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BUILDING SUSTAINABLE CAMPUSES: HOW GREEN INFRASTRUCTURE SATISFACTION AND ACCESSIBILITY DRIVE LONG-TERM PHYSICAL ACTIVITY?

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Abstract:

This study investigates how satisfaction with and accessibility to campus green infrastructure influence students' motivation and long-term participation in physical activity. As universities pursue sustainable development aligned with the United Nations' Sustainable Development Goals (SDGs), green infrastructure—comprising parks, trails, and eco-friendly recreational zoneshas emerged as a crucial driver of health and well-being. Guided by Self-Determination Theory and environmental psychology frameworks, this quantitative study employed a cross-sectional survey of 300 university students and analyzed the data using Structural Equation Modeling (SEM). The results revealed that satisfaction with green infrastructure significantly predicts physical activity motivation ($\beta = 0.42$, $p < 0.001$), which in turn strongly influences long-term participation ($\beta = 0.48$, $p < 0.001$). Accessibility ($\beta = 0.39$, $p < 0.001$) and maintenance ($\beta = 0.35$, $p < 0.001$) were also key determinants of usage frequency, while demographic factors and perceived barriers mediated engagement levels. The Confirmatory Factor Analysis (CFA) confirmed model validity with robust indices (CFI = 0.94; RMSEA = 0.046). The findings highlight that well-maintained, accessible, and aesthetically appealing green spaces enhance motivation, satisfaction, and behavioral persistence toward active living. Universities are therefore encouraged to embed sustainable design, routine maintenance, and inclusive accessibility policies into campus planning to foster long-term student well-being and environmental engagement.

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Keywords:

Green Infrastructure; Sustainable Campus; Physical Activity; Accessibility; Student Motivation; Structural Equation Modeling (SEM); Environmental Satisfaction

Introduction

In recent years, universities have increasingly prioritized sustainable development strategies to foster student well-being and environmental responsibility. A fundamental component of this transition is the incorporation of green infrastructure, which plays a vital role in promoting physical activity and fostering long-term engagement in healthy lifestyle behaviors (Monteiro et al., 2020). Green infrastructure, which includes parks, green roofs, recreational trails, and other nature-based spaces, offers numerous ecological, social, and psychological benefits for students (Pitman et al., 2015). These green spaces align directly with the United Nations' Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being) and SDG 11 (Sustainable Cities and Communities), both of which emphasize the need for accessible, well-maintained public green spaces (Campillo-Sánchez et al., 2025).

Despite the recognized benefits of green infrastructure, disparities in accessibility, maintenance quality, and demographic influences affect student participation rates in outdoor physical activities. Research has established a positive link between well-maintained green spaces and increased physical activity among university students (Dyment & Bell, 2008; Coutts et al., 2013). However, additional factors such as accessibility, perceived barriers, and demographic differences must be examined to understand their role in shaping students' engagement with green spaces. Variables such as gender, socioeconomic background, and residential proximity to green spaces influence student satisfaction and participation (Tayouga & Gagné, 2016). Addressing these challenges can help universities create more inclusive, engaging, and sustainable outdoor environments.

This study examines how satisfaction with, accessibility to, and maintenance of green infrastructure influence students' motivation for physical activity and long-term participation. By utilizing Structural Equation Modeling (SEM), this research aims to develop and validate a predictive framework that explains the complex relationships among these factors. The findings will provide evidence-based recommendations for universities and policymakers to enhance student engagement with green infrastructure, contributing to broader campus sustainability initiatives.

Environmental psychology explores how physical environments influence human behavior, emotions, and well-being. Research suggests that exposure to nature enhances cognitive function, reduces stress, and fosters positive emotional states, making green infrastructure a crucial component of sustainable university campuses (Mataruna-Dos-Santos et al., 2022). The Attention Restoration Theory (Kaplan, 1995) argues that natural settings help individuals recover from mental fatigue, which indirectly motivates physical activity. Additionally, Wilson's (2012) Green Exercise concept highlights the psychological and physiological benefits of engaging in physical activity within natural environments. These theories provide a basis for examining how green spaces impact students' motivation for physical activity.

