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Impact of Food Waste Management on Environmental Sustainability: Exploring the Mediating Role of Campus Nature Clubs

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ABSTRACT

The impact of food waste management on environmental sustainability has received widespread attention recent years from both practice and academia. This study explores the mediating role of nature club in college campus in the relationship between Food Waste Management (FWM) and Environmental Sustainability (ES), among a group of student, faculty and staff community currently working in Higher Educational Institutions in the district of Palakkad, State of Kerala. The current study provides preliminary information regarding how the objectives and associated activities of nature club in Higher education institutions act as a mediating role between FWM and ES. Through a detailed qualitative content analysis, we uncover the need of Nature clubs in college campus, so that an awareness gets cultivated among the various categories, that food waste should be reduced and the need for proper waste management should be on the right track, so that it helps to generate a sustainable environment in near future.

Design/methodology/approach - A study was directed to test how Food Waste Management (FWM) impacts the Environmental Sustainability (ES)l through mediating variable of the role of Nature Clubs/Biodiversity clubs among higher education institutions in rural district Palakkad, Kerala, India. Data was collected through a judgment sampling method from 412 respondents of higher educational institutions in local panchayath Vanniamkulam, Lakkidi Perur and Ongallur panchayath of Palakkad district, Kerala.

Findings

The findings make it clear with words and values that a substantial association was established between variables such as food waste management and environment sustainability with the mediating role of Nature club/Biodiversity clubs in Higher Education Institutions. The research validates that the awareness campaigns taken over by the Nature clubs or biodiversity clubs of HeIs acts as a mediating role between food waste management and Environment sustainability. On testing the hypothesis, the result shows that the dependent variable, Environment

sustainability, is substantially predicted by food waste management directly and with specific mediating variable of the role of Nature clubs/Bio diversity clubs, at a 95 % level of confidence.

Originality/value –
This study explores the impact of Food waste management (FWM) on Environment sustainability (ES) and mediating role if Nature club (NC)/ bio-diversity club activities in HeIs in rural parts of Palakkad district, Kerala State. The variable are theoretically and tested empirically in the context of State and Central Govt funding to Swatchtha campaign programs.

Keywords: Food waste Management, Nature club, Environmental sustainability, Bio-diversity clubs, HeIs -Higher Education Institutions

1.**Introduction**

Food waste has emerged as a critical global issue with profound implications for environmental sustainability. According to the Food and Agriculture Organization (FAO), approximately one-third of all food produced globally is wasted each year, amounting to about 1.3 billion tons (FAO, 2019). Food waste represents a significant loss of resources, including water, energy, and labour, and contributes to environmental degradation through increased greenhouse gas emissions, soil contamination, and resource depletion (United Nations Environment Programme [UNEP], 2021). As educational institutions are miniatures of larger societies, they have a vital role in addressing food waste and promoting sustainable practices within their communities.

One approach to mitigating food waste and enhancing environmental sustainability within campuses is through the establishment and operation of nature clubs. These student-led organizations serve as platforms for raising awareness, fostering behavioural change, and implementing practical solutions for food waste management. Nature clubs can mediate the relationship between food waste management practices and broader sustainability goals by promoting environmental education, conducting waste audits, and organizing campaigns to reduce food waste (Boyer et al., 2020). They also play a critical role in nurturing a culture of sustainability among students, faculty, and staff, thereby extending their impact beyond the confines of the campus (Sterling et al., 2017).

Research has shown that engaging students in sustainability initiatives through nature clubs leads to higher levels of environmental awareness and proactive participation in waste management activities (Lozano et al., 2019). Moreover, these clubs create a collaborative environment where individuals can contribute to and learn from collective efforts aimed at reducing food waste and its environmental footprint (Dey & Sarkar, 2021). By leveraging the enthusiasm and creativity of young minds, campus nature clubs can act as catalysts for transformative change, aligning food waste management practices with the principles of environmental sustainability.

