Economic valuation of green campus practices: A case study of Universitas Sebelas Maret

Muzzazinah[1]*, Murtanti Jani Rahayu[2], Suryanto[3], Feni Andriani[4], Sofyan Sholeh[5], Dinar Rachmadika Baharintasari[5]

[1]Department of Biology Education, Universitas Sebelas Maret, Ir. Sutami Street, No.36A, Surakarta, 57126, Indonesia

[2]Department of Urban Regional Planning, Universitas Sebelas Maret, Ir. Sutami Street, No.36A, Surakarta, 57126, Indonesia

[3]Department of Economic Development, Universitas Sebelas Maret, Ir. Sutami Street, No.36A, Surakarta, 57126, Indonesia

[4]Department of Biology, Universitas Riau, Bangau Sakti Street, Pekanbaru, Riau, 28293, Indonesia.

[5]Master of Environmental Science, Graduate School, Universitas Sebelas Maret, Ir. Sutami Street, No.36A, Surakarta, 57126, Indonesia.

*Corresponding author, email: yayin_pbio@fkip.uns.ac.id

Article History
Received: 16 April 2026
Revised: 16 June 2026
Accepted: 20 July 2026
Published: 1 September 2026

Keywords
Economic valuation
Green campus
Sustainable campus
TEV
Universitas Sebelas Maret

Abstract
The Green Campus concept has emerged as a strategic approach to promoting sustainability and environmentally responsible practices in higher education institutions. This study aimed to evaluate the economic value of Green Campus programs implemented at Universitas Sebelas Maret (UNS), with a particular focus on water conservation, energy efficiency, and waste management initiatives. This study employed a convergent mixed-methods design, combining quantitative data to estimate TEV and qualitative data to support the interpretation of Green Campus benefits. The findings revealed that the total economic value generated by the Green Campus programs at UNS reached IDR 1,197,095,075, indicating substantial environmental and economic benefits. Among the valuation components, Non-Use Value (NUV) contributed the largest share (71.91%), followed by Direct Use Value (27.96%) and Indirect Use Value (0.14%), suggesting that stakeholders place considerable value on the long-term environmental benefits and sustainability outcomes of Green Campus initiatives. This study contributes to the theoretical development of sustainability assessment by extending the use of the Total Economic Valuation framework to the higher education sector, enabling a more comprehensive evaluation of the economic and environmental benefits generated by Green Campus programs. These findings demonstrate that implementing Green Campus programs not only plays an important role in addressing environmental challenges but also provides tangible economic contributions to higher education institutions. Furthermore, this study offers important insights for government stakeholders and university administrators in supporting institutional sustainability and strengthening financial independence within higher education systems.

How to cite: Muzzazinah, M., Rahayu, M. J., Suryanto, S., Andriani, F., Sholeh, S., & Baharintasari, D. R. (2026). Economic valuation of green campus practices: A case study of Universitas Sebelas Maret. *Journal of Environment and Sustainability Education, 4*(3). 485–497. doi: 10.62672/joease.v4i3.274

1. Introduction

Awareness of environmental problems had led to an agreement among universities to focus on sustainability and environmental literacy (Bautista-Puig & Sanz-Casado, 2021; Filho et al., 2021; Ribeiro et al., 2021). University played a crucial role in implementing eco-friendly campus, including the development of educational curricula that offered courses on sustainable environmental practices (Ribeiro et al., 2021; Filho et al., 2023). A good sustainable and environmentally friendly campus provided a competitive advantage for the institution's reputation among students and the public and had the potential to generate significant long-term cost savings for the university.

The concept of Green Campus (GC) was introduced in the late 1990s to early 2000s, with the signing of the Talloires Declaration serving as a foundational step towards universities commitment to environmental sustainability (Tan et al., 2014). Since its establishment, research has been conducted to explore and evaluate methods for green campus practices and to compare the effectiveness of green campus initiatives among universities.

doi: 10.62672/joease.v4i3.274
© 2026 The Authors
This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License
ISSN: 3025-0714

Green Campus initiatives serve as a strategy for promoting environmental knowledge and sustainability in higher education while also enhancing students' pro-environmental behavior and awareness of sustainable development (Ribeiro et al., 2021). Furthermore, the implementation of Green Campus programs contributes to institutional sustainability by improving resource efficiency, reducing operational costs, strengthening stakeholder engagement, and enhancing institutional reputation (Ali, 2025). These benefits not only improve environmental performance but also support the long-term economic and organizational sustainability of higher education institutions.

Universitas Indonesia (UI), through the UI Green Metric World University Ranking, had been ranking universities around the world for their initiatives in green campus practices since 2010. By 2023, a total of 1,183 institutions from 84 countries were involved in the UI Green Metric ranking (UI Green Metric, 2023). The ranking was determined based on six indicators: setting and infrastructure, energy, water, waste, transportation, and the implementation of research and educational activities.

Universitas Sebelas Maret (UNS) has participated in the UI GreenMetric World University Rankings since 2013 and achieved a global ranking of 43rd and a national ranking of 6th in 2023. In the same year, UNS ranked 4th in waste management, 8th in water management, and 10th in energy usage, placing the university among the top ten institutions in Indonesia across these sustainability indicators. These achievements reflect the university's strong commitment to Green Campus implementation and the establishment of comprehensive sustainability programs. Therefore, UNS provides a relevant and representative case for evaluating the economic value generated by Green Campus initiatives and examining their contribution to institutional sustainability in higher education..

Institutional development has led to increased populations and activities, thereby enhancing the demand for appropriate water and energy usage and effective waste management. Sivapalan et al (2014) had reported that water played a crucial role in socio-economic systems, and López-Morales and Rodríguez-Tapia (2019) and Wichelns et al (2015) had explained that effective water management was related to good waste management and energy production, which had the potential to reduce economic impacts.