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Self-Determination Theory (Deci & Ryan, 1985) explains how intrinsic and extrinsic motivations influence behavioral persistence. In the context of green infrastructure, students who perceive campus green spaces as safe, accessible, and aesthetically appealing are more likely to develop intrinsic motivation for outdoor physical activities (Niu et al., 2024). This intrinsic motivation, reinforced by positive environmental attributes, fosters long-term participation in green space activities (Gottsmann & Schnitzler, 2023). The application of SDT in this study enables the assessment of how environmental satisfaction influences students' long-term engagement in physical activity.

Sustainability frameworks emphasize integrating environmental considerations into urban planning and campus development. The Sustainable Urban Design model (Monteiro et al., 2020) promotes green infrastructure to encourage active lifestyles while minimizing environmental footprints. Universities that implement sustainable sports facilities, eco-friendly transportation, and green fitness zones have reported higher student engagement in physical activities (Campillo-Sánchez et al., 2025). The Sustainable Campus Model (Pitman et al., 2015) further supports the role of green infrastructure in shaping sustainable student behaviors, reinforcing the importance of infrastructure investments in promoting long-term engagement.

Research suggests that accessibility and maintenance are key determinants of green space usage. The Place Attachment Theory (Scannell & Gifford, 2010) posits that individuals develop emotional connections to well-maintained, easily accessible environments, thereby increasing the likelihood of repeated engagement. However, perceived barriers—such as safety concerns, distance, and a lack of recreational diversity—can negatively affect students' willingness to use green spaces (Ling et al., 2024). Previous studies have found that universities addressing these barriers through improved security, enhanced transportation options, and structured wellness programs experience greater student participation in green infrastructure activities (Osipov et al., 2019).

This study employs Structural Equation Modeling (SEM) to develop and validate a predictive framework linking green infrastructure satisfaction, accessibility, maintenance, and demographic factors to long-term physical activity participation. Confirmatory Factor Analysis (CFA) and model fit indices will be used to confirm the robustness of the proposed relationships (Pfahl et al., 2015).

Methodology

Research Design

This study employs a quantitative research design using a survey questionnaire to systematically analyse university students' usage patterns, engagement, and satisfaction with green infrastructure. This approach enables the collection of structured data to assess the factors influencing long-term participation in green space activities.

Study Population and Sampling

The study focuses on students from a selected higher education institution, utilizing a stratified random sampling technique to ensure representation across faculties, gender, and physical activity frequency. A total of 300 students participated in the study, providing a comprehensive sample for statistical analysis.

International Journal of Innovation and Industrial Revolution
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Data Collection Instrument

A structured self-administered questionnaire was designed to capture relevant data. It comprises four key sections: Demographic Information, Green Infrastructure Usage Patterns Captures frequency, duration, and types of physical activities performed in green spaces. Environmental Satisfaction and Long-Term Participation and Motivation

Data Analysis

Quantitative data analysis is conducted using SPSS and Structural Equation Modeling (SEM) to evaluate relationships between usage frequency, satisfaction, motivation, and long-term participation, as shown in Table 1

Table 1. Research Objectives and Statistical Methods

Research Objective	Statistical Method Used
1. To examine the impact of green infrastructure satisfaction on physical activity motivation and its influence on long-term participation.	Structural Equation Modeling (SEM)
2. To assess how accessibility and maintenance influence usage frequency and participation in physical activity.	SEM Path Analysis
3. To analyse the role of demographic factors in shaping satisfaction levels, perceived barriers, and engagement in green spaces.	SEM with Mediation Analysis
4. To develop and validate a predictive SEM model linking green infrastructure factors to long-term participation in physical activity.	Confirmatory Factor Analysis (CFA) and Model Fit Indices
5. To provide policy and practical recommendations for enhancing student engagement in green infrastructure activities.	Indirect Effects and Total Effects Analysis

Finding

Model Specification and Fit Indices

The SEM analysis was performed using AMOS, with the hypothesized model including latent variables for Satisfaction, Accessibility, Maintenance, Usage Frequency, Motivation, and Long-Term Participation. The following model fit indices were evaluated in Table 2.

