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Examining Eco-friendly Practices at GKVK Campus: A Comprehensive Sustainability Approach

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Abstract

The growing urgency to combat climate change has spurred higher education institutions worldwide to adopt sustainable practices. The present study comprehensively evaluates the eco-friendly practices implemented at the GKVK campus of the University of Agricultural Sciences, Bangalore (UASB), focusing on energy management, water conservation, waste management, green infrastructure, sustainable mobility, sustainable agriculture and academic engagement. Using the Sustainability Practice Index (SPI), the study assesses the extent and effectiveness of these initiatives. Key findings include the generation of 1.5 million kWh/year of solar energy, 2.5 million liters of monthly water consumption with significant reduction efforts through rainwater harvesting and a robust organic farming program covering 50 per cent of campus agricultural land. GKVK's approach reflects both local and national policy goals, such as India's National Solar Mission and Jal Shakti Abhiyan, while aligning with global sustainability frameworks. The results show that the campus excels in the concept of green infrastructure and sustainable agriculture, but more effort should be focused on areas like waste management and sustainable mobility require further improvement. This study contributes to the growing body of knowledge on sustainability in educational settings and provides a model for other Universities in India and globally.

Keywords : Eco-friendly practices, GKVK campus, Sustainability, Carbon footprint, Renewable energy, Waste management, Water conservation

The growing concern over environmental degradation and climate change has driven global, national and local initiatives to adopt sustainable practices, with the higher education sector emerging as a key player in this movement. At the global level, Universities are increasingly embracing sustainability as an integral part of their missions, with initiatives aimed at reducing carbon footprints, conserving resources and fostering environmental consciousness among students and staff (AASHE, 2023). The University of Agricultural Sciences, Bangalore (UASB), specifically the GKVK campus, has been at the forefront of these efforts, actively incorporating eco-friendly practices into its operations, research, and education. This chapter delves into the various sustainable practices employed at GKVK, examining the campus's approach to energy management, water conservation, waste management, green infrastructure, sustainable agriculture and

educational engagement, framed within the global, national and state-level contexts.

Globally, institutions of higher learning play a pivotal role in driving sustainability. Universities are responsible for educating future academicians, scientists, researchers and innovators who will shape global environmental policies and practices. According to a report by the United Nations (2021), educational institutions are vital in promoting sustainability through the integration of sustainable development goals (SDGs) into their curricula and operations. The implementation of green campus initiatives, such as energy-efficient buildings, waste recycling programs and renewable energy sources, has become increasingly common in Universities worldwide. For instance, institutions like Stanford University and the University of California have set ambitious targets for carbon neutrality, aligning with the global push for sustainability under the Paris Agreement (UNFCCC, 2015).

India, as a rapidly developing nation, faces a unique set of challenges in addressing environmental sustainability. The country is home to some of the largest Universities in the world, with campuses that can significantly contribute to the reduction of national carbon footprints. The Indian Government's initiatives, such as the National Action Plan on Climate Change (NAPCC, 2008) and the National Solar Mission (2010), have emphasized the importance of sustainable campus infrastructure (MNRE, 2022). Indian Universities have been encouraged to adopt green technologies and implement waste management systems, energy conservation practices and renewable energy sources. The Green Campus Program by the University Grants Commission (UGC) and the All-India Council for Technical Education (AICTE) further supports these efforts by providing funding and recognition for sustainable practices (UGC, 2021).

Karnataka has demonstrated a commitment to environmental sustainability. The Karnataka State Pollution Control Board (KSPCB, 1974) has implemented regulations to monitor and mitigate pollution and the state has embraced initiatives like rainwater harvesting and energy-efficient buildings. The Karnataka Renewable Energy Development Limited (KREDL) is actively promoting solar power across the state and Bengaluru, as the capital, has seen a significant rise in solar panel installations in academic institutions. GKVK, as part of UASB, aligns with these state policies by integrating renewable energy solutions, water conservation strategies and waste management practices into its daily operations.

