

Exploring Sustainable Initiatives for Campus Operations at the University of Technology Sarawak

Nurzalikh Sa'adi^{1*}, Faisal Tamrulan^{1,2}, Nur Fasihah Ngah Seron^{1,2}, Maximus Balla Tang¹, Asmah Alia Mohamad Bohari^{1,3}

¹ Centre for Borneo Regionalism and Conservation (BORC), University of Technology Sarawak No. 1 Jalan Universiti, University of Technology Sarawak, 96000, Sibu, Sarawak, MALAYSIA

² School of Built Environment, University of Technology Sarawak

No. 1 Jalan Universiti, University of Technology Sarawak, 96000, Sibu, Sarawak, MALAYSIA

³ College of Built Environment, University Teknologi MARA Cawangan Sarawak

Jalan Meranek, 94300, Kota Samarahan, Sarawak, MALAYSIA

*Corresponding Author: nurzalikh@uts.edu.my

DOI: <https://doi.org/10.30880/ojtp.2025.10.03.005>

Article Info

Received: 27 January 2025

Accepted: 13 November 2025

Available online: 1 December 2025

Keywords

Higher education institutions, sustainable campus operation, sustainable initiatives

Abstract

Sustainable initiatives are crucial for addressing environmental challenges and promoting development. Sustainability is becoming a top priority for educational institutions worldwide, with the higher education sector constantly striving to incorporate environmentally friendly practices into its operations. However, more information about the current sustainable initiatives at the University of Technology Sarawak (UTS) is required. Hence, this research aims to investigate UTS's sustainability initiatives, focusing on campus operations. This research adopted a qualitative approach to investigate sustainable initiatives at the University of Technology Sarawak (UTS). Using a case study method, the study provided an in-depth analysis of sustainable practices across the campus's physical and built environments. Data were collected through campus site inventories from the Maintenance Facilities and Security Department, UTS, and site analyses, which documented and evaluated various operational aspects. The findings identified eight critical areas for achieving sustainable campus operations: buildings, air and climate, energy, food, grounds, transportation, waste management, and water sustainability. The sustainability initiatives implemented by UTS have successfully mitigated its adverse environmental effects and fostered a widespread culture of sustainability across the institution. These notable discoveries have generated a surge of interest from other higher education institutions, motivating them to contemplate and adopt equally extensive, campus-wide strategies that may significantly enhance their sustainability endeavors.

1. Introduction

Higher education institutions have been driven to embrace sustainable activities, considering the growing global awareness of environmental impacts. The ability of higher education institutions to serve as models of sustainability, both locally and globally, has become increasingly important. Serafini et al. (2022) highlight that higher education institutions consume substantial energy, water, and other resources, leading to significant resource usage and waste production. The increased focus on the environmental impact of higher education

institutions has highlighted the importance of placing sustainability measures at the forefront. The University of Technology Sarawak (UTS) has consciously integrated sustainable practices into its daily operations, recognizing the growing importance of sustainability. These methods involve recycling, conserving energy, and implementing other environmentally friendly actions, as Yong et al. (2021) documented. Despite the growing recognition of sustainability, several challenges impede the seamless implementation of environmentally conscious practices at higher education institutions like UTS. However, UTS must overcome these challenges and establish itself as a frontrunner in sustainability, aligning to reduce the environmental impact of university activities. The campus design must meet the Green Building Index's Platinum Certification standards. This demonstrates the exceptional ecological quality and energy efficiency of the constructed environment. This extensive investigation is particularly impressive for its well-rounded methodology, which integrates various aspects of sustainability into a cohesive plan. These extensive programs cover crucial sectors such as transportation, waste management, food systems, ecosystems, air and climate quality, and infrastructure. They prioritize a comprehensive and interconnected approach to studying sustainability activities. This approach aims to maximize the social, economic, and environmental benefits of sustainable practices on campus by thoroughly evaluating all aspects of sustainability. It aims to tackle all aspects of sustainability to bring about a substantial and impactful transformation. This research addresses the knowledge gap by examining the environmentally sustainable initiatives undertaken by the University of Technology Sarawak (UTS) to manage its campus operations effectively. Furthermore, the current sustainability practices pinpoint specific areas that could benefit from potential changes and offer practical solutions to enhance sustainability in all campus activities. The research has important implications, such as cost savings from efficient resource use, improved environmental resilience through sustainable measures, and increased awareness of campus sustainability.

2. Sustainable Initiative Concept

Sustainable initiatives are action plans that prioritize social justice, economic viability, and environmental stewardship for present and future generations. These initiatives aim to enhance the quality of life, minimize adverse environmental effects, and optimize the use of resources. Promoting sustainability involves various initiatives to reduce waste, improve energy efficiency, adopt eco-friendly materials, and embrace renewable energy sources (Geissdoerfer et al., 2017; Kumar et al., 2024). These include waste reduction programs that prioritize recycling, composting, and waste minimization; green building techniques that optimize energy efficiency and use sustainable materials; sustainable agriculture practices that enhance soil health and reduce chemical usage; and renewable energy technologies to diminish dependence on fossil fuels (Bocken & Short, 2021). Higher education institutions should implement sustainable practices to reduce their environmental impact and set standards for sustainability. Many institutions worldwide have followed the American College & University Presidents' Climate Commitment (ACUPCC) and the Talloires Declaration as comprehensive frameworks to guide their sustainability efforts. These frameworks aim to incorporate sustainability into the curriculum, campus operations, and community involvement. Universities and colleges play a crucial role in promoting sustainable development. Several higher education institutions have made notable strides in the past five years by implementing substantial sustainability practices. These strategies help to reduce the environmental impact while promoting sustainability in their research and teaching efforts.