Previous studies on Green Campus initiatives have primarily focused on sustainability indicators, environmental performance, institutional rankings, and stakeholder perceptions. For example, Suwartha and Sari (2013) evaluated the implementation of the UI GreenMetric ranking system as a tool for assessing sustainability performance in universities, while Puertas and Martí (2019) developed a sustainability assessment framework based on UI GreenMetric indicators. Similarly, Tiyarattanachai and Hollmann (2016) examined stakeholders' perceptions and quality of life associated with Green Campus implementation. More recent studies have also emphasized sustainability rankings and indicator-based assessments as measures of campus sustainability performance (Suwartha & Berawi, 2019; Sari et al., 2023). However, relatively few studies have attempted to assess the economic value generated by Green Campus initiatives. Consequently, the economic benefits associated with campus sustainability programs remain insufficiently understood.

This study applies the Total Economic Valuation (TEV) framework, which provides a comprehensive assessment of both use and non-use values associated with environmental resources (Pearce et al., 2006). TEV is widely used in environmental economics to assess the total value of natural resources and environmental goods by incorporating direct, indirect, and non-use values (Freeman et al., 2014). However, its application in assessing Green Campus initiatives remains limited. Therefore, this study evaluates the economic value of water conservation, energy efficiency, and waste management programs at Universitas Sebelas Maret (UNS), providing evidence to support institutional sustainability planning and decision-making.

2. Method

2.1. Study area

The research was conducted at Universitas Sebelas Maret Kentingan campus, located in Surakarta City, Central Java Province (Figure 1), from August to December 2023. The respondents were selected using a non-probability sampling method, specifically purposive sampling, involving students and authorized university officials.

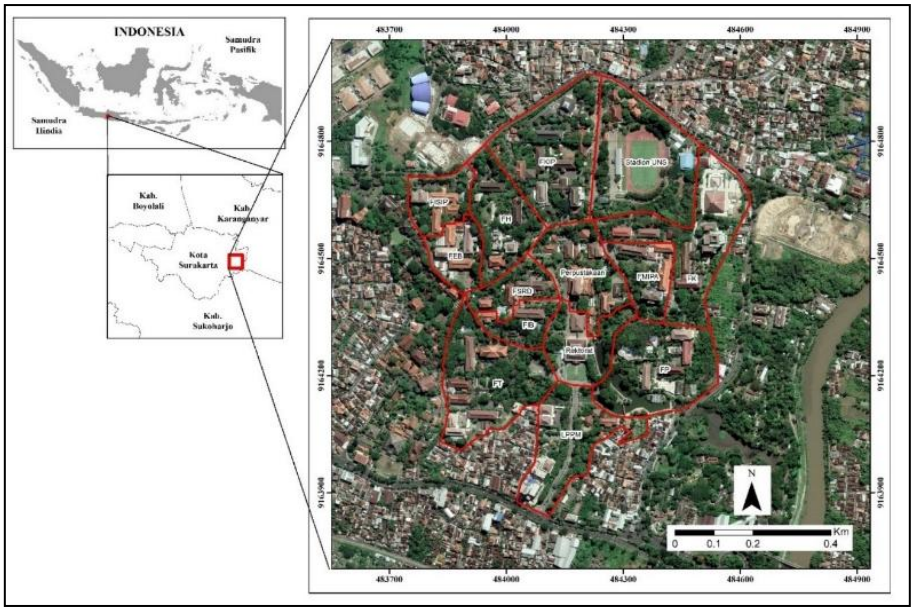

Figure 1. Research Location Map

2.2. Study design

This study focused exclusively on three aspects of Green Campus: water management, energy management, and waste management (Figure 2). This study employed a convergent mixed methods design to assess the Total Economic Value (TEV) of Green Campus implementation. Quantitative data were obtained from resource utilization and operational cost records, while qualitative data were collected through field observations and interviews to document and verify Green Campus practices.

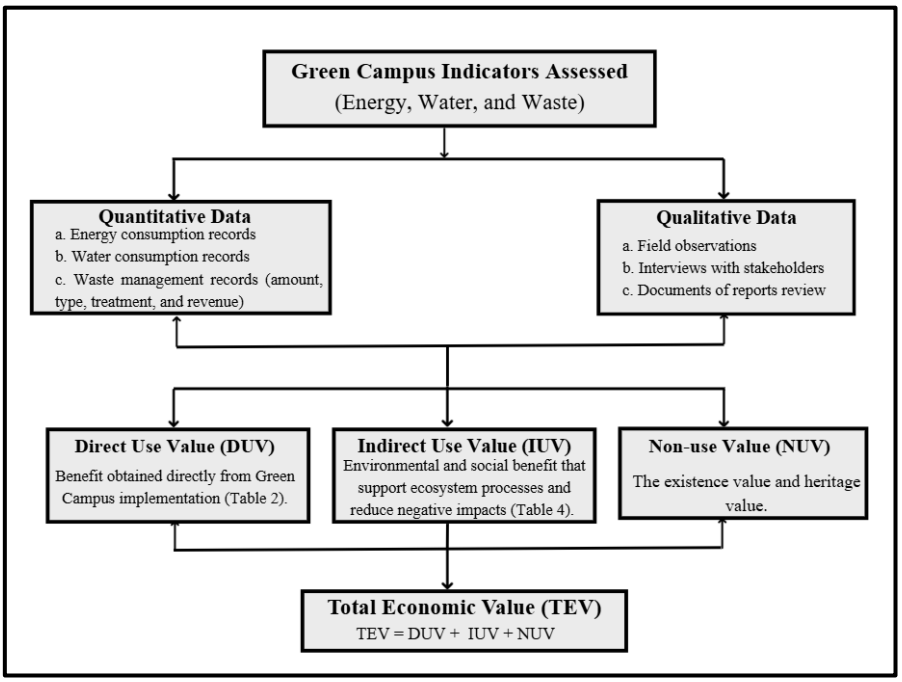

Figure 2. Methodological framework for estimating the Total Economic Value (TEV) of Green Campus implementation

The interviews were conducted to explore the benefits of the Green Campus program from various stakeholders' perspectives and to strengthen and deepen the findings obtained from field observations. The interviews aimed to obtain detail regarding the of water, energy, and waste management at UNS. The questionnaire for the interview was developed from 17 topics (Table 1).