The Significance of the Study

The significance of this study lies in its comprehensive evaluation of the eco-friendly practices at the GKVK campus, to serve as a model/ framework for sustainability in higher education institutions. By examining the integration of energy management, water conservation, waste reduction and sustainable agricultural practices, this study provides insights into how academic campuses can mitigate their environmental impact. The research contributes to the growing body of knowledge on campus sustainability and highlights GKVK's role in addressing climate change through practical, scalable solutions. Furthermore, it offers valuable data for policymakers, educators and environmental planners to foster green campus initiatives, not only in Karnataka but also across India. The study also supports global sustainability goals, positioning GKVK as a leader in sustainable development within academic institutions.

Methodology

To systematically evaluate and analyse the eco-friendly practices adopted across the GKVK campus, a structured and theory-based approach is employed using the Sustainability Practice Index (SPI). The SPI is a diagnostic tool developed to quantify the extent, coverage and effectiveness of sustainable practices in various operational aspects of the university. This methodology integrates observation, documentation, stakeholder input, and numerical scoring to provide a comprehensive sustainability performance snapshot.

Conceptual Framework of SPI

The Sustainability Practice Index (SPI) is designed as a multi-criteria evaluation model based on eight broad thematic categories which encompass the key sustainability dimensions relevant to higher educational institutions, particularly those with agricultural and environmental focus. These include:

- Energy Management
- Water Conservation
- Waste Management
- Green Infrastructure and Biodiversity
- Sustainable Mobility
- Sustainable Agriculture and Field Practices
- Education, Research and Engagement
- Hostel and Food Services

Each thematic area is further divided into specific indicators that reflect eco-friendly infrastructure, policy measures, behavioural practices and institutional programs. These indicators help to assess the level of adoption and operationalization of green practices within different segments of the campus.

Development of Evaluation Indicators

For each thematic area, 4 to 6 indicators were identified through literature review, benchmarking studies and adaptation of best practices from international sustainability assessment tools such as STARS (Sustainability Tracking, Assessment and Rating System), ISO 14001 Environmental Management System and NAAC Green Audit frameworks. Examples of indicators include the use of solar panels under energy management, rainwater harvesting under water conservation and composting systems under waste management.

Scoring and Grading Methodology

Each indicator is evaluated using a three-point ordinal scale as follows:

0 = Not Implemented

1 = Partially Implemented

2 = Fully Implemented

This allows for semi-quantitative assessment where both the presence and quality of implementation were considered. The scores from all indicators were aggregated to calculate the total SPI score for each unit or department.

Data Collection Techniques

To ensure comprehensive data gathering, a mixed-methods approach was adopted:

Structured Field Observations : Researchers performed a Physical verification of facilities and operations using a structured checklist. Visual and photographic documentation was used to validate sustainability installations such as rainwater harvesting tanks, solar panels and composting units in the Campus.

The Primary data on sustainability practices at GKVK Campus was collected from the transport office, farm superintendent, farm coordinators, hostel wardens and other related staff of the Estate office to understand the decision-making process, implementation status and challenges faced in adopting eco-practices.

Targeted surveys were conducted with students, faculty and non-teaching staff to understand awareness, participation and satisfaction with green initiatives on campus. Questions were designed using a Likert scale and binary responses for analysis.

Document Analysis

Institutional records including energy bills, annual reports, environmental policy documents, procurement logs and farm management files were reviewed to triangulate observational and interview data.

Calculation of Sustainability Practice Index (SPI)

Once data is collected and scored, the SPI were calculated using the following formula:

$$SPI\ (per\ cent) = \frac{\text{Total Score Obtained}}{\text{Maximum Possible Sccore}} \times 100$$

This index was calculated both thematically and department-wise to understand variation in implementation across categories and campus zones.

