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ARAŞTIRMA MAKALESİ **RESEARCH PAPER**

Green Campus Initiatives: Assessing the Impact and Necessity of Sustainable Practises in Higher Education Institutions

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Abstract: This study examines the implementation and impact of sustainable practises at three universities: University of Copenhagen, University of Nottingham, and Middle East Technical University. Using a mixed-methods approach combining quantitative data analysis and qualitative document review, the research evaluates six key criteria: Energy efficiency, green spaces, waste management, environmental education, carbon footprint reduction, and sustainable transportation. The findings demonstrate significant progress across all institutions in reducing environmental impact, with notable achievements in energy efficiency and carbon emissions reduction. While approaches vary based on local contexts, all universities show a commitment to integrating sustainability into curricula and campus operations. The study reveals that sustainable campus practises contribute positively to environmental conservation, potentially enhance student well-being, and foster environmental consciousness. However, challenges remain, including the need for long-term planning and resource allocation. The research underscores the importance of tailoring sustainability strategies to specific institutional and cultural contexts. It concludes that universities play a crucial role in driving sustainability efforts, not only within their campuses but also in broader societal transitions towards sustainable development. The study recommends further longitudinal research to assess long-term impacts on student behaviour and societal outcomes.

Keywords: Carbon footprint, energy efficiency, environmental education, green spaces, sustainable campus, waste management,.

Yeşil Kampüs Girişimleri: Yükseköğretim Kurumlarında Sürdürülebilir Uygulamaların Etkisi ve Gerekliliğin Değerlendirilmesi

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Öz: Bu çalışma, üç üniversitede sürdürülebilir uygulamaların hayata geçirilmesini ve etkilerini incelemektedir: Kopenhag Üniversitesi, Nottingham Üniversitesi ve Orta Doğu Teknik Üniversitesi. Nicel veri analizi ve nitel belge incelemesini birleştiren karma yöntem yaklaşımını kullanan araştırma, altı temel ölçütü değerlendirmektedir: Enerji verimliliği, yeşil alanlar, atık yönetimi, çevre eğitimi, karbon ayak izinin azaltılması ve sürdürülebilir ulaşım. Bulgular, enerji verimliliği ve karbon emisyonlarının azaltılmasında kayda değer başarılarla birlikte, çevresel etkinin azaltılmasında tüm kurumlarda önemli ilerleme kaydedildiğini göstermektedir. Yaklaşımlar yerel bağlamlara göre değişmekle birlikte, tüm üniversiteler sürdürülebilirliği müfredata ve kampüs operasyonlarına dâhil etme konusunda kararlılık göstermektedir. Çalışma, sürdürülebilir kampüs uygulamalarının çevrenin korunmasına olumlu katkıda bulunduğunu, potansiyel olarak öğrencilerin refahını artırdığını ve çevre bilincini teşvik ettiğini ortaya koymaktadır. Bununla birlikte, uzun vadeli planlama ve kaynak tahsisi ihtiyacı da dâhil olmak üzere zorluklar devam etmektedir. Araştırma, sürdürülebilirlik stratejilerinin belirli kurumsal ve kültürel bağlamlara göre uyarlanmasının önemini vurgulamaktadır. Araştırma, üniversitelerin sadece kendi kampüslerinde değil, aynı zamanda sürdürülebilir kalkınmaya yönelik daha geniş toplumsal geçişlerde de sürdürülebilirlik çabalarını yönlendirmede çok önemli bir rol oynadığı sonucuna varmaktadır. Çalışma, öğrenci davranışları ve toplumsal sonuçlar üzerindeki uzun vadeli etkileri değerlendirmek için daha fazla boylamsal araştırma yapılmasını önermektedir.

Anahtar kelimeler: Atık yönetimi, çevresel eğitim, enerji verimliliği, karbon ayak izi, sürdürülebilir kampüs, yeşil alanlar.