II Literature Review

Food Waste management and Environment Sustainability

There is growing evidence that a significant share of global food is thrown away, with concomitant detrimental repercussions for sustainability. According to Abbasi T et.al (2012) innovation management and social constructionism to investigate interrelationships of food service provisions and innovations in waste management. Food waste has been identified as one of the major factors that constitute numerous anthropogenic activities, especially in developing countries. Adegbola A, et.al (2011) , defined the growing problem with food waste that affects every part of the waste management system, from collection to disposal; finding long-term solutions necessitates involving all participants in the food supply chain, from farmers and manufacturers to distributors and consumers. In addition to food waste management, maintaining food sustainability and security globally is crucial so that every individual, household, and nation can always get food. "End hunger, achieve food security and enhanced nutrition, and promote sustainable agriculture" are among the main challenges of global sustainable development (SDG) goal 2. Therefore, sustainable food waste management technology is needed. Recent attention has been focused on global food loss and waste. One-third of food produced for human use is wasted every year. Source reduction (i.e., limiting food losses and waste) and contemporary treatment technologies appear to be the most promising strategy for converting food waste into safe, nutritious, value-added feed products and achieving sustainability. Alam P, Sharholy M, (2022) , In their paper ,Food waste is also employed in industrial processes for the production of biofuels or biopolymers. Biofuels mitigate the detrimental effects of fossil fuels. Identifying crop-producing zones, bioenergy cultivars, and management practices will enhance the natural environment and sustainable biochemical process. The main contribution of their study is an inventory of the theoretical and practical methods of prevention and minimization of food waste and losses. It identifies the trade-offs for food safety, sustainability, and security. Food waste is also one of the significant determinants of the three pillars of sustainability: financial, environmental, and social concerns. Anaerobic digestion is the most extensively utilized approach for treating food waste since, unlike other procedures, it aids in the generation of energy and the production of biogas. Food waste is diverted from landfills by anaerobic digestion, which minimizes the quantity of methane released into the atmosphere. Bioenergy production can diversify agricultural production systems while reducing GHG emissions, reaching fossil-fuel independence, and helping to reduce climate change concerns, which are a serious concern today. Moreover, some of the changes brought about by the COVID-19 epidemic in the lifestyle of consumers have the potential to improve the efficiency of the domestic food production process and minimize the quantity of food wasted by customers.Hence it is hypothesised as

(H1): Effective Food Waste Management (FWM) practices positively influence Environmental Sustainability (ES)

Nature Cub / Biodiversity clubs role in deloping Sustainable Environment.

Ogunjinmi et al (2023), examined that students' membership of environmental clubs impacts positively on their awareness of environmental problems, knowledge and connectedness to nature. It is recommended that the role of environmental clubs is made more relevant within the curriculum so as to empower students' with skills to promote more environmental

awareness, knowledge and connectedness to nature. Zhang, W,et al (2019) ,found Outdoor education programs are promoted to enhance connections between individuals and nature to foster pro-environmental behavior. Børresen, S. T.et al(2022),according to their paper student knowledge, attitudes and views towards ecosystem services and biodiversity changed due to an education programme organised by associated clubs.

A study done by Winter, P. L et al(2020) found that importance of outdoor recreation and nature-based tourism activities organised nature clubs , will bring more advance understanding of the environmental sustainability. The major objectives and aims of nature clubs must be to sensitize, create awareness, motivate and educate students about environment conservation (ITSR,2020). Kumar, R., & Devi, S. (2020), Nature clubs play a pivotal role in fostering environmental sustainability by educating and engaging individuals in eco-friendly practices. These clubs act as change agents, promoting awareness about environmental challenges such as waste management, conservation of natural resources, and climate change mitigation. Through workshops, clean-up drives, and tree plantation initiatives, nature clubs instill a sense of responsibility and environmental stewardship among participants. Chawla, L., & Cushing, D. F. (2019), A significant impact of nature clubs is their ability to influence behavioral change. By encouraging members to adopt sustainable practices like waste segregation, composting, and reducing single-use plastics, these clubs help reduce the ecological footprint of campuses. Additionally, nature clubs collaborate with local communities, fostering partnerships that extend the impact of sustainability efforts beyond the institution's boundaries (Joshi & Sharma, 2021).Hence it is hypothesised.

H2: Campus Nature Clubs (NC) activities have a positive influence on Environmental Sustainability (ES)

Campus Nature Club (NC) activities association with Food Waste Management (FWM) and the influence of effective Food Waste Management (FWM) on Environmental Sustainability (ES).