Table 2. SEM Analysis

Fit Index	Value	Acceptable Threshold
Chi-Square (χ^2)	126.89 (df = 78, p < 0.001)	Non-significant preferred, but acceptable
CFI (Comparative Fit Index)	0.94	≥ 0.90
TLI (Tucker-Lewis Index)	0.92	≥ 0.90
RMSEA (Root Mean Square Error of Approximation)	0.046	≤ 0.06
SRMR (Standardized Root Mean Square Residual)	0.041	≤ 0.08

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The results indicate an acceptable model fit, as the CFI, TLI, RMSEA, and SRMR met the recommended thresholds.

- Chi-Square (χ^2) = 126.89, df = 78, $p < 0.001$
- Comparative Fit Index (CFI) = 0.94 (acceptable threshold ≥ 0.90)
- Tucker-Lewis Index (TLI) = 0.92 (acceptable threshold ≥ 0.90)
- Root Mean Square Error of Approximation (RMSEA) = 0.046 (acceptable threshold ≤ 0.06)

This suggests that the theoretical framework appropriately represents the relationships among the key variables.

SEM Path Analysis Results

To analyse the direct and indirect relationships among variables, path coefficients, standard errors, and significance levels were calculated.

Table 3. SEM Path Analysis

Path	Standardized Coefficient (β)	SE	t-value	p-value	Effect
Green Infrastructure Satisfaction → Physical Activity Motivation	0.42	0.06	7.12	< 0.001	Significant
Physical Activity Motivation → Long-Term Participation	0.48	0.07	6.78	< 0.001	Significant
Accessibility → Usage Frequency	0.39	0.05	6.02	< 0.001	Significant
Maintenance → Usage Frequency	0.35	0.05	5.62	< 0.001	Significant
Usage Frequency → Participation in Physical Activity	0.44	0.06	6.95	< 0.001	Significant
Demographics → Satisfaction	0.31	0.07	4.72	< 0.001	Significant
Demographics → Barriers	-0.27	0.06	-4.21	< 0.001	Significant
Barriers → Engagement in Green Spaces	-0.33	0.06	-5.33	< 0.001	Significant

Students are more likely to engage in physical activity when green spaces are well-maintained, accessible, and aesthetically appealing. The strong link between satisfaction and motivation ($\beta = 0.42$, $p < 0.001$) underscores the need for universities to prioritize the quality of green spaces, ensuring they remain safe and functional for student use. Motivation significantly predicts long-term participation in outdoor physical activity ($\beta = 0.48$, $p < 0.001$), reinforcing the importance of structured wellness programs and social fitness activities. By integrating designated workout spaces within green infrastructure, universities can sustain student motivation and promote consistent engagement.

Accessibility ($\beta = 0.39$, $p < 0.001$) and maintenance ($\beta = 0.35$, $p < 0.001$) strongly influence usage frequency, emphasizing the role of well-planned infrastructure. Green spaces with dedicated walkways, proper lighting, and regular upkeep attract more student visitors, underscoring the need for continuous investment in facility improvements. Demographic

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 23 (December 2025) PP. 25-36
DOI 10.35631/IJIREV.723003

factors ($\beta = 0.31$, $p < 0.001$) shape satisfaction levels, while perceived barriers ($\beta = -0.33$, $p < 0.001$) hinder engagement. Safety concerns, distance from student accommodations, and limited recreational options remain key deterrents. Addressing these challenges through improved security, better transportation access, and diverse activity offerings can enhance student participation in green infrastructure activities.

Confirmatory Factor Analysis (CFA) and Predictive Model Validation

To ensure the validity of the predictive SEM model, a Confirmatory Factor Analysis (CFA) was conducted.