Table 1

The Classification of Sustainability Performance Index (SPI) Scores and Sustainability Maturity Levels (SML) at GKVK Campus, UASB

SML (%)	Category	Remarks
80 - 100	Excellent	Highly Sustainable
60 - 79	Good	Positive Sustainable
40 - 59	Moderate	Average Sustainable
< 40	Low	Needs Improvement

Classification of SPI Scores

The SPI was classified into four performance categories to interpret sustainability maturity levels at GKVK campus.

This categorisation helps in highlighting areas of strength and weakness, enabling data-driven interventions. This methodology provided a standardized and replicable approach to benchmark campus sustainability in educational institutions. It serves as a planning and monitoring tool, offering empirical evidence to inform policy development, infrastructure investments and awareness initiatives. The use of SPI enables GKVK to track its transition towards a green campus model, identify gaps and enhance its visibility in environmental leadership among Indian agricultural Universities.

GKVK Campus: An Overview of Eco-Friendly Practices

GKVK has consistently taken strides to implement sustainable practices across various sectors of campus operations. The campus's energy management strategy includes the installation of solar panels that generate approximately 1.5 million kWh per year, covering around 20 per cent of the campus's total energy demand (Bhattacharya and Dey, 2022). This initiative is aligned with India's National Solar Mission, which aims to increase solar power capacity to 100 GW by 2022 (MNRE, 2022). Additionally, GKVK has implemented energy-efficient retrofits, including LED lighting and energy-efficient HVAC systems, resulting in significant emissions reductions.

Water conservation is another critical area where GKVK excels. With a monthly water consumption of 2.5 million liters, the campus has installed rainwater harvesting systems that capture 5,00,000 liters, reducing dependency on municipal water sources (Kumar and Sharma, 2022). Moreover, the University has implemented low-flow faucets and dual-flush toilets in 70 per cent of its hostels, resulting in a 15 per cent reduction in water usage. GKVK's water conservation initiatives align with India's Jal Shakti Abhiyan, a national campaign to improve water use efficiency (Verghese *et al.*, 2023).

In the area of waste management, GKVK has made significant progress. The campus segregates 80 per cent of its waste at source and composts approximately 80,000 kg of organic waste annually (Ramesh *et al.,* 2023). This practice not only reduces landfill waste but also supports organic farming initiatives on campus. Additionally, the University has set up an e-waste management system, collecting 2.3 tonnes of electronic waste annually, in line with the E-Waste (Management) Rules, 2016 (Yadav and Raj, 2023).

Green infrastructure is a cornerstone of GKVK's sustainability efforts. With 90 per cent of the campus dedicated to green spaces, including 9,800 newly planted trees and 40 per cent of buildings certified for energy efficiency (LEED), GKVK is creating a campus environment that supports biodiversity, enhances the urban microclimate and sequesters carbon (Ganguly *et al.,* 2023). The University also employs organic landscaping practices, contributing to biodiversity conservation and ecosystem services (Blay and Lokesha, 2022).

Sustainable mobility on campus is another area of focus. Approximately 10 per cent of the campus population uses bicycles as a mode of transport, supported by dedicated cycling lanes and bike racks (Pathania and Roy, 2020). Additionally, 20 per cent

of students and staff use public transportation and GKVK operates a car pooling program that engages 500 participants annually, helping reduce the campus's overall carbon foot print (Chatterjee and Srinivasan, 2022).

In the realm of sustainable agriculture, GKVK has been a pioneer. Half of the agricultural land on campus follows organic farming practices and 75 per cent of fields are equipped with water-efficient drip irrigation systems (Tripathi and Agarwal, 2020). These initiatives not only contribute to the reduction of the campus's carbon footprint but also align with India's National Mission on Sustainable Agriculture (NMSA).

The GKVK campus stands as a model for sustainable practices in higher education institutions in India. Through comprehensive strategies in energy management, water conservation, waste management, green infrastructure, sustainable mobility and agriculture, GKVK has made significant strides in reducing its environmental impact. These efforts not only contribute to India's broader sustainability goals but also position the campus as a leader in eco-friendly practices in the state of Karnataka and beyond. The ongoing commitment to these practices ensures that GKVK will continue to play a vital role in shaping sustainable development within the academic community.