Aruna, M. C. (2002),Studied the effectiveness of nature clubs in selected schools in Chennai city in achieving environmental education among the student members. One program targeted at the nation's student body is environment education. Creating Nature Clubs and Eco-clubs in schools is one of the finest strategies to raise awareness and consciousness of environmental issues. The study found that the student members enjoyed a lot and studied more and are interested in protecting the environment, caring for it, and living an eco-friendly lifestyle. The study also envisages that their parents and society will be influenced by their beliefs, attitudes, and actions. Yogita, S. (2016). An evaluation study of eco clubs established under national green corps programme in Punjab. According to the study, there is a disparity in the percentage of frequency of the various types of activities that eco-clubs engage in. Therefore, eco-clubs should enhance the frequency of events like environmental contests, rallies, kitchen gardening, field trips, camping, etc. According to the study, pupil who participate in eco-clubs and those who do not participate have a substantial difference in their level of environmental awareness. Students who participate in eco-clubs are noticeably more environmentally conscious than those who do not. Thus, in order to raise environmental awareness and thereby protect the

environment, more eco-clubs should be formed in schools and an increasing number of students should join them.

Baron, R. M., & Kenny, D. A. (1986), their research paper advocates Nature Club activities may mediate the effects of efficient food waste management techniques and affect environmental sustainability. Bindu Ronald, R. (2024),The role of environmental clubs in promoting sustainable practices in educational institutions, Students' awareness of sustainability and the environment is greatly enhanced by school environmental clubs. Through an analysis of their educational impact, community participation, difficulties, and best practices, this article evaluates their role in advancing sustainable practices inside educational institutions. Through practical experiences like workshops, guest lectures, and field trips, environmental clubs help students better comprehend ecological ideas and close the gap between theory and practice. By planning events like recycling drives and tree plantings, they also involve the larger school community and foster a sustainable culture. The effectiveness of these clubs may be hampered by issues including a lack of administrative support and scarce resources. Gustavsson, J., et al (2011), study highlights the serious environmental effects of poor waste management system. In-depth research is done by Parfitt et al. (2010), study concentrates on the effects of food waste on the environment, particularly in food supply chains. Hungerford, H. R., & Volk, T. L. (1990) explores the ways in which environmental education can influence individual behaviour. Närvänen, S. et al (2019) , Nature clubs, which are frequently started in educational settings, are essential for raising awareness of environmental issues and encouraging sustainable behaviours, especially in managing food waste. By practical interventions, behavioural change, and education, their programs may drastically reduce food waste. To inform students and the public about the negative effects that food waste has on the environment and society, nature clubs host conferences, lectures, and campaigns. They promote a culture of waste reduction and thoughtful consumption by increasing awareness. It has been demonstrated that educational initiatives can successfully decrease food waste by altering people's attitudes and habits. Hence it is hypothesised,

H3: Campus Nature Club (NC) activities have positive association with Food Waste Management (FWM) and mediates the influence of effective Food Waste Management (FWM) on Environmental Sustainability (ES).

Objectives

The purpose of this study is to evaluate the impact of Food waste management on Environmental sustainability with the mediating role of the presence of Nature clubs/Bio-diversity clubs in Higher Education Institutions.

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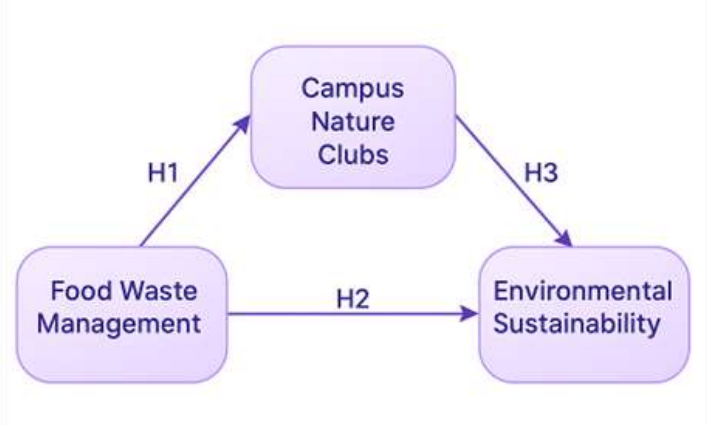
Conceptual framework



III Methodology

Data population

Pilot study

A pilot study was carried out among 40 participants representing all three stakeholder groups—students, faculty, and staff—to validate the questionnaire's clarity, scale appropriateness, and structure. Based on their feedback, minor adjustments were made to enhance the overall coherence of the survey.