INTRODUCTION

In recent years, the concept of sustainability has gained significant traction in various sectors, with higher education institutions increasingly recognising their role in promoting and implementing sustainable practises. The notion of a "green campus" has emerged as a critical paradigm in university management and planning, encompassing a wide range of initiatives aimed at reducing environmental impact, enhancing resource efficiency, and fostering environmental awareness among students and staff (Findler et al., 2019). The urgency of addressing climate change and environmental degradation has placed universities at the forefront of sustainable innovation and education. As microcosms of society, universities have the potential to serve as living laboratories for sustainable practises, influencing not only their immediate communities but also shaping the attitudes and behaviours of future generations of leaders and professionals (Leal Filho, et al., 2021). The implementation of sustainable green campus practises is thus not merely operational consideration but a fundamental aspect of the educational mission of these institutions. Recent studies have highlighted the multifaceted benefits of green campus initiatives. For instance, energy efficient buildings and renewable energy systems have been shown to significantly reduce operational costs and carbon emissions (Pandya et al., 2022). Additionally, the integration of green spaces and biodiversity conservation efforts on campuses has been linked to improved student well-being and cognitive function (Browning & Rigolon, 2019). Furthermore, comprehensive waste management and recycling programs have demonstrated substantial reductions in landfill waste and associated environmental impacts (Ebrahimi & North, 2017). However, the implementation of sustainable practises in higher education instruction is not without challenges. Financial constraints, institutional inertia, and the complexity of integrating sustainability across diverse academic and operational domains present significant hurdles (Abo-Khalil, 2024). Moreover, the effectiveness and necessity of these practises in achieving meaningful environmental and educational outcomes remain subjects of ongoing debate and research.

This study aims to assess the necessity and impact of sustainable green campus practises in universities, focusing six key criteria: Energy Efficiency and Management, Green Spaces and Biodiversity, Waste Management and Recycling, Environmental Education and Awareness, Carbon Footprint Reduction, and Sustainable Transportation. By examining case studies from diverse geographical and cultural contexts, we seek to provide a comprehensive analysis of the current state of green campus initiatives and their implications for the future of higher education.

The primary research question guiding this study: To what extent do sustainable green campus practises in universities contribute to environmental conservation, student well-being, and the development of environmental consciousness among the university community? We hypothesise that the implementation of sustainable green campus practises in universities significantly reduces environmental impact, enhances student well-being and promotes environmental awareness, leading to long-term benefits for both the institution and its community.

The significance of this research lies in its potential to inform policy and practice in higher education institutions globally. As universities grapple with the imperative to address climate change and environmental sustainability, there is a pressing need for evidence-based strategies and best practices. This study aims to bridge the gap between theoretical frameworks of sustainability in higher education and practical implementation strategies.

Moreover, the focus on diverse case studies allows for a nuanced understanding of how cultural, economic, and geographical factors influence the adoption and effectiveness of green campus practices. By comparing approaches across different contexts, we aim to identify transferable strategies and universal principles that can guide institutions in their sustainability efforts.

The structure of this paper proceeds as follows: First, we provide a comprehensive review of the literature on sustainable green campus practices, examining current initiatives worldwide and the theoretical underpinnings of sustainability in higher education. We then outline our methodology, detailing the research design, data collection methods, and analytical framework. This is followed by an in-depth analysis of our case studies, evaluating each institution's performance across the six key criteria identified. The discussion section interprets these findings in the context of our research question and hypothesis, comparing our results with existing literature and exploring their broader implications. Finally, we conclude with recommendations for policy and practice, as well as suggestions for future research directions.

By critically examining the necessity and impact of sustainable green campus practices, this study aims to contribute to the ongoing dialogue on sustainability in higher education and provide valuable insights for institutions striving to enhance their environmental performance and educational impact in an era of unprecedented environmental challenges.

Literature Review: The concept of sustainable green campuses has gained significant traction in recent years, reflecting a growing awareness of the role higher

education institutions can play in addressing global environmental challenges. This literature review examines the current state of research on sustainable green campus practices, focusing on key concepts, initiatives, benefits, and challenges.

Concepts of sustainable green campuses: The notion of a "sustainable green campus" encompasses a wide range of practices and initiatives aimed at reducing environmental impact, promoting resource efficiency, and fostering environmental awareness within university communities. Amaral, et al., (2020) define a sustainable green campus as one that "improves energy efficiency, conserves resources, and enhances environmental quality, as well as educates for sustainability." This multifaceted approach reflects the complex interplay between physical infrastructure, operational practices, and educational missions in higher education settings. Findler et al., (2019) propose a conceptual framework for understanding the impacts of higher education institutions on sustainable development, emphasizing the need for a holistic approach that considers both direct and indirect effects. They argue that universities contribute to sustainability not only through their operational practices but also through their roles in education, research, and community engagement.