Amaral et al. (2020) classified eight dimensions for sustainable campus operation initiatives: energy, buildings, waste, water, transportation, grounds, air quality, and food. This research discussed the operational aspects of sustainability initiatives using Amaral et al.'s 2020 model framework. The first key area is the energy domain, which focuses on renewable energy production, distribution, storage, and reduction in consumption. Renewable energy systems, combined heat and power (CHP) systems, district heating, energy storage systems, microgrids, cooling and heating systems, energy audits, intelligent meter displays, and energy management systems are all examples of variables. Second, the building's dimensions emphasize energy efficiency through active and passive design. Passive design, green building certification, efficient HVAC systems, thermal insulation, efficient lighting systems, external shading, efficient glazing, efficient appliances, green roofs, environmental management systems, and active system automation controls are all examples of variables. Integrated energy management systems use information and communication technologies to remotely control HVAC schedules, lighting, and appliances, while real-time smart meter displays monitor and reduce energy consumption (Shakir & Salem, 2024). Third, waste management entails treating organic waste, conducting waste audits, recycling, enacting sustainable purchasing policies, managing solid and hazardous waste, waste-to-energy initiatives, e-waste recycling, and recycling campaigns. Many universities practice composting, converting organic waste into fertilizer for campus green spaces, and promoting a circular economy by converting waste into energy (El-Halwagy, 2024). Fourth, water management encompasses rainwater harvesting, water use audits, wastewater treatment, water use strategies, efficient plumbing, waterless urinals, automated irrigation, and low-flow fixtures. Water bills can be significantly reduced through effective water management initiatives (Abo-Khalil, 2024). Fifth, transportation initiatives promote sustainable systems that reduce fossil fuel vehicles while encouraging

alternatives such as bicycles, bus services, car sharing, and electric vehicles. Variables include bicycle facilities, bus services, special public transportation conditions, parking reductions, flexible employment policies, carpooling, online meetings/courses, and transportation demand management. Sixth, the ground dimension emphasizes sustainable landscape management, campus activities, and the use of native plants to protect biodiversity and reduce irrigation water consumption. Green open spaces, native vegetation, solar streetlights, academic involvement in campus cleaning, and tree carbon sequestration are among the variables. Seventh, air and climate initiatives seek to reduce greenhouse gas and pollutant emissions, improve air quality, and address climate change. Climate resiliency action plans, indoor air quality (IAQ) monitoring, inventory of GHG emissions, and ecological footprint assessment are among the variables. Finally, the food dimension emphasizes sustainable systems that reduce industrial food production's environmental and social impacts by focusing on organic ingredients and local producers. The variables considered in this research encompass the integration of agriculture and aquaculture, meals with a limited shelf life, promoting organic alternatives, food donation, and sourcing food from local producers. Research on sustainable food supply explores various aspects, including economic affordability and nutritious food, food safety, fair profit distribution, vegetarian alternatives, and reducing food waste (Rad & Sonesson, 2024).

3. Sustainable in Higher Education Institutions (HEIs)

Given the growing awareness of environmental issues, many businesses, including higher education institutions, have embraced sustainable practices (Leal Filho et al., 2019). The importance of higher education institutions in promoting sustainability and driving sustainable development has been widely acknowledged (Zilahy et al., 2009). Furthermore, Anthony Jnr (2021) found that Malaysian higher education institutions have implemented the United Nations' 2013 'Greening University Toolkit' to advance sustainability initiatives. Recent academic research has highlighted the importance of comprehensively evaluating campuses' sustainability to understand their environmental impact. In addition, numerous methods have been proposed to assess and classify higher education institutions based on their global sustainability accomplishments. In their research, Beynaghi et al. (2016) presented three comprehensive models that illustrate the future of higher education institutions, with a specific emphasis on social, environmental, and economic considerations. The authors referred to this scenario as "Universities and Sustainable Development." Aleixo et al. (2018) assert that higher education institutions encompass various aspects and are responsible for teaching, conducting research, overseeing operations, and engaging with the community, economy, environment, and society. Rahat et al. (2023) suggested that integrating research programs and curricula in higher education institutions could positively impact the economy, culture, and environment in the long term. From an academic standpoint, institutions can be deemed green or sustainable when all these elements are environmentally sustainable.

The heightened emphasis on sustainability in campus operations reflects a broader social movement towards sustainability. Prior studies have extensively documented various strategies higher education institutions use worldwide to mitigate their environmental impact. For instance, research at the University of California, Davis, showcased the effectiveness of energy management strategies, including using renewable and energy-efficient technology, in achieving substantial reductions in greenhouse gas emissions (Celniker et al., 2021). Similarly, waste management initiatives, such as recycling and zero-waste strategies, have shown their effectiveness at campuses with high rates of diverting garbage, such as the University of British Columbia (Moore et al., 2021). Water conservation initiatives, such as those implemented at the University of Cape Town, which use drought-resistant landscaping and greywater systems, also provide substantial water savings (Rodina et al., 2024). A higher education institution's campus may be a central location for implementing diverse environmentally friendly activities inside and in partnership with the surrounding community. Universities use programs to interact with the community and contribute to sustainable endeavors by expanding their influence outside the campus (Zizka et al., 2021).

Nevertheless, the campus itself might serve as a center for environmental projects. It may promote social entrepreneurship by empowering students and faculty to cultivate ideas that provide a beneficial influence. In addition, institutions are taking action to provide sustainable food options that promote our well-being and the preservation of the environment (Rad & Sonesson, 2024). They also endorse projects such as the "bike hub" to encourage more bicycle use among students on campus (Hosseini, et al., 2024). When the goal is to enhance the sustainability of campuses, the focus is often on improving universities' physical structures and operations (Amaral et al., 2019). However, a clear theoretical framework has yet to guide Malaysia's sustainable initiatives. Some studies have investigated current methods and initiatives, such as creating green spaces, studying sustainability, and involving non-governmental organizations in campus events. Some examples are worth noting, such as Universiti Teknologi Malaysia's in-depth study on making offices more eco-friendly by using information systems to measure and evaluate sustainability initiatives (Zen et al., 2016).