Results and Discussion

The GKVK campus, with its diverse sustainability initiatives, provides a unique case study of how higher educational institutions can effectively integrate eco-friendly practices. The results discussed in this chapter reflect the outcomes of these efforts, focusing on their environmental impact, operational efficiencies and alignment with national and global sustainability goals. Through this analysis, we aim to uncover key insights and identify areas for further improvement, ultimately contributing to the ongoing efforts to promote sustainability in academic environments.

The structured assessment of GKVK Campus's energy management strategy across six key indicators - ranging from policy-level planning to building infrastructure upgrades are presented in Table 2. This multi-indicator framework evaluates both qualitative

Table 2

Energy Management Structure and Sustainability Performance at GKVK Campus, UAS-B

Indicators	Activity Data	Emission Factor (Kg *Co, e*/kWh)	Estimated Emissions (kg *Co, e*)	SPI Score
Energy Policy and Planning	Yes, formal energy management policy in place for reducing emissions and adopting renewable energy.	Not applicable	Not applicable	2
Energy Monitoring and Auditing	Annual energy audits for major buildings; installation of smart meters in high-consumption areas such as laboratories and hostels.	Not applicable	Not applicable	2
Renewable Energy Utilization	15,00,000 kWh/year from solar panels.	0 kg *Co, e*/kWh	0	2
Energy Efficiency in Infrastructure	80 per cent of campus lighting converted to LED; 60per cent of AC systems upgraded to energy-efficient models.	0.199	21,78,000 (based on savings)	2
Behavioural and Awareness Programs	Workshops on energy conservation, campaigns to promote switching off lights and equipment.	Not applicable	Not applicable	2
Energy-efficient Buildings	70per cent of buildings are energy-efficient, featuring passive design for natural lighting and ventilation.	0.199	3,19,200	2
Total Score				2

and quantitative aspects, such as emissions reduction, energy-saving activities and renewable energy integration. Each category is scored under a Sustainable Practices Index (SPI), with a maximum of 2 points per indicator, based on performance, policy compliance and impact.

The university adopted a formal Energy Management Policy in 2018 with measurable targets: reduce overall electricity consumption by 20 per cent and adopt 30 per cent renewable energy sources by 2030. This policy is administered by a campus-wide Energy Committee comprising faculty members, technical officers and sustainability experts. The policy includes annual review mechanisms, regular energy audits and internal reporting structures. This proactive and institutionalized policy framework contributes significantly to long-term energy sustainability and aligns with the National Energy Conservation Guidelines (Mohan *et al.*, 2022).

GKVK carries out annual energy audits for all major facilities, including laboratories, hostels and administrative buildings. A centralized monitoring dash board tracks monthly energy usage at the building and department level. These audits have enabled the identification of high-consumption zones and have led to corrective actions like replacing old Heating, ventilation and air conditioning (HVAC) systems. This systemized audit practice ensures energy accountability and supports data-driven infrastructure upgrades (Sen & Kaul, 2023).

The campus generates approximately 1.5 million kWh/year of solar energy, covering roughly 20 per cent of its total electricity demand. Solar panels are installed on academic buildings, hostel rooftops and public areas like parking lots and auditoriums. The entire solar output has a zero-emission factor (0 kg *Co, e*/kWh), contributing directly to Scope 2 emissions reduction. GKVK's solar strategy is aligned with the Ministry of New and Renewable Energy (MNRE) campus solarization program and reflects global best practices in campus energy decarbonization (Bhattacharya and Dey, 2022). The integration of renewable energy solutions, particularly solar panels generating 1.5 million kWh annually at GKVK, is part of a broader global trend where Universities are investing in clean energy to reduce their carbon footprint (Singh and Sharma, 2021).