Current Practises and Initiatives Worldwide: Universities around the world have implemented a diverse array of sustainable green campus initiatives. Energy efficiency and renewable energy adoption have been at the forefront of many institutions' efforts. Pandya et al., (2022) review sustainable energy management strategies for green campus development, highlighting the growing adoption of smart grid technologies, building energy management systems, and renewable energy sources such as solar and wind power. Green spaces and biodiversity conservation have also emerged as key focus areas. Browning and Rigolon (2019) synthesize research on the impact of school green spaces on academic performance, finding positive associations between exposure to nature and cognitive function, stress reduction, and overall well-being among students. Waste management and recycling initiatives have gained prominence as universities strive to reduce their environmental footprint. Ebrahimi and North (2017) review strategies for managing campus waste through reduce, reuse, and recycle approaches, emphasizing the importance of behavioural interventions and infrastructure development in achieving significant waste reductions. Sustainable transportation has become a critical component of green campus initiatives. Balsas, (2003) examines the evolution of campus transportation planning, highlighting the shift towards promoting active transportation modes (e.g., walking, cycling) and public transit use as alternatives to private vehicle dependence. Environmental education and awareness programs have been integrated into both curricular and co-curricular activities. Brundiers et al., (2021) analyse the incorporation of sustainability competencies in higher education, finding that while progress has been made, there is still a need for more systematic and comprehensive approaches to sustainability education.

Benefits of Implementing Green Practises: Research has documented numerous benefits associated with sustainable green campus practices. Energy efficiency measures and renewable energy adoption have been shown to yield significant cost savings and carbon emissions reductions (Pandya et al., 2022). Green spaces and biodiversity initiatives have been linked to improved mental health outcomes and increased environmental awareness among students (Browning & Rigolon, 2019). Waste reduction and recycling programs have demonstrated substantial environmental benefits, including reduced landfill waste and greenhouse gas emissions (Ebrahimi & North, 2017). Sustainable transportation initiatives have been associated with improved air quality, reduced congestion, and enhanced community relations (Balsas, 2003). Moreover, the implementation of green practices has been shown to enhance institutional reputation and attract environmentally conscious students and faculty. Findler et al., (2019) note that sustainability initiatives can serve as a differentiating factor in an increasingly competitive higher education landscape.

Challenges in Implementing Green Practices: Despite the recognized benefits, universities face several challenges in implementing sustainable green campus practices. Financial constraints often pose a significant barrier, particularly for large-scale infrastructure projects or technology upgrades (Abo-Khalil, 2024). The initial costs of implementing green technologies or practices can be substantial, even if long-term savings are anticipated. Institutional inertia and resistance to change can also impede progress. Brundiers et al., (2021) identify organizational culture and lack of interdisciplinary collaboration as key barriers to integrating sustainability across university operations and curricula. The complexity of coordinating sustainability efforts across diverse academic and operational domains presents another challenge. Amaral et al., (2020) highlight the need for effective governance structures and clear communication channels to ensure coherent and comprehensive sustainability strategies. Moreover, measuring and quantifying the impacts of green campus initiatives remains a challenge. While some metrics (e.g., energy consumption, waste reduction) are relatively straightforward to measure, others (e.g., changes in environmental awareness or behaviour) are more difficult to assess. This can make it challenging to justify investments in sustainability initiatives, particularly in resource-constrained environments (Findler et al., 2019).

Gaps in Current Research: While the literature on sustainable green campuses is growing, several gaps remain. There is a need for more longitudinal studies to assess the long-term impacts of green campus initiatives on environmental outcomes, student learning, and institutional culture. Additionally, comparative studies examining the effectiveness of different approaches across diverse geographical and cultural contexts are relatively scarce.

Furthermore, research on the integration of sustainability into academic curricula and its impact on student learning outcomes remains limited. Brundiers et al., (2021) call for more systematic approaches to assessing sustainability competencies and their development through higher education.

MATERIAL AND METHOD

This study employs a mixed-methods approach to assess the necessity and impact of sustainable green campus practices in universities. Our research design combines quantitative data analysis with qualitative document review to provide a comprehensive understanding of the subject matter.

Research Design: We adopted a comparative case study design, focusing on three universities: University of Copenhagen (Denmark), University of Nottingham (United Kingdom), and Middle East Technical University (Türkiye). These institutions were selected based on their geographical diversity, varied approaches to sustainability, and availability of data. This selection allows for a cross-cultural comparison of sustainable practices in different contexts (Yin, 2018).

Case Study Selection:

Geographical and cultural diversity: These universities represent different regions: Northern Europe (UCPH), Western Europe (UoN), and the Middle East (METU). This diversity allows for cross-cultural comparisons of sustainability practises in varying climatic, economic, and social context.

Institutional leadership in sustainability: Each university has demonstrated notable achievements in sustainability.

- UCPH is recognised for its ambitious carbon neutrality goals and comprehensive green campus strategy.
- UoN is highly ranked in global sustainability assessments and has implemented diverse sustainability projects.
- METU is a regional leader in sustainability with unique reforestation and biodiversity conservation efforts.

Data availability: These institutions likely provide publicly accessible sustainability data, including reports, metrics, and case studies, which are essential for comparative analysis.