Although international examples are helpful, tailored strategies are required due to differences in Malaysian campus climate, culture, and infrastructure. That is the gap in conducting localized research to convert

international best practices into actionable plans for UTS. Recent literature also demonstrates the importance of stakeholder engagement. According to Leal Filho et al. (2019), involving students, teachers, and staff in sustainability programs not only implements but also fosters a sustainable culture within the institution community. This holistic and integrated approach to sustainability, which incorporates systems thinking and stakeholder engagement, results in solutions that work individually and collectively to make the campus sustainable. Higher education institutions are launching sustainable initiatives ranging from waste reduction to energy management and water conservation projects. Sustainability research recognizes the need for collaborative efforts that involve the entire institution community in the path to sustainability. Higher education institutions can use advanced knowledge and innovative solutions to reduce their environmental footprint and promote a sustainable culture effectively. Despite recent advances in sustainable campus management, many issues still need to be solved, particularly in Malaysian educational institutions. By filling these gaps, the University of Technology Sarawak will be able to apply current knowledge and theoretical inputs to develop an overarching framework for sustainability that can be implemented efficiently and cooperatively.

4. Methodology

This research employed a qualitative approach to explore the operational aspects of sustainable initiatives implemented at the University of Technology Sarawak. The research process started with selecting a case study method focused on sustainable campus practices at UTS. This method was chosen as it allowed for a comprehensive analysis of the physical and built environment dimensions, offering detailed insights into how sustainable initiatives were implemented in UTS campus operations. The research instruments used to collect the data encompassed campus site inventories from the Maintenance Facilities and Security Department (MFSD), UTS, and site analyses around the campus. These instruments are needed to document and assess the existing sustainable initiatives at UTS. Campus site inventories were systematically recorded in numerous dimensions of campus operations, such as energy consumption, waste management, water usage, transportation, and the efficiency of buildings and infrastructure. Site analyses were conducted to assess the initiatives implemented and provide real-time insights into areas to be improved. Creswell & Poth (2018) claimed that this approach could provide in-depth, real-time insight into areas needing improvement and current practices without interfering with the studied environment. The operational parts of an institution are the most significant contributors to greenhouse gas emissions, as they consume substantial amounts of energy, water, materials, food, transportation, and waste management.

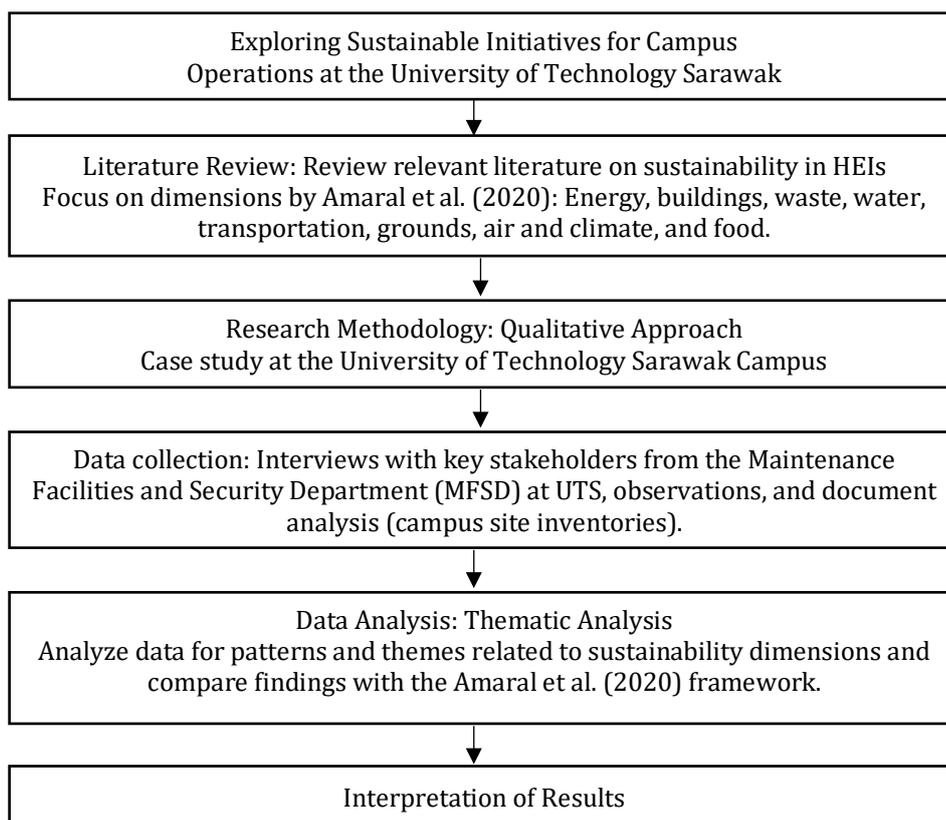


Fig. 1 Research process

Data analyses were evaluated using a structured framework proposed by Amaral et al. (2020). The site inventories and analysis data were grouped according to the sustainability dimension: energy, buildings, waste, water, transportation, grounds, air and climate, and food. Each dimension was examined to assess the initiatives implemented and pinpoint potential areas for improvement. The findings from this analysis were then synthesized to provide comprehensive data on the sustainable initiatives and practices at the UTS campus. Combining case study methods and rigorous data analysis offered valued insights into the effort of the UTS campus toward sustainability, underscoring strengths and areas for future enhancement. This research methodology effectively captured the commitment of higher education institutions towards sustainability, contributing to a more profound tolerance of how operational aspects could be improved for more significant environmental impact. The research process for this research is illustrated in Figure 1.

5. Results and Discussion

5.1 Data Collection

As shown in Table 1, the University of Technology Sarawak has implemented several sustainable initiatives to improve environmental performance on its campus. These initiatives cover many essential topics and demonstrate a comprehensive commitment to sustainability.