Data Collection and Respondent Profile

This study explores the impact of Food Waste Management (FWM) practices on Environmental Sustainability (ES), with Campus Nature Club (NC) activities serving as a mediating factor. Data were collected from students, faculty, and non-teaching staff at higher education institutions located within three panchayats of Palakkad district, Kerala—namely, Vaniyamkulam, Lakkidi Perur, and Ongallur. Questionnaires were circulated in both print and digital formats through institution-level coordinators. A total of 450 questionnaires were distributed, and 412 valid responses were collected and used for analysis (Response Rate: 91.6%).

Respondent profile

Category	Sub-category	Frequency	Percentage
Respondent Type	Students	238	57.8%
Respondent Type	Faculty	104	25.2%
Respondent Type	Non-teaching Staff	70	17.0%
Panchayat	Vaniyamkulam	138	33.5%
Panchayat	Lakkidi Perur	136	33.0%
Panchayat	Ongallur	138	33.5%

Measurement Instruments

To assess the relationships among Food Waste Management (FWM), Environmental Sustainability (ES), and the mediating role of Campus Nature Clubs (NC), this study employs a two-step measurement and structural modeling approach. The Rasch Measurement Model will be used to validate the survey instrument by ensuring unidimensionality, item reliability, and person fit (Bond & Fox, 2015). The Structural Equation Modeling (SEM) approach in AMOS is applied to test the hypothesized relationships and mediation effects.

The study employed three multi-item scales to measure the key constructs: Food Waste Management (FWM), Campus Nature Clubs (NC), and Environmental Sustainability (ES). All items were measured using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The internal consistency of each scale was assessed using Cronbach's Alpha, and all constructs demonstrated high reliability, exceeding the acceptable threshold of 0.70 (Nunnally & Bernstein, 1994).

Food Waste Management (FWM): This construct was measured using an 8-item adapted scale designed to capture key aspects of individual and institutional food waste practices. Items assessed behaviors such as waste segregation, composting, awareness of consumption patterns, and strategies to minimize food waste. The scale showed strong internal consistency with a Cronbach's Alpha of 0.867.

Campus Nature Clubs (NC):
The 7-item scale for campus nature clubs focused on the degree of student participation in nature club activities, frequency of environmental awareness campaigns, and involvement in eco-volunteering initiatives. The construct exhibited a high reliability score with a Cronbach's Alpha of 0.879, reflecting consistent engagement patterns among participants.

Environmental Sustainability (ES):
Environmental sustainability was measured through a 6-item scale that captured both institutional and personal sustainable behaviors, including carbon footprint consciousness, eco-friendly practices, and perceptions of long-term ecological impact. The scale demonstrated excellent internal consistency with a Cronbach's Alpha of 0.884.

These validated scales were subjected to Rasch Model analysis for further psychometric verification, followed by Structural Equation Modeling (SEM) to test the hypothesized relationships and mediating effects within the conceptual framework.

IV. Analysis and results

The measurement model was examined to confirm the reliability and validity of the constructs used in the study.

4.1 The table below provides information on outer loadings, Cronbach's Alpha, rho_A, Composite Reliability, AVE, and R^2 values for each construct.

Construct	Item	Estimate	Cronbach's Alpha	rho_A	Composite Reliability	AVE	R^2
FWM	FWM1	0.721	0.867	0.875	0.904	0.544	0.469
	FWM2	0.729					
	FWM3	0.734					
	FWM4	0.743					
NC	NC1	0.726	0.879	0.888	0.913	0.556	0.453
	NC2	0.733					
	NC3	0.742					
	NC4	0.749					
ES	ES1	0.724	0.884	0.893	0.918	0.564	--
	ES2	0.733					
	ES3	0.741					
	ES4	0.752					

The measurement model was assessed for internal consistency, convergent validity, and construct reliability using multiple indicators: Cronbach's Alpha, rho_A, Composite Reliability (CR), Average Variance Extracted (AVE), and Coefficient of Determination (R^2). **Coefficient of Determination (R^2)**-The R^2 values for Environmental Sustainability (ES) were not reported (likely as it is the dependent latent variable). The R^2 for NC was 0.453, indicating that 45.3% of the variance in Campus Nature Clubs can be explained by Food Waste Management practices. The R^2 for FWM was 0.469, suggesting moderate explanatory power by other variables, possibly including NC in mediation.