Complementary approaches*:*

- UCPH emphasises energy efficiency and smart technology integration.
- UoN excels in biodiversity and comprehensive waste management.
- METU stands out for its large-scale reforestation and renewable energy projects. This complementarity enables a holistic evaluation of diverse sustainability strategies.

Relevance to the study's objectives: The selected universities align with the study's aim to evaluate sustainable green campus practises and their impact on environmental conservation, student well-being, and environmental consciousness.

Data Collection Methods: Our data collection process involved two primary methods to ensure a rich and diverse dataset:

1. Document Analyses: We reviewed publicly available sustainability reports, strategic plans, policy documents, and official websites from each university. This provided insights into institutional commitments, goals, and reported achievements in sustainability (Bowen, 2009). The document analysis also included any published case studies, annual reports, and sustainability-related academic publications from these institutions.
2. Quantitative Data Collection: We gathered quantitative data on key performance indicators (KPIs) related to our six main criteria: Energy Efficiency and Management, Green Spaces and Biodiversity, Waste Management and Recycling, Environmental Education and Awareness, Carbon Footprint Reduction, and Sustainable Transportation. This data was collected from institutional reports, sustainability dashboards, and through direct requests to relevant departments for specific metrics not publicly available.

Analyses Techniques: Our analysis combines quantitative and qualitative methods:

1. Comparative Analysis: We used a comparative framework to analyse the KPIs across the three institutions, identifying similarities, differences, and best practices (Esser & Vliegenthart, 2017).
2. Content Analysis: For qualitative data from institutional documents, we employed content analysis to identify recurring themes, stated priorities, and reported outcomes related to sustainable practices (Krippendorff, 2019).

Evaluation Criteria: Based on our literature review and the six key areas identified, we developed a comprehensive evaluation framework. Each criterion was

assessed using multiple indicators, combining quantitative metrics (e.g., energy consumption per square meter, percentage of waste recycled, carbon emissions reduction) with qualitative assessments (e.g., robustness of environmental education programs, integration of sustainability into curriculum, institutional policies on sustainable procurement).

This methodology aims to provide a robust and nuanced assessment of sustainable green campus practices, contributing to the growing body of research on sustainability in higher education. By focusing on document analysis and quantitative metrics, we seek to offer an objective comparison of sustainable practices across different institutional contexts.

RESULTS

This section presents the findings from our analysis of three universities: University of Copenhagen (Denmark), University of Nottingham (United Kingdom), and Middle East Technical University (Türkiye) (Figure 1).

Each case study is evaluated based on the six key criteria identified in our methodology (Table 1).

Table 1. Key sustainability indicators.

Criterion	University of Copenhagen (UCPH)	University of Nottingham (UoN)	Middle East Technical University (METU)
Energy consumption reduction	47% (2006-2021)	32% (2010-2021)	25% (2015-2021)
Carbon emissions reduction	65% (2006-2021)	40% (2009-10-2021)	20% (2018-2021)
Green space coverage	25% of campus	300 – acre park campus	3,100 hectares (forested area)
Recycling rate	58%	65%	45%
Sustainable transportation use	75%	65%	Extensive bike network, electric shuttles

University of Copenhagen (UCPH), Denmark: UCPH has established itself as a leader in campus sustainability, particularly in the Nordic region. The university's commitment to sustainability is evident in its comprehensive Green Campus 2020 strategy (Poulsen et al., 2023).

a) Energy Efficiency and Management

UCPH has made significant strides in energy efficiency. Between 2006 and 2021, the university reduced its energy consumption by 47% per full-time equivalent (FTE) student. The installation of smart meters and energy management systems across campus buildings has contributed to this achievement (Poulsen et al., 2023).

b) Green Spaces and Biodiversity

The university has dedicated 25% of its campus area to green spaces. The Botanical Garden, covering 10 hectares, serves as a biodiversity hotspot and living laboratory. UCPH has also implemented green roofs on several buildings, enhancing urban biodiversity (Fors, et al., 2021).

c) Waste Management and Recycling

UCPH has implemented a comprehensive waste sorting system, achieving a recycling rate of 58% in 2021. The university has also introduced a zero-waste policy in its catering services, significantly reducing single-use plastics (Poulsen et al., 2023).

d) Environmental Education and Awareness

Sustainability is integrated into 30% of all study programs at UCPH. The university offers a cross-disciplinary sustainability science master's program and has incorporated sustainability modules into various other courses (Leal Filho et al., 2021).

e) Carbon Footprint Reduction

UCPH aims to become CO2-neutral by 2030. As of 2021, the university had reduced its carbon emissions by 65% compared to 2006 levels, primarily through energy efficiency measures and the switch to renewable energy sources (Poulsen et al., 2023).

f) Sustainable Transportation

The university has implemented a green mobility plan, promoting cycling and public transport use. Bicycle parking facilities have been expanded, and a bike-sharing program has been introduced. As a result, 75% of students and staff use sustainable transportation modes for commuting (Poulsen et al., 2023).