Table 1 Sustainable initiatives for campus operation at the University of Technology Sarawak

Sustainable Campus Operation Initiatives		
Key Area	Key Drivers	Status
Building/Infrastructure	Smart building facilities	/
	Renovation policy	X
	Environmental certification	/
	Efficient lighting system	/
	Efficient glazing area	/
	Efficient Heating, Ventilation, and Air Conditioning (HVAC) system	/
	External shading system	/
	Green roof	/
	Eco-home building/eco-campus	/
	Living labs	X
	Sustainable campus design	/
	Passive ventilation design	/
	Sustainable materials	/
	Air and Climate	CO2 emission reduction management
Climate resilience action plan		X
Monitoring of Indoor Air Quality (IAQ)		X
Greenhous Gas (GHG) emissions inventory		X
Carbon calculator		x
Energy	Renewable energy	/
	Energy efficient appliances	/
	Smart meter	/
	Combined heat and power system	X
	Air quality and temperature control	/
	Micro-grids	X
	Building retrofit	/
	Energy storage system	/
	Cooling system for ambient air	/
	Building automation system	/
	District heating	/

	Energy management systems/ scheme/procedure/policy	/
	Self-made biodiesel	X
	Billing management systems	X
	Electric Vehicle Charging Station	/
	Building Management System	/
	Efficient Passive Design	/
	Energy audit	/
Food	Organic/healthy foods	X
	Food bank	/
	Cheaper meals with short validity food	X
	Combined aquaculture and agriculture	X
	Green / Biodegradable packaging	/
	Food purchased from local producers	/
	Donation of unused food	/
	Reducing food packaging	/
	Sustainable food arcade	X
Ground/Geological/Ecosystem	Trees planting	/
	Ecosystem Services	/
	Landscape	/
	Green open spaces	/
	Solar streetlights	X
	Streetscape	/
	hardscape	/
	Vegetation	X
	Biodiversity	/
	Urban garden	X
Transportation	Cycling facilities	X
	Pedestrian infrastructure	/
	Institution's electric vehicles	X
	Car free day	X
	Transportation demand management	X
	Public transportation	X
	Car sharing / carpooling	/
	Bus service	/
	Eco-friendly transport policy	X
	Online courses and meetings	/
	Sustainable facilities/system	/
	Smart parking	/
	Restriction of motorcycle (avoid noise pollution)	X
Waste	Sewage disposal	/
	Upcycling innovation	X
	Recycling bins	/
	Online meeting (to avoid printing)	/
	Solid waste management/treatment	/
	Waste policy	/
	Treatment of hazardous waste	X
	Forbiddance of non-recyclable waste	X
	Sustainable purchasing policies	X
	Electronic waste management	X

	Waste audit	X
	Organic waste treatment	X
	Recycling operation/center	X
	Bio-recycling station (food and landscape waste)	X
	Waste to energy	X
	Compost pit	X
Water	Rainwater harvesting	/
	Waterless urinals	/
	Low flow fixtures	/
	Water control system	/
	Water management policy	X
	Water efficient appliances	/
	Lake and pond system	X
	Gray water recycling	/
	Tube well	X
	Water audit	/
	Efficient plumbing network	/
	Automated irrigation system	X
	Storm water management	/
	Efficient water management/treatment	/

The data collection on sustainable efforts at the University of Technology Sarawak demonstrates a concerted effort to improve sustainability across different campus areas. Significant progress is evident in building/infrastructure with brilliant building facilities, environmental certification, efficient lighting, HVAC systems, green roofs, and sustainable materials. However, improvements are needed in renovation policies and living labs. In the Air and Climate area, CO₂ emission reduction management is implemented. Still, a climate resilience action plan, detailed indoor air quality monitoring, a greenhouse gas emissions inventory, and a carbon calculator are needed. Energy programs focus on renewable energy, energy-efficient appliances, smart meters, and energy management systems. However, combined heat and power systems, microgrids, self-produced biodiesel, and billing management systems are potential areas for future innovation. The Food category shows successes with food banks, biodegradable packaging, and local purchasing but needs more organic foods, cheaper meals, aquaculture-agriculture integration, and a sustainable food arcade. In the ground/geological/ecosystem sector, tree planting, ecosystem services, and biodiversity programs are vital, but more solar lighting, urban gardens, and vegetation are needed. Transportation projects include pedestrian infrastructure, carpooling, and bus services, but cycling facilities, institutional electric vehicles, car-free days, and public transportation improvements are necessary. Waste management includes sewage disposal, recycling bins, and waste-reduction strategies, yet it needs to improve upcycling innovation, hazardous waste treatment, electronic waste management, and waste-to-energy projects. Water management has rainwater harvesting, waterless urinals, low-flow fixtures, stormwater management, and efficient plumbing but needs a complete water management policy, greywater recycling, automated irrigation, and water audits. While the university is firmly committed to sustainability with numerous initiatives, significant room for improvement remains across all key areas.

5.2 Result Discussion



Fig. 2 Green roof on top of the parking area

Figure 2 shows the green roofs, exterior shading, and efficient HVAC systems underscore UTS's commitment to sustainable campus architecture. Research highlights that incorporating these technologies enhances building performance and reduces campus facilities' overall environmental footprint (De Oliveira Santos et al., 2024).



Fig. 3 Double-glazed wall and UTS smart home

The sustainable practices implemented at the University of Technology Sarawak (UTS) in building and infrastructure, such as intelligent building facilities, environmental certification, and efficient lighting systems, reflect a significant commitment to energy conservation and enhanced building performance as shown in figure 3. The achievement of a GBI Platinum ecological certification and the development of the UTS Smart Home are notable milestones in their eco-campus initiative (Abdul Rahman et al., 2022). Research supports that such comprehensive approaches in building design and technology integration are essential for advancing sustainability goals (Kee et al., 2022). Integrating advanced technologies and sustainable materials in the UTS Smart Home exemplifies effective energy efficiency and resource management. Studies emphasize that smart home technologies, such as those used in UTS Smart Home, significantly reduce energy consumption and improve environmental sustainability (Shakir & Salem, 2024). These technologies help manage resources efficiently and provide a comfortable living environment, aligning with global sustainability objectives. Despite these advancements, gaps in living labs and refurbishment strategies suggest areas for further improvement.