Table 1. The interview topics

Topics
Number and types of renewable energy sources in faculty
Renewable energy sources production in faculty (kWh)
The faculty's electricity usage per year
The total faculty population
Ratio of total electricity usage to faculty population
Ratio between renewable energy sources with total electricity usage
Number of faculty zero-emission transportations
Volume or amount of organic waste produced per year (m3 or kg/year)
Volume of treated organic waste per year (kg/year)
Volume or amount of inorganic waste produced per day or per month (m3 or kg/year)
Volume of treated inorganic waste per year
Cost of waste collection services
Number of biopores
Number of shallow infiltration wells
The number and volume of rainwater harvesting reservoirs (RHRs), including their coordinates, were recorded before August 2023.
The amount of clean water used for activities at the faculty
The quantity of rainwater/wastewater that has been treated and ready for immediate utilization

2.3. Total Economic Value (TEV) analysis

The economic analysis of Green Campus implementation was conducted quantitatively using the Total Economic Valuation (TEV) formula can be seen in Equation 1. The assessment method was adapted from the application of TEV in natural resource valuation. The TEV formula was the sum of use value (UV) and non-use value (NUV); where use value was comprised of direct use value (DUV), indirect use value (IUV), and option value (OV), while non-use value included existence value (EV) and other non-use values such as bequest value (BV) (Bobylev & Tishkov, 1999; Dushin & Yurak, 2019).

$$TEV = UV + NUV = (DUV + IUV + OV) + (EV + BV) \quad (1)$$

Although the TEV framework generally includes direct use value (DUV), indirect use value (IUV), option value (OV), existence value (EV), and bequest value (BV), the present study focused on DUV, IUV, and non-use value (NUV) components that could be quantified using the available data. DUV represents the economic benefits directly obtained from resource utilization, whereas IUV refers to environmental benefits that support ecosystem functions and mitigate negative environmental impacts (Dushin & Yurak, 2019). In this study, DUV was estimated from the economic benefits generated by Green Campus programs, including savings in water and energy consumption as well as revenue from waste management activities. IUV was estimated from the environmental and social benefits associated with water conservation, energy efficiency, and waste reduction programs using appropriate proxy values. NUV, comprising existence and bequest values, was estimated based on the environmental capacity of water, energy, and waste indicators and their corresponding monetary values.

2.4. Data analysis

The quantitative data collected from the field surveys and observations were subsequently processed and analyzed using Microsoft Office Excel 2020 to calculate and summarize the research findings. Meanwhile, the qualitative data obtained from interviews and field documentation were analyzed descriptively to provide deeper explanations and interpretations of the study results and were presented in the form of figures and descriptive narratives.

3. Results and Discussion

The results showed that Universitas Sebelas Maret (UNS) has implemented various energy, water, and waste management practices based on the green campus concept to support environmental sustainability within the university environment. These initiatives included efforts to improve energy efficiency, promote water conservation, and optimize integrated waste management systems, which contributed to creating a more sustainable, environmentally friendly, and resource-efficient campus.

3.1. The Implementation of Green Campus in Energy Program

Universitas Sebelas Maret used solar panel and biodiesel for implementing green campus in energy (Figure 3). According to Lottu et al (2023), the use of renewable energy sources like solar panels fostered a sustainable learning ecosystem and mitigated the impacts of climate change. University of California, Irvine was one of the universities worldwide which installed solar panels. This university has a total of 11.760 solar panels and achieved an energy production of 3.2 megawatts (Lottu et al., 2023). The use of solar panels was also implemented by several universities in Indonesia, including Universitas Indonesia, Universitas Airlangga, and Universitas Negeri Malang.

The use of renewable energy sources contributed approximately 8% of the electricity consumption on the Kentingan campus, according to the Green Campus Energy Report for 2023. Based on the UI GreenMetric Guidelines (2023), the utilization of renewable energy sources at 8% is classified in score level 4, which corresponds to the 2–25% range.

Renewable energy production was applied by the Faculty of Mathematics and Natural Sciences (FMIPA), which generated 33.000 kWh of solar panels and 15.600 kWh of biodiesel annually. Besides FMIPA, solar panels were also used by several institutions at UNS, including the UNS Water Supply Management Unit and the Arboretum. The use of solar panels and biodiesel was employed by UNS to support campus lighting during the night and to serve as alternative energy sources for various electronic devices.

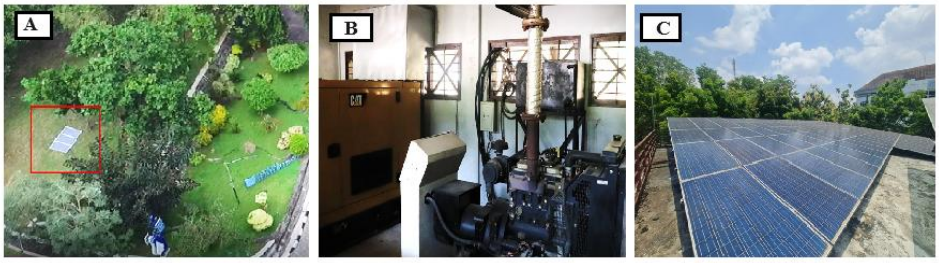

Figure 3. The use of renewable energy sources at UNS. Descriptions: (A) Solar panels and (B) Biodiesel at Faculty of Cultural Science (FIB); (C) Solar panels at UNS water supply (SPAM). Source: Green Campus Energy Report 2023.

The commitment to implementing the green campus initiative was also manifested using energy-efficient electronic devices such as LED lights, LED monitors, and eco-friendly air conditioners. Furthermore, UNS constructed its building faculties to support electricity savings through features such as adequate ventilation and heat-absorbing glass windows. The Kentingan campus also managed public transportation and established the "Emission-Free Friday" program to reduce fuel combustion.

Electricity costs represent one of the largest expenditures in the budgets of higher education institutions worldwide because electricity requires the highest level of energy consumption (Quispe et al., 2025). The use of renewable energy sources is highly encouraged to address the challenges associated with future energy resource scarcity (Lo et al., 2023). The contribution of Universitas Sebelas Maret in utilizing renewable energy sources represents a strategic step toward supporting environmental sustainability and energy efficiency within the university environment.