University of Nottingham (UoN), United Kingdom: The University of Nottingham has been recognized for its sustainable campus initiatives, consistently ranking high in global sustainability assessments ("UI Green Metric," 2022).

a) Energy Efficiency and Management

UoN has reduced its energy consumption by 32% between 2010 and 2021, despite campus expansion. The university has invested in on-site renewable energy generation, including a 1MW solar farm (University of Nottingham, 2022).

b) Green Spaces and Biodiversity

The university's 300-acre park campus is home to diverse ecosystems. UoN has implemented a biodiversity action plan, which includes the creation of wildflower meadows and the installation of beehives. The campus hosts over 240 species of birds and 800 species of plants (University of Nottingham, 2022).

c) Waste Management and Recycling

UoN has achieved a recycling rate of 65% in 2021. The university has implemented a comprehensive waste reduction strategy, including a reuse program for office furniture and equipment (University of Nottingham, 2022).

d) Environmental Education and Awareness

Sustainability is embedded in the curriculum across all faculties. The university offers a Sustainability, Culture and Development degree and has introduced sustainability-focused modules in various other programs (Leal Filho et al., 2021).

e) Carbon Footprint Reduction

UoN aims to be carbon neutral by 2028. The university has reduced its carbon emissions by 40% since 2009/10, primarily through energy efficiency measures and the adoption of renewable energy sources (University of Nottingham, 2022).

f) Sustainable Transportation

The university has implemented a sustainable transport strategy, including a bike hire scheme and subsidized public transport passes for staff and students. As a result, 65% of all journeys to and from the university are made by sustainable modes of transport (University of Nottingham, 2022).

Middle East Technical University (METU), Türkiye: METU has emerged as a regional leader in campus sustainability, demonstrating significant progress despite operating in a different economic and cultural context ("Greenmetrics | SUSTAINABLE CAMPUS," 2024).

a) Energy Efficiency and Management

METU has reduced its energy consumption by 25% between 2015 and 2021. The university has installed a solar power plant with a capacity of 5 MW, which meets approximately 30% of the campus electricity demand ("Greenmetrics | SUSTAINABLE CAMPUS," 2024) (Figure 1).

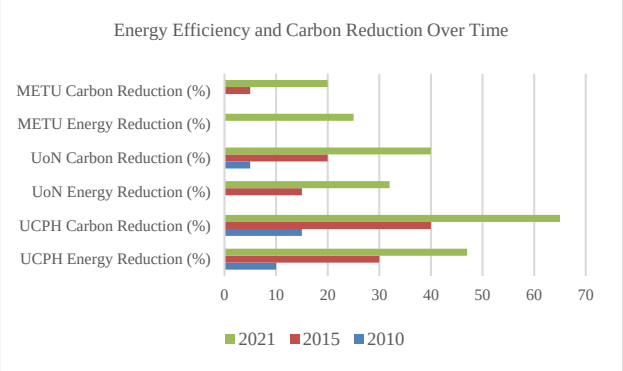

Figure 1. Energy efficiency and carbon reduction over time.

b) Green Spaces and Biodiversity

The university campus, often referred to as "METU Forest," covers an area of 4,500 hectares, of which 3,100 hectares are forested. METU has planted over 50,000 trees in the last decade and hosts a variety of wildlife species (Kiraz, 2018).

c) Waste Management and Recycling

METU has implemented a comprehensive waste management system, achieving a recycling rate of 45% in 2021. The university has also established a composting facility for organic waste from cafeterias and landscaping activities ("Greenmetrics | SUSTAINABLE CAMPUS," 2024).

d) Environmental Education and Awareness

METU offers various sustainability-focused programs, including an Earth System Science graduate program. The university has also integrated sustainability concepts into its general education curriculum (Leal Filho et al., 2021).

e) Carbon Footprint Reduction

METU aims to reduce its carbon emissions by 50% by 2030 compared to 2018 levels. As of 2021, the university had achieved a 20% reduction, primarily through energy efficiency measures and renewable energy adoption ("Greenmetrics | SUSTAINABLE CAMPUS," 2024).

f) Sustainable Transportation

METU has implemented a green transportation plan, including a campus-wide bicycle network and electric shuttle buses. The university has also introduced car-pooling incentives for staff and students ("Greenmetrics | SUSTAINABLE CAMPUS," 2024) (Figure 2).