Fig. 4 Garden space and tree planting

The University of Technology Sarawak (UTS) has made notable strides in CO₂ emission reduction through carbon offsetting and sequestration strategies. Tree planting campaigns involving students, staff, and the community significantly reduce the campus's carbon footprint by absorbing CO₂ and enhancing green spaces (Clabeaux et al., 2020). Figure 4 shows the installation of vertical gardens and green roofs further supports CO₂ sequestration and improves campus aesthetics (De Oliveira Santos et al., 2024). These initiatives are consistent with practical strategies for integrating green infrastructure into urban environments to combat climate change and enhance sustainability (Rahat et al., 2023). However, despite these efforts, gaps exist, including the need for a carbon calculator, indoor air quality (IAQ) monitoring, a greenhouse gas (GHG) emissions inventory, and a climate resilience action plan. Literature suggests that comprehensive monitoring and management tools are essential for effectively managing CO₂ emissions and enhancing climate resilience in institutional settings (Clabeaux et al., 2020). Implementing these tools will enable UTS to control air quality better and develop robust strategies for climate adaptation.



Fig. 5 Electric car charging station and tilting the building facade



Fig. 6 Solar panels have been installed on the roof of the maintenance building and near the UTS smart home

Figure 5 shows UTS’s energy management initiatives, including adopting renewable energy, energy-efficient appliances, smart meters, and energy management systems, aligning with broader sustainability practices in higher education institutions. Moreover, Figure 6 shows the installation of solar panels and the inclusion of energy-efficient designs like tilting building facades and electric vehicle charging stations demonstrate UTS's commitment to reducing its carbon footprint. According to Kaan et al. (2024), integrating renewable energy sources, such as solar power, significantly reduces greenhouse gas emissions and promotes sustainability. Tiagarajan & Go (2024) highlight the benefits of energy-efficient building designs and intelligent energy management systems in optimizing campus energy use. However, the absence of self-produced biodiesel, microgrids, and combined heat and power systems at UTS indicates opportunities for further innovation. Research by Terada et al. (2024) suggests that integrating decentralized energy systems, such as microgrids, can enhance energy resilience and sustainability, particularly in institutional settings. Exploring these technologies could allow UTS to advance its energy infrastructure, improving overall efficiency and reducing environmental impact.

UTS's initiatives in food sustainability, such as establishing a food bank, adopting green packaging, and sourcing food from local producers, align with current practices aimed at reducing environmental impact and promoting sustainability. These actions are consistent with findings by Willett et al. (2019), who emphasize the significance of sustainable food systems in reducing environmental footprints and enhancing the well-being of campus communities. Despite these efforts, UTS has room for improvement in areas like offering organic or healthy foods, providing affordable meals from short-validity food, and integrating combined aquaculture and agriculture systems. Research by Rad & Sonesson (2024) highlights the potential of these strategies to enhance food sustainability further, suggesting that UTS could significantly benefit from exploring these avenues to bolster its commitment to sustainability and health. These gaps highlight opportunities for UTS to expand its food sustainability efforts, further aligning with the broader goal of creating a healthier, more sustainable campus environment.

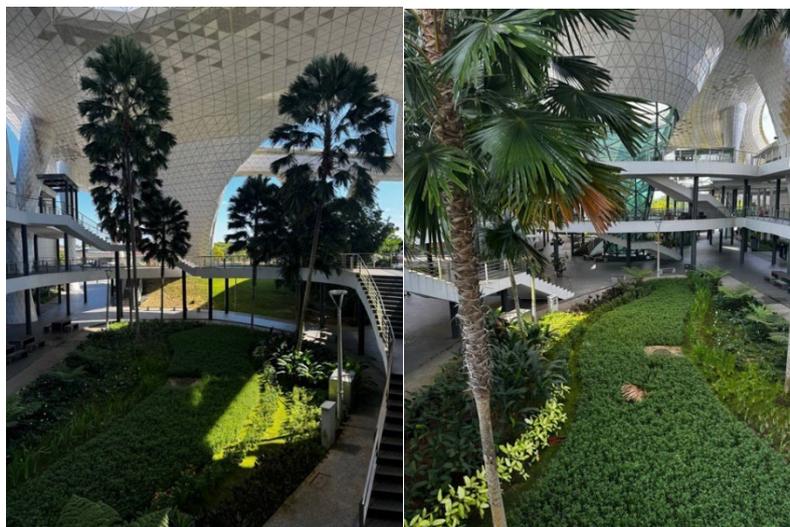


Fig. 7 Green open space

UTS's ground, geological, and ecosystem sustainability efforts, such as tree planting, ecosystem services, landscape design, green open spaces (refer to figure 7), and biodiversity conservation, reflect well-established practices in enhancing environmental quality. Research supports these initiatives, highlighting their ecological balance and benefits for community well-being. According to De Oliveira Santos et al. (2024), green open spaces and biodiversity conservation contribute significantly to urban ecosystems by improving air quality and providing habitat for wildlife. However, the absence of solar streetlights and urban gardens indicates potential areas for further enhancement. Solar streetlights can reduce energy consumption and improve safety, while integrating urban gardens can promote local food production and further biodiversity. Buechler & Martínez-Molina (2021) emphasize that urban gardens and renewable energy installations, such as solar streetlights, enhance the sustainability of campus environments by supporting ecological functions and reducing reliance on non-renewable resources. These elements could further bolster UTS's commitment to green infrastructure and sustainability.



