes shape behavioral intentions. However, the negative effect of sustainable behavior on campus sustainability goals is unexpected and may indicate a misalignment between individual actions and institutional- level sustainability metrics. This result aligns with findings by Buckner and Zhang [25] who argue that individual efforts may not always yield immediate or measurable outcomes at a broader organizational scale.

The non-significant moderating effect of the perceived effectiveness of green infrastructure suggests that stakeholders' perceptions alone may not enhance the relationship between green infrastructure and sustainability goals. This finding contrasts with Jones and Russo [26] Technology Acceptance Model, which highlights the importance of perceived usefulness in influencing outcomes. It suggests a need for further exploration of how perceptions of green infrastructure can be translated into actionable benefits.

These findings offer practical implications for policymakers and university administrators. Strengthening institutional policies, providing financial resources, and enhancing environmental education are crucial for promoting green infrastructure and sustainable behaviors. However, universities should also focus on aligning individual behaviors with institutional sustainability metrics to bridge the gap between actions and measurable outcomes. Future research could investigate other potential moderators, such as organizational culture or technological integration, to further refine the model.

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6.1. Research Novelty

This study introduces a novel approach to understanding the factors influencing campus sustainability by integrating Institutional Support (IS), Environmental Awareness (EA), Green Infrastructure (GI), and Sustainable Behavior (SB) in Bangkok's university context. Unlike prior research, which often focuses on Western or developed contexts, this study addresses the unique environmental and cultural dynamics of a rapidly urbanizing Southeast Asian city. Structural Equation Modeling (SEM) enables a rigorous quantitative examination of these variables' direct and indirect relationships, providing a deeper understanding of their interactions. A key contribution of this research lies in identifying an unexpected negative relationship between SB and Campus Sustainability Goals (CSG), a phenomenon not widely documented in previous literature. This result points to potential misalignments between individual sustainable practices and institutional-level outcomes, highlighting a critical area for future investigation. Additionally, the non-significant moderating role of Perceived Effectiveness of Green Infrastructure (PEGI) challenges established theories, such as the Technology Acceptance Model (Davis, 1989), emphasizing the need to explore other factors that might influence the GI-CSG relationship. By addressing these gaps, the study provides practical insights for improving sustainability initiatives in universities across emerging economies. It offers a replicable framework for policymakers and administrators to design more effective strategies, aligning individual behaviors with institutional sustainability metrics to achieve measurable outcomes.

6.2. Suggestions

Exploring Alternative Moderating Variables: Given the non-significant moderating role of Perceived Effectiveness of Green Infrastructure (PEGI) in the GI-CSG relationship, future research should explore alternative moderating variables, such as organizational culture, technological readiness, or stakeholder trust. These factors may provide deeper insights into how green infrastructure initiatives translate into sustainability outcomes in academic institutions.

Addressing the Negative Impact of Sustainable Behavior (SB): The unexpected negative relationship between Sustainable Behavior (SB) and Campus Sustainability Goals (CSG) highlights the need to investigate the underlying causes of this misalignment. Future studies could use qualitative methods, such as interviews or focus groups, to explore how individual sustainable behaviors might conflict with or fail to align with broader institutional sustainability metrics. Contextual Comparisons Across Regions: To generalize the findings, future research could conduct comparative studies between universities in other urban Southeast Asian contexts or between developed and developing countries. This would provide a broader understanding of how cultural, economic, and environmental factors influence the effectiveness of green infrastructure and sustainable behaviors in achieving campus sustainability goals.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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