3.2. The Implementation of Green Campus in Waste Management

Universitas Sebelas Maret released a policy for applying the 3R principles (Reuse, Reduce, Recycle) in daily activities to reduce waste (Figure 4). The policy also regulated the use of reusable drinking bottles, the provision of drinking water supply, paper less in administration, and the waste processing into compost and other products. Several faculties such as the FMIPA and the Faculty of Medicine also build communal wastewater treatment to handle liquid waste. The effluent from the treatment could be directed to infiltration wells or discharged directly into water bodies.

Organic and non-organic waste generated by each faculty at UNS in 2023 varied depending on the number of people and the activities held by the faculties. However, the estimated average amount of organic waste produced by each faculty per day ranged from 10-50 kg, while the average non-organic waste produced was around 20-60 kg per day. This result was very low compared to the daily solid waste generated by several universities with the same number of students (around 4000 students), such as Jordan University, which produced 8113 kg of solid waste per day (Moqbel, 2018).

Figure 4. Waste Management at UNS. Description: (A) Recycle Bin in FMIPA; (B) Recycle Bin and (C) Composting in the Faculty of Agriculture (FP). Source: Green Campus Energy Report 2023

The waste management practices implemented by Universitas Sebelas Maret not only contribute to environmental sustainability efforts but also promote circular economy activities. Waste management through the 3R mechanism (reduce, reuse, and recycle) can be applied in the long term and provides significant impact on institutional economic management. One of the challenges faced by UNS in waste management is the conversion of waste into bioenergy. Kral et al (2019) stated that waste-to-energy management and final disposal systems are key elements of waste management that support the implementation of a circular economy.

3.3. The Implementation of Green Campus in Water Management

Water use at the UNS faculties varied depending on the number of people and the activities conducted over the course of the year. Water at UNS was utilized for purposes such as sanitation, performing ablution, and watering plants. To prevent water waste, UNS implemented technologies such as automatic faucets and the use of eco-flush toilets. In addition, UNS undertook efforts to recycle water for plant irrigation, established alternative water sources through wells and rainwater collection systems, and built biopores infiltration holes and shallow infiltration wells to manage water use across various faculties (Figure 5).

About 56% of the faculties at UNS had implemented a water management system using biopores infiltration holes. Biopores infiltration holes were a solution to improve water absorption into the soil due to the reducing land area for water catchment caused by urban planning and construction (Simanjuntak et al., 2021). The faculties with the highest number of biopores infiltration holes at UNS were the Faculty of Agriculture, the Faculty of Mathematics and Natural Sciences, and the Faculty of Law, with 25, 14, and 8 biopores holes, respectively.

Biopores infiltration holes were not available at the Faculty of Cultural Sciences, Faculty of Business Economics, Faculty of Psychology, Faculty of Sports Sciences, Faculty of Animal Husbandry, Faculty of Science and Data, the Graduate School Building, and the Vocational School. The unavailability of biopores infiltration holes at these buildings was due to ongoing renovation and construction activities, or the integration of biopores systems with nearby faculties. For example, the Faculty of Animal Husbandry and the Faculty of Technology, Science, and Data were integrated with the Faculty of Agriculture and the Faculty of Mathematics and Natural Sciences for biopores implementation.

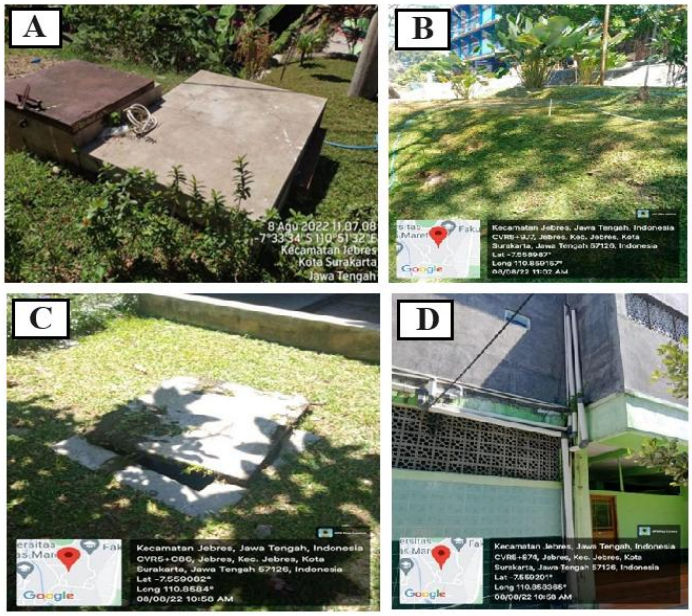

Figure 5. Implementation of Green Campus Initiatives in Water Management at UNS. Description: (A) Rainwater Harvesting System; (B) Plant Irrigation System; (C) Construction of Shallow Infiltration Wells; (D) Reuse of Ablution Water System. Source: Personal Documentation.

In addition to biopores infiltration holes, UNS utilized shallow infiltration wells to manage their water management system. The number of shallow infiltration wells was higher compared to the number of biopores infiltration holes. Approximately 77% of the total faculties at UNS had shallow infiltration wells, except for the Faculty of Teacher Training and Education, the Graduate School building, and the Vocational School. The presence of shallow infiltration wells helped in water absorption, flood prevention, and reduction of the volume of water entering the drainage system (Kusumastuti et al., 2017).

In addition to waste management, water management also represents a major component of the circular economy, providing benefits for institutional economic management (Boiocchi et al., 2025). Efficient water management indirectly reduces electricity consumption through the implementation of automatic faucets, eco-flush toilet systems, and rainwater harvesting systems used for plant irrigation. Although water management programs have already been implemented at Universitas Sebelas Maret, the institution still needs to develop further innovations, particularly in water quality monitoring to support sustainable water utilization. Similar practices have been implemented by National Taiwan University of Science and Technology, which conducted monitoring of metal content, dissolved oxygen, and total coliform levels to determine water reuse suitability (Chiang et al., 2013).