Fig. 8 Pedestrian infrastructure and the institution's bus

Figure 8 shows UTS's initiatives in transportation sustainability, such as pedestrian infrastructure, buses, smart parking, and car-sharing systems, aligning with practical strategies for reducing transportation-related emissions and promoting sustainable commuting. According to Hancock & Nuttman (2013), integrating various transportation modes and innovative systems contributes to reducing carbon footprints and enhancing the sustainability of campus transport systems. However, the absence of cycling facilities, institutional electric vehicles, car-free days, and comprehensive eco-friendly transport policies indicates areas for improvement. Research highlights the benefits of developing comprehensive transportation policies that include cycling infrastructure and electric vehicle integration. Atherton & Giurco (2011) emphasize that multi-modal transportation systems, including cycling and electric vehicles, are crucial for reducing greenhouse gas emissions and promoting low-carbon commuting. Incorporating these elements could further advance UTS's transportation sustainability efforts and align with best practices in educational institutions.



Fig. 9 Recycle bins

Moreover, figure 9 shows UTS's progress in waste management, including sewage disposal, recycling bins, solid waste management, and electronic waste management, demonstrates a strong commitment to reducing environmental impact. These practices are supported by research highlighting the effectiveness of comprehensive waste management strategies in educational settings. Sa'adi et al. (2016) emphasize that effective waste management, including recycling and electronic waste management, is essential for minimizing environmental footprints. However, gaps in upcycling innovation, hazardous waste treatment, and the prohibition of non-recyclable waste suggest areas for enhancement. Donato et al. (2024) highlight that upcycling and properly treating dangerous waste is crucial for advancing waste management practices and reducing environmental impact. These strategies could further strengthen UTS's waste management efforts, aligning with best practices for sustainability in higher education.



Fig. 10 Rainwater harvesting

UTS's initiatives in water conservation, including rainwater harvesting, waterless urinals, low-flow fixtures, stormwater management, and efficient plumbing networks, reflect well-regarded practices in sustainable water management (refer figure 10). Research supports these measures, indicating their effectiveness in reducing water consumption and managing resources more efficiently. Almeida et al. (2023) highlight that integrating techniques such as rainwater harvesting and low-flow fixtures contributes significantly to water conservation in institutional settings. However, the absence of advanced water conservation techniques, such as automated irrigation systems, tube wells, and lake and pond systems, suggests further opportunities for improvement. Sa'adi & Ismail (2015) emphasize that comprehensive water management strategies, including automated systems and diverse water sources, are crucial for enhancing water conservation efforts. Addressing these gaps can improve UTS's sustainability performance and be a robust model for other educational institutions.

Table 2 Overall result implementation of sustainable initiatives for campus operation at the University of Technology Sarawak

Key Area	Total Key Drivers	Implementation of Key Drivers	Result
Building/Infrastructure	13	11	85%
Air and Climate	5	1	20%
Energy	18	14	78%
Food	9	5	56%
Ground/Geological/ Ecosystem	10	7	70%
Transportation	13	6	46%
Waste	16	5	31%
Water	14	10	71%

The results in Table 2 reveal varying levels of effectiveness in implementing sustainable initiatives across different areas at the University of Technology Sarawak (UTS). The high implementation rate in Building/Infrastructure (85% effectiveness) and Energy (78% effectiveness) aligns with research showing that

comprehensive infrastructure and energy management strategies are crucial for achieving sustainability goals (Tian et al., 2022). Effective building designs and energy-efficient systems have been well-documented as critical drivers of sustainability in campus environments (González & Rodríguez, 2020). In contrast, the low implementation and effectiveness in air and climate (20%) and waste management (31%) suggest significant areas for improvement. Studies emphasize that addressing air quality and climate impacts requires robust strategies and interventions (Edo et al., 2024), while waste management improvements, such as increased recycling and waste reduction practices, are essential for enhancing campus sustainability (Hoornweg & Bhada-Tata, 2012). The moderate success in food sustainability (56%) and ground/geological/ecosystem (70%) indicate progress but also highlight opportunities for further development. Research supports the importance of advancing sustainable food practices and ecosystem management to reduce environmental impacts and promote ecological health (Rad & Sonesson, 2024). The transportation area (46%) also shows potential for improvement. Practical transportation sustainability requires integrated policies and infrastructure, including cycling facilities and electric vehicle support (Creutzig et al., 2015). Overall, UTS's sustainability performance demonstrates substantial progress in some areas but underscores the need for focused efforts in low-performing sectors. Enhancing air and climate, transportation, and waste management initiatives will be crucial for achieving a more comprehensive sustainability strategy.

Conclusion

Ultimately, the University of Technology Sarawak (UTS) has successfully implemented diverse, sustainable measures across its campus operations, demonstrating a profound commitment to environmental stewardship. UTS has implemented a comprehensive strategy to enhance sustainability, including many solutions in construction and infrastructure development, transportation, waste management, water conservation, food sustainability, air and climate management, energy efficiency, and ground and ecosystem conservation. The institution is actively attempting to reduce its carbon footprint and create a more environmentally friendly campus by integrating intelligent technologies, eco-friendly infrastructure, renewable energy systems, and waste reduction strategies. Although remarkable efforts have been made, areas still provide potential for advancement. These areas include the planning of climate resilience, the implementation of comprehensive air quality monitoring, the promotion of increased energy innovation, and the establishment of sustainable food production. By focusing on these areas, UTS will maintain its status as a pioneer in ecologically sustainable campus operations and serve as an exemplary example for other educational institutions aiming to enhance their resilience. By engaging in these initiatives, the institution is reducing its environmental impact and establishing a model for sustainability in higher education, cultivating an ecologically aware mindset among staff, students, and campus community members.