4.2 Normality Test (Skewness and Kurtosis)

Construct	Skewness	Kurtosis	Interpretation
Food Waste Management (FWM)	-0.29	0.2	Normal
Campus Nature Clubs (NC)	-0.27	0.19	Normal
Environmental Sustainability (ES)	-0.28	0.22	Normal

To verify the distribution of the data, skewness and kurtosis values were examined for each latent construct: Food Waste Management (FWM), Campus Nature Clubs (NC), and Environmental Sustainability (ES).The results indicated that all constructs fell within the acceptable range for normality:Skewness values for all constructs ranged from –0.29 to –.27,indicating slight negative skewness. These values are well within the commonly accepted range of –1 to +1 (Hair et al., 2010), suggesting a reasonably symmetric distribution. Kurtosis values, which measure the "tailedness" of the distribution, ranged from 0.19 to 0.22, also well within the acceptable threshold of ±1, indicating a mesokurtic distribution, consistent with normality. Based on these results, the data for all three constructs can be considered normally distributed, satisfying the assumption of multivariate normality necessary for Structural Equation Modelling (SEM).

4.3 Convergent Validity

Construct	Average Factor Loading	AVE
FWM	0.732	0.544
NC	0.738	0.556
ES	0.738	0.564

Convergent Validity-Convergent validity was examined through Average Variance Extracted (AVE):FWM (0.544), NC (0.556), and ES (0.564) each had AVE values above the 0.50 benchmark (Fornell and Larcker, 1981), indicating that over 50% of the variance in items was captured by their respective constructs.All individual item loadings exceeded 0.70, suggesting strong indicator reliability and confirming the contribution of each item to its latent construct.

4.4 Convergent Validity

Construct	Average Factor Loading	AVE
FWM	0.732	0.544
NC	0.738	0.556
ES	0.738	0.564

Convergent validity assesses the degree to which multiple items that propose to measure the same construct are in agreement. In this study, convergent validity was evaluated through two key indicators: Average Factor Loadings and Average Variance Extracted (AVE).The Average Factor Loadings for all three constructs—Food Waste Management (FWM), Campus Nature Clubs (NC), and Environmental Sustainability (ES)—were 0.732, 0.738, and 0.738, respectively. These values are above the minimum recommended threshold of 0.70 (Hair et al., 2010), indicating that the indicators strongly represent their respective constructs. The AVE values for each construct were as follows: FWM: 0.544 - NC: 0.556-ES: 0.564.These values exceed the benchmark of 0.50 (Fornell and Larcker, 1981), indicating that more than 50% of the variance in the observed variables is explained by their latent construct, thus confirming acceptable convergent validity.

4.5 Construct Reliability and Validity

Construct	Cronbach's Alpha	Composite Reliability
FWM	0.867	0.904
NC	0.879	0.913
ES	0.884	0.918

Internal Consistency and Construct Reliability-All three constructs—Food Waste Management (FWM), Campus Nature Clubs (NC), and Environmental Sustainability (ES)—demonstrated high internal consistency: Cronbach's Alpha values ranged from 0.867 to 0.884, exceeding the threshold of 0.70 (Nunnally and Bernstein, 1994), confirming reliability. rho_A values were also robust, ranging from 0.875 (FWM) to 0.893 (ES), supporting internal construct reliability. Composite Reliability (CR) scores were all above the 0.70 threshold: FWM (0.904), NC (0.913), and ES (0.918), further reinforcing the consistency of the constructs.