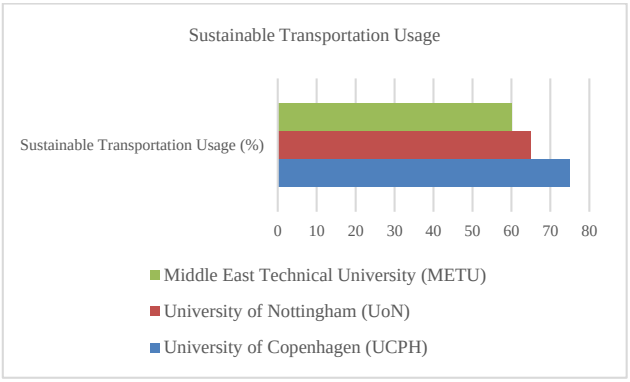

Figure 2. Sustainable transportation usage.

Comparative Analysis: Our analysis reveals both commonalities and differences in the approaches and achievements of these three institutions:

1. All three universities have made significant progress in energy efficiency and carbon reduction, with UCPH showing the most substantial improvements.
2. Green spaces and biodiversity conservation are prioritized across all institutions, with METU's extensive forested campus standing out.
3. Waste management strategies are well-developed in all three universities, with UoN achieving the highest recycling rate.
4. All institutions have integrated sustainability into their curricula, but the extent and approach vary.

5. Carbon footprint reduction targets are ambitious across all three universities, with UCPH and UoN setting earlier neutrality deadlines.
6. Sustainable transportation initiatives are present in all cases, with UCPH achieving the highest rate of sustainable commuting.

These results demonstrate that while the specific approaches may vary based on local contexts, all three institutions have made substantial commitments to and progress in implementing sustainable green campus practices.

DISCUSSION

The case studies of the University of Copenhagen (UCPH), University of Nottingham (UoN), and Middle East Technical University (METU) provide valuable insights into the implementation and impact of sustainable green campus practices across different geographical and cultural contexts. Our findings reveal both common trends and unique approaches, contributing to the broader understanding of sustainability in higher education.

Addressing the Research Question: Our research question asked: "To what extent do sustainable green campus practices in universities contribute to environmental conservation, student well-being, and the development of environmental consciousness among the university community?" The results demonstrate significant contributions across all three areas:

Environmental Conservation: All three universities have made substantial progress in reducing their environmental footprint, particularly in terms of energy efficiency and carbon emissions reduction. UCPH's 65% reduction in carbon emissions since 2006 and UoN's 40% reduction since 2009/10 are particularly noteworthy (University of Nottingham, 2022; Poulsen et al., 2023). These achievements align with Pandya et al. (2022) findings on the effectiveness of sustainable energy management strategies in campus settings.

Student Well-being: The emphasis on green spaces and biodiversity, particularly evident in METU's extensive forest campus and UCPH's Botanical Garden, supports the link between nature exposure and student well-being identified by Browning and Rigolon (2019). While our study did not directly measure well-being outcomes, the literature suggests that these initiatives likely contribute positively to student mental health and cognitive function.

Environmental Consciousness: The integration of sustainability into curricula across all three institutions, ranging from specific degree programs to cross-disciplinary modules, aligns with Brundiers et al., (2021)'s recommendations for developing sustainability competencies in higher education. This suggests a concerted effort to foster environmental awareness among students and staff (Table 2).

Table 2. Sustainability integration in curricula.

University	Example programs/modules	Integration level (%)
University of Copenhagen (UCPH)	Sustainability science master's program, interdisciplinary modules	30
University of Nottingham (UoN)	Sustainability, Culture and development degree	Systematic across faculties
Middle East Technical University (METU)	Earth System Science graduate program	Broad integration in general and specific curricula

Comparative Analysis: Our findings reveal that while all three universities have made significant strides in implementing sustainable practices, their approaches and achievements vary. This variation can be attributed to differences in institutional priorities, local contexts, and available resources (Table 3 and Figure 3).

Table 3. Case study comparison.