Acknowledgement

The researchers sincerely thank the University of Technology Sarawak (UTS) for their financial assistance under the UTS Research Grant (URG), reference UTS/RESEARCH/2/2024/01.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

*The authors confirm their contribution to the paper as follows: **Literature review:** Nurzalikha Sa'adi, Maximus Balla Tang; **data collection:** Nurzalikha Sa'adi, Faisal Tamrulan, Nur Fasihah Ngah Seron; **analysis and interpretation of results:** Nurzalikha Sa'adi, Faisal Tamrulan, Nur Fasihah Ngah Seron; **draft manuscript preparation:** Nurzalikha Sa'adi, Asmah Alia Mohamad Bohari. All authors reviewed the results and approved the final version of the manuscript.*

References

- Abdul Rahman, H.F., Abdul Gapor, S., Kim, K.K. & Yaacob, A.R. (2022). UTS Smart Home, 53, UTS Publisher
- Abo-Khalil, A. G. (2024). Integrating sustainability into higher education challenges and opportunities for universities worldwide. *Heliyon*, 10(9), e29946. <https://doi.org/10.1016/j.heliyon.2024.e29946>
- Aleixo, A.M., Azeiteiro, U. & Leal, S. (2018). The implementation of sustainability practices in Portuguese higher education institutions. *International Journal of Sustainability in Higher Education*, 19, 1, pp. 146-178. <https://doi.org/10.1108/IJSHE-02-2017-0016>

- Almeida, A. P., Liberalesso, T., Silva, C. M., & Sousa, V. (2023). Combining green roofs and rainwater harvesting systems in university buildings under different climate conditions. *Science of The Total Environment*, 887, 163719. <https://doi.org/10.1016/j.scitotenv.2023.163719>
- Amaral, A. R., Rodrigues, E., Gaspar, A. R., & Gomes, Á. (2020). A review of empirical data of sustainability initiatives in university campus operations. *Journal of Cleaner Production*, 250. <https://doi.org/10.1016/j.jclepro.2019.119558>
- Amaral, L.P., Martins, N. & Gouveia, J.B. (2015). Quest for a sustainable university: a review. *International Journal of Sustainability in Higher Education*, 16, 2, pp. 155-172. <https://doi.org/10.1108/IJSHE-02-2013-0017>
- Anthony Jnr, B. (2021). Green campus paradigms for sustainability attainment in higher education institutions – a comparative study. *Journal of Science and Technology Policy Management*, 12, 1, pp. 117-148. <https://doi.org/10.1108/JSTPM-02-2019-0008>
- Atherton, A. and Giurco, D. (2011). Campus sustainability: climate change, transport and paper reduction. *International Journal of Sustainability in Higher Education*, 12, 3, pp. 269-279. <https://doi.org/10.1108/14676371111148054>
- Beynaghi, A., Trencher, G., Moztarzadeh, F., Mozafari, M., Maknoon, R. & Leal Filho, W. (2016). Future sustainability scenarios for universities: Moving beyond the United Nations Decade of Education for Sustainable Development. *Journal of Cleaner Production*, pp. 112, 3464-3478. <https://doi.org/10.1016/j.jclepro.2015.10.117>
- Bocken, N. M. P. & Short, S. W., (2021). Towards a sufficiency-driven business model: Experiences and opportunities. *Environmental Innovation and Societal Transitions*, 31, 1-16. <https://doi.org/10.1016/j.eist.2015.07.010>
- Buechler, S., & Martínez-Molina, K. G. (2021). Energy justice, renewable energy, and the rural-urban divide: Insights from the Southwest U.S. *Energy and Climate Change*, 2, 100048. <https://doi.org/10.1016/j.egycc.2021.100048>
- Celniker, C., Chen, S., Meier, A., & Levinson, R. (2021). Targeting buildings for energy-saving cool-wall retrofits: A case study at the University of California, Davis. *Energy and Buildings*, 249, 111014. <https://doi.org/10.1016/j.enbuild.2021.111014>
- Clabeaux, R., Carbajales-Dale, M., Ladner, D., & Walker, T. (2020). Assessing the carbon footprint of a university campus using a life cycle assessment approach. *Journal of Cleaner Production*, 273, 122600. <https://doi.org/10.1016/j.jclepro.2020.122600>
- Creswell, J. W., Poth, C.N., (2018). *Qualitative inquiry and research design: Choosing among five approaches*. SAGE Publications.
- De Oliveira Santos, T. D., Pacheco, F. A. L., & Fernandes, L. F. S. (2024). A systematic analysis on the efficiency and sustainability of green facades and roofs. *Science of The Total Environment*, 932, 173107. <https://doi.org/10.1016/j.scitotenv.2024.173107>
- Donato, C., Grappi, S., & Romani, S. (2024). Transforming waste into wellness: Enhancing well-being through domestic food upcycling. *Resources, Conservation and Recycling*, 209, 107770. <https://doi.org/10.1016/j.resconrec.2024.107770>
- Edo, G. I., Itoje-akpokiniovo, L. O., Obasohan, P., Ikpekor, V. O., Samuel, P. O., Jikah, A. N., Nosu, L. C., Ekokotu, H. A., Ugbune, U., Oghrora, E. E. A., Emakpor, O. L., Ainyanbhor, I. E., Mohammed, W. A. S., Akpogheli, P. O., Owhero, J. O., & Agbo, J. J. (2024). Impact of environmental pollution from human activities on water, air quality and climate change. *Ecological Frontiers*. <https://doi.org/10.1016/j.ecofro.2024.02.014>
- El-Halwagy, E. (2024). Towards waste management in higher education institute: The case of architecture department (CIC-New Cairo). *Results in Engineering*, 23, 102672. <https://doi.org/10.1016/j.rineng.2024.102672>
- Geissdoerfer, M., Savaget, P., Bocken, N. M. P., Hultink, E.J., (2017). The circular economy – A new sustainability paradigm? *Journal of Cleaner Production*, pp 143, 757-768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- Hancock, L., & Nuttman, S. (2013). Engaging higher education institutions in the challenge of sustainability: Sustainable transport as a catalyst for action. *Journal of Cleaner Production*, 62, 62-71. <https://doi.org/10.1016/j.jclepro.2013.07.062>