3.4. Total Economic Value of Green Campus Programs in UNS

The formula of economic valuation was divided into two main components: use value and non-use value. Use value was further categorized into direct use value and indirect use value. Universitas Sebelas Maret had gained both direct and indirect benefits from the implementation of the green campus program. The green campus program also generated non-use values such as existence value and bequest value from the shallow infiltration wells, wastewater treatment, biopores holes, and energy-saving devices.

3.4.1. Economic Valuation of Use Value

Direct Use Value

The implementation of Green Campus initiatives has become an important strategy in promoting environmental sustainability within higher education institutions. In addition to improving environmental quality, Green Campus programs also contribute to social and economic benefits for academic communities and surrounding society. At Universitas Sebelas Maret, the implementation of the Green Campus has provided direct benefits to the UNS community and the surrounding area (Table 2).

Table 2. Direct use value

Indicators	Programs	Direct use value
Water	Rain storage and management	Plant watering Toilet flushing Lower water cost
	Comunnal Waste Water Treatment	Reduce water pollution Minimizing unpleasant odur
	Shallow infiltration well and Biopore infiltration	Alternative water supply Reducing surface water accumulation Water storage
Energy	Solar Panels	Saving electricity costs Eco-friendly
	Smart Building	Less energy consumption Integrated and fast network Automatic building management Saving building maintenance Safety and comfort
	LED Lamps	Cost-effective electricity Eco-friendly
	Public Transport	Less carbon emission Reduce fuel-based fossil combustion Cost-effective
Waste	Waste Treatment	Reduce waste production Revenue from fertilizer sales
	Canteen with a free inorganic waste policy	Reduce of anorganic waste

The calculation of the direct use value was presented in Table 3. The total economic value of the direct use value from the green campus program amounted to IDR 334.649.626. The highest economic value was generated by energy management and non-organic waste management. The dominance of energy and waste components in the direct use value suggests that the economic benefits of Green Campus implementation were primarily derived from direct cost savings and resource utilization.

This result is consistent with a previous study showing that energy management initiatives implemented across 12 Korean campuses supported energy conservation ranging from 6% to 30% (Chung & Rhee, 2014). Therefore, investments in Green Campus energy initiatives, such as renewable energy systems and energy-efficient technologies, not only support environmental sustainability but also improve the financial performance of higher education institutions by reducing conventional energy expenditures. In addition, effective waste management has been shown to support the circular economy in higher education institutions through

reductions in plastic, packaging, and paper waste, thereby generating both environmental and economic benefits (Rodríguez-Guerreiro et al., 2024).

Table 3. Economic value of the direct use values

Indicators	Sources	Capacity (year)	Monetary Price (Rp)	Total Price
Energy	Solar Panels	125049/watt	1074/Watt	134.302.626
Waste	Organic waste	5400/kg	800/kg	4.320.000
	Inorganic waste	25550/kg	800/kg	166.075.000
Water	Water treatment for plant watering	2.304/m3	13000/m3	29.952.000
Total				334.649.626

Energy management provided benefits by reducing electricity consumption from fossil-based electricity. The implementation of solar panels on campus reduced dependence on costly and environmentally harmful fossil fuels. The long-term reduction in energy costs led to decreased operational expenses. The use of eco-friendly technologies also positively impacted the campus's reputation and fostered innovation in renewable energy.

The inorganic waste policy at the canteen reduced the production of inorganic waste, which reducing inorganic waste generation and the annual waste management costs. The development of compost from organic waste created a new economic resource, such as organic fertilizer that could be sold or reused for campus garden and agricultural needs. The implementation of green technology, such as anaerobic composting to produce biogas from organic waste also became alternative energy sources. The use of plant watering from ablution treatment and rainwater harvesting system helped to save water expenses.

The implementation of energy-saving programs, water management, and waste management has been proven to provide direct economic benefits to Universitas Sebelas Maret through reductions in electricity consumption and waste management practices that support the circular economy. However, environmentally friendly campus implementation has not yet been fully adopted across Indonesia. Muzayyinah et al (2024) reported that only 4% of universities in Indonesia participated in the UI GreenMetric ranking. Several participating universities even recorded zero points in energy, water, and waste management systems.

Indirect Use Value

Indirect values were obtained from the calculation of environmental value, encompassing various aspects that were not directly related to traditional economic activities but had a significant impact on sustainability and environmental well-being. These indirect benefits reflected the ecological and social contributions generated through the implementation of Green Campus programs, including improved environmental quality, reduced pollution, enhanced resource efficiency, and increased environmental awareness among the academic community. In addition, the implementation of energy conservation, sustainable water management, and integrated waste management practices contributed to reducing environmental burdens and supporting long-term campus sustainability. The indirect value of the Green Campus program in the areas of energy, water, and waste was displayed in Table 4.

Table 4. Indirect use value

Indicators	Programs	Indirect use value
Water	Rain storage and management	Reducing run off/erorion
	Communal Waste Water Treatment	Beautifull views Recreation sites Fish cultivation
	Shallow infiltration well and Biopore infiltration	Reducing flood risk
Energi	Solar Panels	Preventing form UV irradiation
	Smart Building	Smart building management system
	LED Lamps	Reducing fire risk
	Public Transport	Reducing pollution and more healthy
Waste	Waste Treatment	Enhanced campus aesthetics
	Canteen with a free inorganic waste policy	Reduced environmental pollution

Calculation of the indirect value showed a total value of IDR 1.635.045 (Table 5). This value was derived from the existence of biopores holes and infiltration wells. The calculation of the benefits of biopores holes and infiltration wells was performed by assessing the ecological benefits of these structures. The calculation was based on the volume requirements for the creation of biopores holes and infiltration wells (Minister of the Environment, 2009), resulting in volumes of 0.00785 m^3 and 31.4 m^3 per unit, respectively.

Table 5. Economic values of indirect values

Indicator	Programs	Number	Volume (m3)	Monetary Price (Rp)	Amount (Rp)
Water	Biopore Infiltration	22	0.00785	13000/m3	2.245
	Shallow Water Infiltration	4	31.4	13000/m3	1.632.800
Total					1.635.045

Mısırlı and Şişman (2024) demonstrated that rainwater management can meet campus water demands while supporting environmental conservation and the hydrological cycle. Furthermore, Boiocchi et al (2025) emphasized that water management is a key component of sustainability in higher education institutions, as it contributes to resource efficiency, long-term environmental resilience, and circular economy practices, including the production of aquatic plants derived from wastewater management systems.