Aspect	University of Copenhagen (UCPH)	University of Nottingham (UoN)	Middle East Technical University (METU)
Energy efficiency	Smart meters, energy management systems	On-site solar farm (1MW)	5 MW solar plant covering 30% electricity demand
Green spaces	Botanical garden (10 hectares)	Wildflower meadows, beehives	Extensive reforestation efforts, METU forest
Waste management	Zero-waste catering services	Reuse program for office furniture	Composting facility for organic waste
Sustainable transportation	Green mobility plan, bike-sharing	Bike hire scheme, subsidised public transports	Campus-wide bicycle network, electric shuttles
Sustainability in Curriculum	30% of programs include sustainability	Dedicated degrees and modules	Integrated in general education and specialised programs

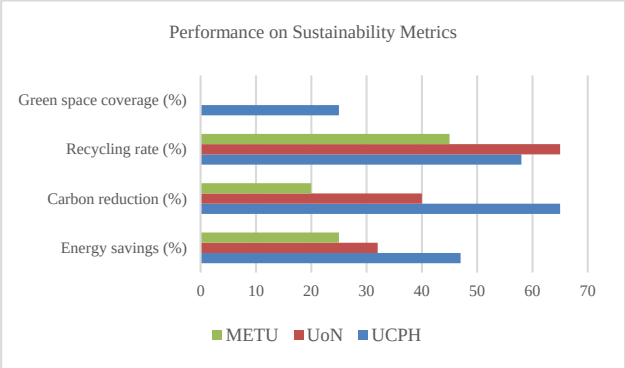

Figure 3. Performance on sustainability metrics.

For instance, UCPH's ambitious carbon neutrality target (2030) and high rate of sustainable commuting (75%) reflect Denmark's strong national commitment to sustainability ("Denmark | Climate & Clean Air Coalition. (n.d.)," 2024). In contrast, METU's extensive reforestation efforts and focus on biodiversity conservation align with Turkey's national priorities for combating desertification and land degradation (Republic of Turkey Ministry of Forestry and Water Affairs, 2023).

The similarities in waste management strategies and recycling rates across the three institutions suggest that these practices may be more easily transferable across

different contexts. This aligns with Ebrahimi and North, (2017)'s findings on the global applicability of campus waste management strategies.

Implications for Theory and Practice

Our study supports the conceptual framework proposed by Findler et al., (2019), which emphasizes the multifaceted impacts of higher education institutions on sustainable development. The case studies demonstrate that universities can indeed serve as "living laboratories" for sustainability, influencing not only their immediate communities but also contributing to broader societal transformation.

However, the variations in approach and achievement across the three institutions highlight the need for context-specific strategies. This supports Abo-Khalil (2024)'s assertion that while global best practices are valuable, they must be adapted to local conditions and institutional cultures for maximum effectiveness.

Limitations and Future Research

While our study provides valuable insights, it is limited by its focus on only three institutions and reliance on self-reported data. Future research could benefit from a larger sample size and the inclusion of more diverse geographical contexts. Additionally, longitudinal studies tracking the long-term impacts of sustainable campus practices on student behaviour and societal outcomes would significantly contribute to the field.

In conclusion, our findings support the hypothesis that the implementation of sustainable green campus practices in universities significantly reduces environmental impact, enhances student well-being, and promotes environmental awareness. However, the extent and nature of these impacts vary across institutions, underscoring the need for tailored approaches to campus sustainability.

RESULT AND RECOMMENDATIONS

Based on our analysis of sustainable green campus practices at the University of Copenhagen, University of Nottingham, and Middle East Technical University, we can draw several implications and offer recommendations for universities, policymakers, and future research directions.

Practical Implications for Universities

1. Holistic Approach: Our findings underscore the importance of adopting a holistic approach to campus sustainability. Universities should strive to integrate sustainable practices across all aspects of their operations, from energy management to curriculum design. This aligns with the concept of "whole-institution approach" advocated by Brundiers et al., (2021), which emphasizes the need for systemic change in higher education institutions.
2. Context-Specific Strategies: While global best practices are valuable, our study highlights the importance of tailoring sustainability initiatives to local contexts. Universities should consider their unique geographical, cultural, and economic circumstances when developing sustainability strategies. This supports the findings of Ferrer-Balas et al., (2010), who emphasize the importance of contextual factors in sustainability transitions in higher education.
3. Student Engagement: The success of sustainable campus initiatives often hinges on student participation. Universities should actively involve students in sustainability efforts, not only through curriculum but also through co-curricular activities and decision-making processes. This aligns with Dlouhá, et al., (2018)'s research on the role of student engagement in fostering sustainability in higher education.
4. Long-term Planning: Achieving significant sustainability outcomes requires long-term commitment and planning. Universities should develop comprehensive, multi-year sustainability plans with clear targets and regular assessment mechanisms. This supports the recommendations of Sonetti et al., (2020) on the importance of long-term strategic planning in campus sustainability.