- Hosseini, K., Pramod Choudhari, T., Stefaniec, A., O'Mahony, M., & Caulfield, B. (2024). E-bike to the future: Scalability, emission-saving, and eco-efficiency assessment of shared electric mobility hubs. *Transportation Research Part D: Transport and Environment*, 133, 104275. <https://doi.org/10.1016/j.trd.2024.104275>
- Kaan, M., Bozkurt, A., Genç, M. S., & Genç, G. (2024). Optimization study of an energy storage system supplied solar and wind energy sources for green campus. *Process Safety and Environmental Protection*, 190, 863-872. <https://doi.org/10.1016/j.psep.2024.07.066>
- Kee, K., Ting, H., Lim, Y., Ting, J., Peter, M., Ibrahim, K., & Show, P. L. (2022). Feasibility of UTS Smart Home to Support Sustainable Development Goals of United Nations (UN SDGs). *Water and Energy Conservation Sustainability*, 14(19), 12242. <https://doi.org/10.3390/su141912242>
- Kumar, P., Sharma, L., Sharma, N.C., (2024). Sustainable development balancing economic viability, environmental protection, and social equity. In B. Paul & S. Poddar (Eds.), *Sustainable Partnership and Investment Strategies for Startups and SMEs* (pp. 212–234). IGI Global. <https://doi.org/10.4018/979-8-3693-2197-3.ch012>
- Leal Filho, W., Vargas, V.R., Salvia, A.L., Brandli, L.L., Pallant, E., Klavins, M., Ray, S., Moggi, S., Maruna, M., Conticelli, E., Ayanore, M.A., Radovic, V., Gupta, B., Sen, S., Paço, A., Michalopoulou, E., Saikim, F.H., Koh, H.L., Frankenberger, F. & Vaccari, M. (2019). The role of higher education institutions in sustainability initiatives at the local level. *Journal of Cleaner Production*, 233, 1004–1015. <https://doi.org/10.1016/j.jclepro.2019.06.059>
- Rad, M., & Sonesson, U. (2024). Drivers of a more sustainable future food system – Lessons from Sweden. *Journal of Cleaner Production*, 462, 142639. <https://doi.org/10.1016/j.jclepro.2024.142639>
- Rahat, R., Pradhananga, P. & ElZomor, M. (2023). A step toward nurturing infrastructure sustainability and rating systems through construction management curricula. *International Journal of Sustainability in Higher Education*, 24, 8, pp. 1877-1896. <https://doi.org/10.1108/IJSHE-09-2022-0296>
- Rodina, L., Harris, L., Ziervogel, G., & Wilson, J. (2024). Resilience counter-currents: Water infrastructures, informality, and inequities in Cape Town, South Africa. *World Development*, 180, 106619. <https://doi.org/10.1016/j.worlddev.2024.106619>
- Sa'adi, N., & Ismail, Z. (2015). Government Initiatives Pertaining to Construction Waste Minimization in Malaysia. *International Journal of Energy and Environment*, 9 (2015), 165-170.
- Sa'adi, N., Ismail, Z., & Alias, Z. (2016). A review of construction waste management and initiatives in Malaysia. *Journal of Sustainability Science and Management*, 11, 2: 101-114.
- Serafini, P. G., Moura, J. M. de, Almeida, M. R. de, & Rezende, J. F. D. de. (2022). Sustainable Development Goals in Higher Education Institutions: A systematic literature review. *Journal of Cleaner Production*, 370. <https://doi.org/10.1016/j.jclepro.2022.133473>
- Shakir, H., & Salem, F. (2024). Energy management enhancement of a smart home supplied by renewable energy system. *Indonesian Journal of Electrical Engineering and Computer Science*, 35(1), 20-31. <http://doi.org/10.11591/ijeecs.v35.i1.pp20-31>
- Terada, L. Z., Cortez, J. C., Chagas, G. S., López, J. C., & Rider, M. J. (2024). Towards sustainable energy systems: Multi-objective microgrid sizing for environmental and economic optimization. *Electric Power Systems Research*, 235, 110731. <https://doi.org/10.1016/j.epsr.2024.110731>
- Tiagarajan, T., & Go, Y. I. (2024). Integration of BIPV design and energy efficient technologies for low energy building in meeting net zero target. *E-Prime - Advances in Electrical Engineering, Electronics and Energy*, 8, 100554. <https://doi.org/10.1016/j.prime.2024.100554>
- Tian, X., Zhou, Y., Morris, B., & You, F. (2022). Sustainable design of Cornell University campus energy systems toward climate neutrality and 100% renewables. *Renewable and Sustainable Energy Reviews*, 161, 112383. <https://doi.org/10.1016/j.rser.2022.112383>
- Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., & others. (2019). Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, 393(10170), 447-492. [https://doi.org/10.1016/S0140-6736\(18\)31788-4](https://doi.org/10.1016/S0140-6736(18)31788-4)
- Yong, N.H., Kwong, Q.J., Ong, K.S. & Mumovic, D. (2021). Post occupancy evaluation of thermal comfort and indoor air quality of office spaces in a tropical green campus building. *Journal of Facilities Management*, 20,4. <https://doi.org/10.1108/JFM-12-2020-0092>

- Zen, I. S., Subramaniam, D., Sulaiman, H., Saleh, A. L., Omar, W., & Salim, M. R. (2016). Institutionalize waste minimization governance towards campus sustainability: A case study of Green Office initiatives in Universiti Teknologi Malaysia. *Journal of Cleaner Production*, 135, 1407–1422. <https://doi.org/10.1016/j.jclepro.2016.07.053>
- Zizka, L., McGunagle, D. M., & Clark, P. J. (2021). Sustainability in science, technology, engineering and mathematics (STEM) programs: Authentic engagement through a community-based approach. *Journal of Cleaner Production*, 279, 123715. <https://doi.org/10.1016/j.jclepro.2020.123715>
- Zilahy, G., Huisingh, D., Melanen, M., Phillips, V. D., & Sheffy, J. (2009). Roles of academia in regional sustainability initiatives: Outreach for a more sustainable future. *Journal of Cleaner Production*, 17(12), 1053-1056. <https://doi.org/10.1016/j.jclepro.2009.03.006>