Although several indirect environmental benefits were identified for energy, water, and waste programs, only water-related benefits were included in the monetary valuation because they could be quantified using measurable physical indicators and market-based proxy values. Other indirect benefits, such as improved environmental quality, reduced pollution, enhanced aesthetics, and health benefits, were recognized qualitatively but were not monetized due to the lack of reliable valuation parameters.

The indirect use value generated from Green Campus implementation at Universitas Sebelas Maret reflects broader environmental and social benefits beyond direct economic gains. In addition, the implementation of environmentally friendly practices enhances environmental awareness among students and academic communities, creating a more sustainable campus culture. These initiatives also strengthen institutional reputation and support the university's commitment to sustainable higher education development.

3.4.2. Non-use value

The non-use value was calculated based on the existence value and heritage value of each indicator (Table 6). In the energy sector, the presence of solar panels and the implementation of energy-saving devices provided long-term benefits for future generations and indirectly contributed to a healthier environmental quality. The existence of the wastewater treatment, infiltration wells, and biopore holes, along with waste management facilities, also served as a legacy for UNS students and staff.

Table 6. Economic value of non-use value

Indicator	Capacity	Unit (Year)	Monetary Price (Rp)	Amount (Rp)
Energy	705.481	watt	1074/Watt	757.686.594
Waste	40.150	Kg	896/kg	36.000.000
Water	5.163,37	m^3	13000/m3	67.123.810
Total				860.810.404

The total economic value was calculated based on the summation of direct use value, indirect use value, and non-use value, showing that the green campus program provided an economic value of IDR 1.197.095.75 (Table 7). This total calculation result represented the actual benefit if the campus had implemented sustainability principles. This calculation was for one year. If projected over the investment's economic lifespan, the value could be multiplied by the economic lifespan and adjusted for depreciation.

Non-use value represented the largest share (72%) of the Total Economic Value, indicating that the benefits of Green Campus implementation extend beyond immediate economic gains derived from operational cost savings. The result suggests that sustainability programs in the areas of energy, water, and waste management generate substantial long-term value through environmental preservation, resource conservation, and the maintenance of ecosystem functions, thereby enhancing the overall value of higher education institutions.

Table 7. Total economic value of UNS green campus programs

Component	Value (Rp/Year)
Direct Use value	334.649.626
Indirect Use value	1.635.045
Non-use Value	860.810.404
Total Economic Value	1.197.095.75

Overall, the implementation of Green Campus initiatives generated a Total Economic Value (TEV) of IDR 1.19 billion, highlighting that the benefits of sustainability programs extend beyond direct resource utilization to encompass broader environmental values. The results of this study aligned with Bautista-Puig & Sanz-Casado (2021), Filho et al (2021), and Ribeiro et al (2021) which showed the implementation of a green campus

required a higher investment but, in the long term, provided greater The indirect use value contributed only IDR 1.635.045 to the Total Economic Value. This relatively low value may be attributed to the difficulty of quantifying and monetizing the full range of ecological benefits generated by Green Campus initiatives, which represents a limitation of the present study. Furthermore, water management efforts in this study primarily focused on biopore infiltration systems and rainwater harvesting facilities, whereas other indirect environmental programs, such as tree planting and green space development, were not extensively incorporated into the valuation. A study conducted at Thompson Rivers University, Canada, demonstrated that campus trees intercepted approximately 3,066 m^3 of stormwater annually, generating cost savings of about CAD 7.970 through reduced pressure on stormwater drainage and water management infrastructure (Kadaleevanam, 2025).

In Indonesia, an economic valuation study conducted in the Sylva Arboretum of Tanjungpura University estimated a total economic value of IDR 15.346.872.680 per year (Roslinda et al., 2020). This value is substantially higher than the economic value estimated for the Green Campus programs in the energy, waste, and water sectors in the present study. The difference may be explained by the broader range of ecosystem services provided by the arboretum, including ecological, environmental, and social benefits that were comprehensively incorporated into the valuation. These findings suggest that the economic contribution of Green Campus initiatives could be considerably greater if additional ecosystem services and environmental assets were included in future assessments.

In 2025, there were 196 universities in Indonesia participating in the UI GreenMetric ranking. The indicators of energy and climate change, waste, and water contributed 21%, 18%, and 10%, respectively, with maximum scores of 2100, 1800, and 1000 in the UI GreenMetric ranking (UI GreenMetric, 2025). Based on the data, there are still 1.5% of higher education institutions in Indonesia that obtained a score of 0 in waste management. Many universities may perceive the implementation of a green campus as a burden for institutional management, even though green campus initiatives can provide significant economic benefits (Gao et al., 2019; Barnett-Itzhaki et. al., 2025)

The findings of this study suggest that higher education institutions should integrate long-term strategies into Green Campus policies, not only through improving energy efficiency, developing renewable energy sources, and implementing sustainable water and waste management practices, but also through the development of green open spaces and tree-planting programs. Such policies can generate long-term environmental benefits, including enhanced water conservation, reduced surface runoff and flood risks, increased carbon sequestration, and improved campus environmental quality. In addition, green spaces and vegetation can contribute to energy efficiency by providing shading and reducing ambient temperatures. Therefore, the integration of these sustainability strategies can strengthen environmental performance while supporting the long-term sustainability of higher education institutions.

The Ministry of Higher Education, Science, and Technology in Indonesia encourages universities to become autonomous state universities (Perguruan Tinggi Negeri Badan Hukum/PTNBH) in order to promote independent campus management. The implementation of Green Campus programs across higher education institutions may serve as a strategic step in supporting the government's efforts to strengthen the establishment of PTNBH. Therefore, stronger integration between the government and higher education institutions is needed to establish campuses with effective energy, water, and waste management systems that can contribute to improved institutional financial management.