Table 4. Confirmatory Factor Analysis

Model Fit Index	CFA Result	Acceptable Threshold
Factor Loadings (≥ 0.50)	0.61 - 0.88	≥ 0.50
Composite Reliability (CR)	0.83	≥ 0.70
Average Variance Extracted (AVE)	0.57	≥ 0.50

The results of the Confirmatory Factor Analysis (CFA) in Table 4 demonstrate that the measured variables align well with their respective latent constructs, reinforcing the validity of the proposed model. The high Composite Reliability (CR = 0.83) indicates strong internal consistency, ensuring that the variables reliably measure the intended constructs. Additionally, the Average Variance Extracted (AVE = 0.57) supports good construct validity, confirming that the latent variables adequately capture the variance of their indicators. These findings validate the model's robustness and suitability for examining the relationships among green infrastructure satisfaction, accessibility, motivation, and long-term participation in physical activity.

Indirect Effects and Policy Recommendation

The indirect effects analysis in Table 5 explored mediation mechanisms within the model.

Table 5. Indirect Effects Analysis

Pathway	Direct Effect	Indirect Effect	Total Effect
Satisfaction → Long-Term Participation	0.00	0.20	0.20
Satisfaction → Motivation	0.42	0.00	0.42
Motivation → Long-Term Participation	0.48	0.00	0.48
Accessibility → Participation in Physical Activity	0.00	0.17	0.17
Maintenance → Participation in Physical Activity	0.00	0.15	0.15
Usage Frequency → Participation in Physical Activity	0.44	0.00	0.44

The findings indicate that satisfaction with green infrastructure plays a crucial role in fostering long-term participation in physical activity, primarily through its indirect effect on motivation (0.20). This suggests that students who perceive green spaces as well-maintained and appealing are more likely to develop a sustained interest in outdoor activities. Additionally, accessibility and maintenance were found to indirectly influence participation through usage frequency, with effect sizes of 0.17 and 0.15, respectively. This highlights the importance of infrastructure

International Journal of Innovation and Industrial Revolution
IJIREV
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DOI 10.35631/IJIREV.723003
planning, ensuring that green spaces are easily reachable and consistently maintained to encourage more frequent visits. Ultimately, well-maintained green spaces not only offer immediate opportunities for recreation but also foster long-term engagement in physical activity by creating a supportive, inviting environment for students.

Discussion

To Examine the Impact of Green Infrastructure Satisfaction on Physical Activity Motivation and Its Influence on Long-Term Participation.

Green infrastructure satisfaction refers to the extent to which students perceive green spaces as well-maintained, aesthetically pleasing, and conducive to physical activity. The availability of well-designed green spaces has been associated with increased motivation for physical activity, as students are more likely to engage in outdoor activities when these areas are accessible and inviting (Dyment & Bell, 2008; Coutts et al., 2013). Research indicates that green spaces provide psychological and social benefits, enhancing motivation for physical activity through stress reduction, improved mood, and social interaction (Pitman et al., 2015; Monteiro et al., 2020). When students feel satisfied with their access to quality green spaces, they are more likely to adopt an active lifestyle, reinforcing long-term participation in physical activity (Bikomeye et al., 2021).

The continuous use of green infrastructure influences long-term engagement in physical activity. The findings suggest that satisfaction with green infrastructure positively affects motivation for physical activity ($\beta = 0.42$, $p < 0.001$), which, in turn, significantly predicts long-term participation ($\beta = 0.48$, $p < 0.001$). This aligns with previous studies indicating that green environments encourage sustainable engagement in active behaviors (Raney et al., 2019; Kraft et al., 2021). As such, policymakers and educational institutions should focus on improving the quality of green spaces through strategic planning, ensuring these areas remain attractive, safe, and well-maintained to support students' long-term participation in physical activity.

To Assess How Accessibility and Maintenance Influence Usage Frequency and Participation in Physical Activity.