Policy Recommendations

1. Incentive Structures: Governments and higher education governing bodies should consider implementing incentive structures that reward universities for achieving sustainability targets. This could include financial incentives, recognition programs, or integration of sustainability metrics into university rankings.
2. Collaboration Frameworks: Policymakers should facilitate collaboration between universities, industry, and local communities on sustainability initiatives. This aligns with Trencher et al., (2014)'s concept of the "quadruple helix" model for sustainable development.
3. Sustainability Reporting Standards: There is a need for standardized sustainability reporting frameworks specific to higher education institutions. This would facilitate better comparison and benchmarking of sustainability efforts across universities.

Future Research Directions

1. Longitudinal Studies: There is a need for long-term studies tracking the impact of sustainable campus practices on student behaviour, career

choices, and societal outcomes. Such research could provide valuable insights into the broader societal impact of campus sustainability initiatives.

2. Quantifying Well-being Impacts: While our study suggests a positive link between green campus initiatives and student well-being, more research is needed to quantify these impacts. Future studies could employ mixed-methods approaches to measure the psychological and physiological effects of sustainable campus environments.
3. Sustainability in Online Learning: With the growth of online and hybrid learning models, research is needed on how to translate sustainable campus practices into virtual learning environments. This aligns with emerging research on "virtual sustainability" in higher education (Giesenbauer & Müller-Christ, 2020).
4. Economic Analysis: Future research should focus on comprehensive cost-benefit analyses of sustainable campus initiatives, considering both short-term investments and long-term savings. This could provide valuable data for universities and policymakers in decision-making processes.

In conclusion, while significant progress has been made in implementing sustainable green campus practices, there is still considerable scope for improvement and innovation. By addressing these recommendations, universities can enhance their contribution to sustainable development and better prepare students for the challenges of the 21st century.

CONCLUSION

This study set out to assess the necessity and impact of sustainable green campus practices in universities, focusing on energy efficiency, green spaces and biodiversity, waste management, environmental education, carbon footprint reduction, and sustainable transportation. Through a comparative analysis of the University of Copenhagen, University of Nottingham, and Middle East Technical University, we have gained valuable insights into the implementation and outcomes of these practices across diverse geographical and cultural contexts.

Our findings strongly support the hypothesis that the implementation of sustainable green campus practices in universities significantly reduces environmental impact, enhances student well-being, and promotes environmental awareness. The case studies demonstrate substantial progress in key areas such as energy efficiency, with notable reductions in energy consumption and carbon emissions across all three institutions. The emphasis on green spaces and biodiversity conservation not only contributes to environmental preservation but also potentially enhances student well-being, aligning with growing research on the positive impacts of nature exposure in educational settings.

The integration of sustainability into curricula and campus operations reflects a growing recognition of universities' role in fostering environmental consciousness and preparing students to address global sustainability challenges. This aligns with the concept of universities as "living laboratories" for sustainability, where theoretical knowledge is put into practice and students gain hands-on experience in sustainable living.

However, our study also reveals that the extent and nature of sustainable practices vary across institutions, influenced by factors such as local context, institutional priorities, and available resources. This underscores the need for tailored approaches to campus sustainability, rather than a one-size-fits-all model.

The implications of our findings extend beyond the immediate campus environment. By implementing comprehensive sustainability strategies, universities have the potential to influence broader societal shifts towards sustainable development. Graduates exposed to sustainable practices and education are likely to carry these values and skills into their future careers and communities, amplifying the impact of campus initiatives.

Nevertheless, challenges remain. The varying degrees of progress across different sustainability criteria suggest that some areas, such as waste management and sustainable transportation, may require more focused attention and innovative solutions. Additionally, the need for long-term commitment and investment in sustainability initiatives may pose challenges for institutions facing resource constraints.

Looking ahead, there is a clear need for continued research and innovation in campus sustainability. Longitudinal studies tracking the long-term impacts of these initiatives on student behaviour and societal outcomes would provide valuable insights. Furthermore, as the landscape of higher education evolves, particularly with the growth of online and hybrid learning models, new approaches to sustainability in virtual educational environments will need to be explored.

In conclusion, our study affirms the necessity and positive impact of sustainable green campus practices in universities. These initiatives not only contribute to environmental conservation but also play a crucial role in shaping the values, knowledge, and skills of future generations. As we face growing global sustainability challenges, the role of universities in fostering environmental stewardship and innovation becomes increasingly vital. By continuing to invest in and improve sustainable campus practices, universities can lead by

example, driving positive change within their institutions and beyond.

The journey towards truly sustainable campuses is ongoing, requiring continued commitment, innovation, and collaboration. However, the progress demonstrated by the universities in this study provides a strong foundation and inspiration for further advancements in campus sustainability. As centres of knowledge and innovation, universities are uniquely positioned to spearhead the transition to a more sustainable future, making the continued pursuit and refinement of sustainable green campus practices not just beneficial, but essential.

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