4. Conclusion

The economic valuation calculated that the green campus initiative yielded a benefit of IDR 1.197.095.075. The integration of renewable energy, efficient water management, and green transportation practices helped the campus to reduce environmental impacts on both the local community and the broader society for sustainability. This study is limited to the TEV components that could be quantified based on data availability. Consequently, several environmental and social benefits generated by Green Campus programs were not fully reflected in the estimated economic value. In addition, the valuation approaches and economic values applied to certain TEV components could be further refined to provide more comprehensive estimates. Therefore, future studies should expand the range of assessed components and develop more comprehensive valuation methods to capture sustainability benefits that have not yet been monetized.

We further recommend that the campus should development long term green campus programs while the government provide support for private higher education institutions in maintaining energy, waste, and water management programs to ensure that the benefits of green campus initiatives are widely distributed across universities in Indonesia.

Author Contributions

Muzzazinah: Conceptualization, Methodology, Supervision, Muryanti Jani Rahayu: Conceptualization, Writing-Reviewing and Editing, Suryanto: Conceptualization, Writing - Original draft preparation. Supervision, Feni Andriani: Visualization, Writing-Reviewing and Editing, Sofyan Sholeh: Investigation, Software, Validation, Dinar Rachmadika Baharintasari: Data Curation, Software. All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

Funding

This research was funded by the Fundamental Research Scheme of Universitas Sebelas Maret for the academic year 2023/2024 with registration number 00060464023832023.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

Acknowledgement

The author would like to express gratitude to the research team, academic advisors, and all collaborators for their valuable contributions. This research was funded by the Fundamental Research Scheme of Universitas Sebelas Maret for the academic year 2023/2024 with registration number 00060464023832023.

References

Ali A (2025), "Universities as sustainability agents! Does green campus ensure green intellectual capital? A quantitative approach to the triggering role of green knowledge sharing and green innovation". *Journal of Intellectual Capital, 26*(1) pp. 253–278, doi: https://doi.org/10.1108/JIC-03-2024-0080

Barnett-Itzhaki, Z., Tifferet, S., Etstein, Y., Gefen, I., Ravid, O., Barokas, G., Vilnai-Yavetz, I., Carasso Romano, G. H., & Levi, A. (2025). A holistic approach to sustainability in higher education institutes: Social, economic, educational, and mobility perspectives. *Frontiers in Education, 10,* 1588223. https://doi.org/10.3389/feduc.2025.1588223

Bautista-Puig, N., & Sanz-Casado, E. (2021). Sustainability practices in Spanish higher education institutions: An overview of status and implementation. *Journal of Cleaner Production, 295*, 126320. https://doi.org/10.1016/j.jclepro.2021.126320

Bobylev, S. N., & Tishkov, A. A. (Eds.). (1999). *Economic assessment of biodiversity*. Moscow: Institut Ekonomiki Prirodopolzovaniya.

Boiocchi, R., Peruzzi, C., Giurea, R., & Rada, E. C. (2025). Towards a structured approach to advance sustainable water management in higher education institutions: A review. *Water, 17*(24), 3526. https://doi.org/10.3390/w17243526

Chiang, V. C., Kao, M. H., & Liu, J. C. (2013). Assessment of rainwater harvesting systems at a university in Taipei. *Water Science and Technology, 67*(3), 564–571. https://doi.org/10.2166/wst.2012.592

Chung, M. H., & Rhee, E. K. (2014). Potential opportunities for energy conservation in existing buildings on university campus: A field survey in Korea. *Energy and Buildings, 78*, 176-182. 10.1016/j.enbuild.2014.04.018

Dushin, A. V., & Yurak, V. V. (2019, January). Total economic value concept: essence, evolution and author's approach. In International Scientific Conference" Far East Con"(ISCFEC 2018) (pp. 91-97). *Atlantis Press*. https://doi.org/10.2991/iscfec-18.2019.21

Filho, W. L., Abubakar, I. R., Mifsud, M. C., Eustachio, J. H. P. P., Albrecht, C. F., Dinis, M. A. P., Borsari, B., Sharifi, A., Levesque, V. R., Ribeiro, P. C. C., LeVasseur, T. J., Pace, P., Trevisan, L. V., & Dibbern, T. A. (2023). Governance in the implementation of the UN sustainable development goals in higher education: global trends. *Environment, Development and Sustainability,* 0123456789. https://doi.org/10.1007/s10668-023-03278-x

Filho, W. L., Amaro, N., Avila, L. V., Brandli, L., Damke, L. I., Vasconcelos, C. R. P., Hernandez-Diaz, P. M., Frankenberger, F., Fritzen, B., Velazquez, L., & Salvia, A. (2021). Mapping sustainability initiatives in higher education institutions in Latin America. *Journal of Cleaner Production, 315*(June). https://doi.org/10.1016/j.jclepro.2021.128093

Freeman Iii, A. M., Herriges, J. A., & Kling, C. L. (2014). *The measurement of environmental and resource values: theory and methods.* Routledge.

Gao, W., Ding, X., Chen, R., & Min, W. (2019). An empirical study of the role of higher education in building a green economy. *Sustainability, 11*(23), 6823. https://doi.org/10.3390/su11236823

GreenCampus UNS. (2023). *UNS UI Green Metrics Report*. https://greencampus.uns.ac.id [unpblished]

Kadaleevanam, K. (2025). Multidimensional Valuation of Trees at Thompson Rivers University: An Ecological, Cultural, and Socio-Economic Exploration. *Future Earth: A Student Journal on Sustainability and Environment, 1*(1). https://doi.org/10.29173/bcelnfe661

Kral, U., Morf, L. S., Vyzinkarova, D., & Brunner, P. H. (2019). Cycles and sinks: Two key elements of a circular economy. *Journal of Material Cycles and Waste Management, 21*(1), 1–9. https://doi.org/10.1007/s10163-018-0786-6

Kusumastuti, D. I., Jokowinarno, D., Khotimah, S. N., & Dewi, C. (2017). The use of infiltration wells to reduce the impacts of land use changes on flood peaks: An indonesian catchment case study. *Pertanika Journal of Science and Technology, 25*(2), 407-424.