Accessibility plays a critical role in determining how often students engage in physical activity. The SEM analysis shows that accessibility significantly predicts usage frequency ($\beta = 0.39$, $p < 0.001$), highlighting the importance of proximity and ease of access to green spaces. Previous studies have found that students who live closer to parks or green trails are more likely to use them for recreational and fitness purposes (Coutts et al., 2013; Pfahl et al., 2015). Maintenance is another crucial factor influencing participation in physical activity. Poorly maintained green spaces, characterized by unclean environments, damaged pathways, and insufficient lighting, discourage use, whereas well-maintained spaces enhance safety and appeal (Chatzimentor et al., 2020). The results confirm that maintenance positively influences usage frequency ($\beta = 0.35$, $p < 0.001$), which, in turn, affects participation in physical activity ($\beta = 0.44$, $p < 0.001$). This suggests that investment in regular maintenance and safety measures is essential to encourage sustained use of green spaces.

International Journal of Innovation and Industrial Revolution
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Volume 7 Issue 23 (December 2025) PP. 25-36
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To increase participation, universities and local governments should implement policies that enhance accessibility and ensure consistent maintenance of green spaces. This includes improving transport connectivity to parks, ensuring well-lit and safe environments, and engaging students in co-managing these spaces through sustainability programs.

To Analyse the Role of Demographic Factors in Shaping Satisfaction Levels, Perceived Barriers, And Engagement in Green Spaces.

Demographic factors such as age, gender, and socioeconomic background influence satisfaction levels with green infrastructure. The SEM results show that demographics significantly predict satisfaction ($\beta = 0.31$, $p < 0.001$), suggesting that different student groups perceive green spaces differently based on their backgrounds and personal experiences (Tayouga & Gagné, 2016). For instance, female students may prioritize safety features when assessing satisfaction, while students from higher-income families might have higher expectations regarding facility quality (Bikomeye et al., 2021). These findings underscore the need for inclusive design that caters to diverse user needs.

Demographic variables also affect perceived barriers, with results indicating a significant negative relationship between demographics and barriers ($\beta = -0.27$, $p < 0.001$). Common barriers include distance, safety concerns, and lack of time due to academic commitments (Monteiro et al., 2020). The impact of barriers on engagement in green spaces ($\beta = -0.33$, $p < 0.001$) underscores the need for interventions that address accessibility challenges and promote inclusivity. To mitigate barriers, universities should focus on providing free or subsidized transport to green spaces, enhancing security measures, and integrating physical activity opportunities within academic schedules to make engagement more feasible.

To Develop and Validate a Predictive SEM Model Linking Green Infrastructure Factors to Long-Term Participation in Physical Activity.

A Confirmatory Factor Analysis (CFA) was conducted to validate the SEM model, ensuring that the hypothesized relationships align with observed data. The model fit indices indicate a strong model fit. The results confirm that the model adequately explains the relationships between green infrastructure satisfaction, motivation, accessibility, and participation, reinforcing its predictive validity. The validated model provides a theoretical framework for future research on sustainability-driven physical activity. Future studies could explore additional mediators such as environmental awareness and peer influence to further refine the model.

To Provide Policy and Practical Recommendations for Enhancing Student Engagement in Green Infrastructure Activities.

Policy and practical recommendations for enhancing student engagement in green infrastructure activities (Refer to Table 6).

Table 6. Policy And Practical Recommendations

Policy Recommendation	**Description**	**Reference**
Strengthening Green Infrastructure Development	Higher education institutions should prioritize the expansion and enhancement of green spaces to foster student engagement in outdoor physical activities. Investments should focus on improving accessibility,	Savely et al., 2007

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EISSN: 2637-0972
IJIREV
Volume 7 Issue 23 (December 2025) PP. 25-36
DOI 10.35631/IJIREV.723003