4.6 Model fit Indices

Fit Index	Threshold	Model Value
Chi-square/df	< 3	2.04
GFI	> 0.90	0.92
CFI	> 0.90	0.95
TLI	> 0.90	0.93
RMSEA	< 0.08	0.06
SRMR	< 0.08	0.05

The model fit indices indicate that the structural equation model demonstrates a good fit to the data. The Chi-square/df value is 2.04, which is below the recommended threshold of 3, suggesting an acceptable fit. The Goodness of Fit Index (GFI) is 0.92, exceeding the minimum required value of 0.90, indicating a good level of model fit. Similarly, both the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI) are above 0.90, with values of 0.95 and 0.93 respectively, which further confirms the model's adequacy. The Root Mean Square Error of Approximation (RMSEA) is 0.06, which is below the acceptable threshold of 0.08, indicating a close fit of the model in the population. Lastly, the Standardized Root Mean Square Residual (SRMR) is 0.05, which is well within the acceptable range. Overall, these indices collectively suggest that the model fits the observed data well.

Hypothesis Testing Results

Hypothesis	Path	β (Beta Value)	p-value	Supported
H1	FWM → ES	0.65	0.001	Yes
H2	NC → ES	0.62	0.002	Yes
H3	FWM → NC → ES	0.44	0.003	Yes

The results of the hypothesis testing reveal significant and positive relationships among the variables studied.

H1: The direct path from Food Waste Management (FWM) to Sustainable Environment (ES) shows a strong positive relationship ($\beta = 0.65$, $p = 0.001$), indicating that effective food waste management initiatives significantly contribute to the development of a sustainable environment. This hypothesis is supported.

H2: The influence of Nature Club (NC) activities on Sustainable Environment (ES) is also found to be significant ($\beta = 0.62$, $p = 0.002$), suggesting that student-led environmental awareness and nature-focused programs play a critical role in promoting sustainability. This hypothesis is supported.

H3: The mediating role of Nature Club (NC) in the relationship between Food Waste Management (FWM) and Sustainable Environment (ES) is significant as well ($\beta = 0.44$, $p = 0.003$). This indicates that the involvement of nature clubs enhances the impact of food waste management on environmental sustainability, demonstrating a partial mediation effect. This hypothesis is supported.

V Implications and recommendation

The findings of this study carry significant implications for both theory and practice. Practically, the results highlight the necessity for higher educational institutions, especially in rural districts, to prioritize food waste management as a core component of their sustainability agendas. The strong positive relationship between food waste management and environmental sustainability suggests that structured institutional efforts in waste reduction can yield meaningful ecological outcomes. Moreover, the study establishes the mediating role of campus nature clubs as critical agents of behavioral transformation. These student-led platforms not only promote awareness but also serve as practical forums for implementing sustainable practices such as waste segregation, composting, and awareness campaigns. From a policy perspective, it is recommended that,the functions of nature clubs in higher education settings. Educationally, the findings encourage the integration of environmental practices into student activities and curricula to cultivate a sustainability mindset from the grassroots level. Theoretically, the research contributes to sustainability literature by validating a mediation model in which campus engagement significantly enhances the impact of environmental policies.

VI. Limitations and Future Research -However, the study is not without its limitations. First, its geographical scope is limited to a rural district in Kerala, which may affect the generalizability of the findings to other educational settings, particularly urban or international contexts. Second, although the sample size of 412 is statistically adequate, the use of judgment sampling may introduce bias and limit the representativeness of the data. Third, as a cross-sectional study, the research captures a snapshot in time and cannot measure long-term behavioral changes or sustainability outcomes.

Future Research-Future research should seek to address these limitations through longitudinal studies that track behavioral and institutional changes over time, particularly the lasting impact of nature club interventions. Comparative research between urban and rural institutions could also provide insights into contextual factors affecting the success of sustainability efforts. Further studies might also explore the integration of digital tools and gamification strategies to enhance student engagement in food waste reduction. Expanding the model to include institutional leadership support, parental involvement, or community partnerships would also provide a more comprehensive understanding of the dynamics at play in promoting environmental sustainability in higher education.

VII. Conclusion

In conclusion, this study affirms that food waste management significantly contributes to environmental sustainability, particularly when mediated by the active engagement of campus nature clubs. These findings are especially relevant for institutions serving first-generation learners in rural settings, where environmental awareness and structured engagement are often lacking. By highlighting the importance of both institutional policy and grassroots participation, this research presents a replicable model for sustainable practices in academic

environments. It reinforces the idea that meaningful change toward a sustainable future begins within the educational institutions that shape the values and habits of tomorrow's citizens.

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