Lo, K. (2013). Energy conservation in China's higher education institutions. *Energy Policy, 56,* 703–710. https://doi.org/10.1016/j.enpol.2013.01.036

López-Morales, C. A., & Rodríguez-Tapia, L. (2019). On the economic analysis of wastewater treatment and reuse for designing strategies for water sustainability: Lessons from the Mexico Valley Basin. *Resources, Conservation and Recycling, 140*, 1-12. https://doi.org/10.1016/j.resconrec.2018.09.001

Lottu, O. A., Ehiaguina, V. E., Ayodeji, S. A., Ndiwe, T. C., & Izuka, U. (2023). Global review of solar power in education: initiatives, challenges, and benefits. *Engineering Science & Technology Journal, 4*(4), 209-221. https://doi.org/10.51594/estj.v4i4.583

Minister of the Environment. (2009). *Peraturan Menteri Negara Lingkungan Hidup Nomor 06 Tahun 2009 tentang Laboratorium Lingkungan. Kementerian Lingkungan.* https://pusfaster.bsilhk.menlhk.go.id/wp-content/uploads/2016/04/PERMEN-06-TAHUN-2009-LABORATORIUM-LINGKUNGAN.pdf

Mısırlı, N., & Şişman, E. E. (2024). Assessing the potential of rainwater harvesting and reuse for sustainable university campus. *Environmental Research and Technology, 7*(4), 363–375. https://doi.org/10.35208/ert.1485825

Moqbel, S. (2018). Solid waste management in educational institutions: the case of the University of Jordan. *Environmental Research, Engineering and Management, 74*(2), 23-33. https://doi.org/10.5755/j01.erem.74.2.21037

Muzayyinah, Andriani, F., Rahayu, M. J., Suryanto, Baharintasari, D. R., & Sulistyana, Y. (2024). Green campus implementation and challenges in education and research in Indonesia. *IOP Conference Series: Earth and Environmental Science, 1425*(1), 012012. https://doi.org/10.1088/1755-1315/1425/1/012012

Puertas, R., & Martí, L. (2019). Sustainability in universities: DEA-GreenMetric. *Sustainability, 11*(14), 3766. https://doi.org/10.3390/su11143766

Quispe, E. C., Viveros Mira, M., Chamorro Díaz, M., Castrillón Mendoza, R., & Vidal Medina, J. R. (2025). Energy management systems in higher education institutions' buildings. *Energies, 18*(7), 1810. https://doi.org/10.3390/en18071810

Ribeiro, J. M. P., Hoeckesfeld, L., Dal Magro, C. B., Favretto, J., Barichello, R., Lenzi, F. C., ... & De Andrade, J. B. S. O. (2021). Green Campus Initiatives as sustainable development dissemination at higher education institutions: Students' perceptions. *Journal of Cleaner Production, 312*, 127671. DOI: https://doi.org/10.1016/j.jclepro.2021.127671

Rodríguez-Guerreiro, M.-J., Torrijos, V., & Soto, M. (2024). A review of waste management in higher education institutions: The road to zero waste and sustainability. *Environments, 11*(12), 293. https://doi.org/10.3390/environments11120293

Roslinda, E., Munir, A., Haryono, A., & Ansyari, A. (2020). Nilai Ekonomi Arboretum Sylva Universitas Tanjungpura Pontianak (Economic Value of the Sylva Arboretum of the Tanjungpura University Pontianak). *Jurnal Sylva Lestari, 8*(1), 42–53. https://doi.org/10.23960/jsl1842-53

Sari, R. F., Suwartha, N., Setiani, H., & Sidiyanto, Y. A. (2023). The Impact of UI GreenMetric Involvement on Universities' Performance in Shaping a Sustainable Campus. *Journal of Sustainability Perspectives, 3*(3), 399–414. https://doi.org/10.14710/jsp.2023.20847

Simanjuntak, I. V., Mulyani, A. S., & Hutabarat, L. E. (2021, October). The effectiveness of biopore technology on infiltration rate and organic waste processing. *In IOP Conference Series: Earth and Environmental Science 878*(1), p. 012045). IOP Publishing. https://doi.org/10.1088/1755-1315/878/1/012045

Sivapalan, M., Konar, M., Srinivasan, V., Chhatre, A., Wutich, A., Scott, C. A., Wescoat, J. L., & Rodríguez-Iturbe, I. (2014). Socio-hydrology: Use-inspired water sustainability science for the Anthropocene. *Earth's Future, 2*(4), 225-230. https://doi.org/10.1002/2013EF000164

Suwartha, N., & Berawi, M. A. (2019). The role of UI GreenMetric as a global sustainable ranking for higher education institutions. *International Journal of Technology, 10*(5), 862–865. https://doi.org/10.14716/ijtech.v10i5.3670

Suwartha, N., & Sari, R. F. (2013). Evaluating UI GreenMetric as a tool to support green universities development: Assessment of the year 2011 ranking. *Journal of Cleaner Production, 61*, 46–53. https://doi.org/10.1016/j.jclepro.2013.02.034

Tan, H., Chen, S., Shi, Q., & Wang, L. (2014). Development of green campus in China. *Journal of Cleaner Production, 64*, 646-653. https://doi.org/10.1016/j.jclepro.2013.10.019

Tiyarattanachai, R., & Hollmann, N. M. (2016). Green Campus initiative and its impacts on quality of life of stakeholders in Green and Non-Green Campus universities. *SpringerPlus, 5,* 84. https://doi.org/10.1186/s40064-016-1697-4

UI GreenMetrics. (2023). *UI Green Metric World University Rankings 2023*. https://greenmetric.ui.ac.id/rankings/overall-rankings-2023

UI GreenMetrics. (2025). *UI GreenMetric guideline 2025*. https://greenmetric.ui.ac.id/wp-content/uploads/2025/06/UI-GreenMetric-Guideline-2025.pdf

Wichelns, D., Drechsel, P., & Qadir, M. (2015). Wastewater: Economic asset in an urbanizing world. *Wastewater: Economic asset in an urbanizing world,* 3-14. https://doi.org/10.1007/978-94-017-9545-6_1