Policy Recommendation	**Description**	**Reference**
	ensuring safety, and enhancing aesthetic appeal to maximize usage and participation.	
Enhancing Maintenance and Security	To sustain engagement, universities must allocate dedicated resources for routine maintenance, including landscaping, waste management, and infrastructure upkeep. Additionally, improving lighting, surveillance systems, and security measures can create a safer environment, addressing student concerns about personal safety in green spaces.	Monteiro et al., 2020
Increasing Awareness and Participation	Raising awareness about the benefits of green space utilization is crucial for motivating students to engage in outdoor activities. Universities should incorporate sustainability education programs that promote eco-conscious physical activity habits, fostering long-term engagement with green infrastructure.	Nguyen Dang et al., 2023
Ensuring Inclusivity and Reducing Barriers	To promote equitable participation, universities should address socioeconomic disparities by implementing targeted initiatives such as subsidized fitness programs, improved transportation access to green spaces, and financial aid for recreational activities. These efforts can help eliminate barriers to participation for students from diverse backgrounds.	-
Embedding Sustainability in Institutional Planning	Sustainability efforts should be integrated into universities' long-term strategic frameworks, aligning green infrastructure initiatives with the Sustainable Development Goals (SDGs). Collaborative efforts with environmental organizations, government agencies, and private stakeholders can further support the development of eco-friendly campuses and long-term sustainability projects.	Pfahl et al., 2015

Conclusion

This study highlights the crucial role of green infrastructure in fostering sustainable campus environments that promote students' physical activity and long-term well-being. Findings demonstrate that when students perceive campus green spaces as accessible, well-maintained, and aesthetically pleasing, they are more likely to develop a consistent motivation to engage in outdoor physical activities. Green infrastructure, therefore, functions not only as an environmental asset but also as a behavioral catalyst that nurtures active lifestyles and psychological restoration. The study reaffirms that sustainability in higher education extends beyond energy or resource management, it encompasses the creation of spaces that enhance learning, social connection, and holistic health. When universities integrate environmental psychology principles into campus design, students experience greater satisfaction and emotional attachment to their surroundings. Such experiences strengthen their sense of belonging and encourage continued participation in outdoor activities.

International Journal of Innovation and Industrial Revolution
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IJIREV
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Moreover, accessibility and maintenance emerge as central components of this relationship. A campus environment that is easy to navigate, inclusive, and safe fosters equitable participation across diverse student groups. The study reinforces the need for university management to view green infrastructure not as a decorative feature, but as an essential dimension of educational and social sustainability. In conclusion, the research underscores that a sustainable campus is one in which green infrastructure, physical activity, and student well-being coexist harmoniously. By nurturing environments that are both ecologically responsible and behaviorally engaging, universities can contribute meaningfully to the broader sustainability agenda outlined in the United Nations' Sustainable Development Goals (SDG 3 and SDG 11).

Suggestions

1. Enhance Campus Planning and Design
   Universities should prioritize the inclusion of green spaces in campus master plans. These areas must be designed for functionality, comfort, and inclusivity, ensuring that all students—regardless of ability or background can access and benefit from them.
2. Ensure Continuous Maintenance and Safety
   Regular maintenance and adequate safety measures are vital for sustaining long-term student engagement. Clean, well-lit, and secure green spaces not only encourage use but also foster trust and comfort among the campus community.
3. Promote Awareness and Behavioral Engagement
   Awareness programs that emphasize the mental and physical health benefits of outdoor activities can encourage students to use green spaces more actively. Integrating such initiatives into campus events, wellness programs, or physical education courses can help normalize active lifestyles.
4. Encourage Student Involvement in Sustainability Efforts
   Student participation in designing, maintaining, and managing campus green spaces promotes ownership and accountability. Collaborative sustainability projects can enhance students' leadership, creativity, and social responsibility.
5. Adopt Policy Support for Sustainable Well-being
   Institutional policies should link sustainability initiatives with health promotion strategies. By embedding these values into academic and administrative frameworks, universities can ensure that green infrastructure remains a long-term priority rather than a short-term development goal.

In essence, sustainable campuses thrive when environmental design aligns with human motivation. Universities that invest in meaningful, accessible, and engaging green spaces cultivate not only a healthier student population but also a culture of environmental stewardship that extends beyond the classroom.

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