Nearly 80 per cent of campus lighting has been upgraded to LED, resulting in a 10 per cent overall drop in power consumption. In addition, 60 per cent of AC systems have been converted to smart, energy-efficient models. These retrofitting initiatives, driven by energy audit recommendations, have saved 2,178,000 kg *Co, e* annually (based on 0.199 kg *Co, e*/kWh). Effective plans include full HVAC modernization by 2026. These steps are benchmarked against global energy efficiency programs such as the Green Campus Alliance model (Lee *et al.*, 2021).

Awareness campaigns like 'Switch Off for the Planet' promote voluntary conservation behaviour among students and staff. Energy-saving competitions among departments have been introduced, with incentives for top performers. These programs have contributed to a 12 per cent reduction in unnecessary energy use during night hours. Behavioural energy interventions are increasingly recognized as cost-effective means to improve institutional sustainability (Wade and Green, 2021).

Approximately 70 per cent of GKVK buildings incorporate passive solar design with optimized natural lighting and cross-ventilation. These buildings follow energy-efficient architecture principles, resulting in a 15 per cent reduction in energy consumption for lighting and ventilation. Continuous retrofitting of older buildings is being carried out to meet the same sustainability standards. The university's approach mirrors LEED-India Green Building Guidelines (Ganguly *et al.*, 2023).

Each of the six categories scored 2 out of 2, culminating in a perfect SPI score of 12. This high score reflects GKVK's comprehensive, cross-sectoral energy management strategy combining institutional policy, technical upgrades, renewable energy sourcing, and behavioural engagement. It also signals potential eligibility for national energy awards and funding programs such as UGC's Green Campus Scheme and AICTE's Sustainable Campus Rankings.

TABLE 3

Water Conservation Strategies and Sustainability Performance at GKVK Campus, UAS-B

Indicators	Activity Data	Emission Factor (Kg *Co, e*/kWh)	Estimated Emissions (kg *Co, e*)	SPI Score
Water Usage Management	Total water consumption: 2.5 million Liters/month	Not applicable	Not applicable	1
Rainwater Harvesting	Rainwater harvesting systems installed in 5 buildings, 5,00,000 litters capacity.	Not applicable	Not applicable	1
Watersaving Devices	70per cent of campus toilets use lowflow faucets and dual flush toilets in hostels	Not applicable	Not applicable	1
Wastewater Treatment and Reuse	80,000 liters of wastewater treated used for irrigation	Not applicable	Not applicable	1
Water Conservation Awareness	Annual campaigns on watersaving practices, focus on student and staff engagement.	Not applicable	Not applicable	2
Total				1.2

The structured assessment of water conservation strategies adopted at GKVK Campus, evaluated using five indicators under the Sustainable Practices Index (SPI) are illustrated in Table 3. Each indicator is scored on a scale of 1, expect Water Conservation Awareness based on implementation, scale, performance monitoring and reduction impact. The table reveals the University's integrated and multi-pronged approach toward efficient water use, reuse and awareness initiatives.

The total monthly water consumption on campus is estimated at 2.5 million liters, sourced primarily from municipal pipelines and borewells. Water is used for sanitation, landscaping, hostel facilities and laboratory cooling. To monitor and manage this, water meters are installed in key consumption points and high-usage departments. The University has initiated water budgeting and tracking at department levels to encourage conservation through benchmarking. These efforts reflect global trends in campus-based water auditing for demand-side management (Kumar & Sharma, 2022).

Rainwater harvesting systems with a cumulative storage capacity of 5,00,000 liters are installed in five academic and hostel buildings. These systems collect rooftop rainwater during monsoon months and are used for irrigating botanical garden and other spaces, which account for a significant share of campus water demand. This initiative reduces dependency on groundwater and aligns with the Ministry of Jal Shakti's Jal Shakti Abhiyan - Catch the Rain campaign (Verghese *et al.*, 2023). Future expansion plans aim to integrate additional buildings to enhance water resilience. Similar practices in other Indian Universities, such as rainwater harvesting and water reuse, have shown significant reductions in water consumption, as highlighted by Rao & Joshi (2020). Water management policies at GKVK, including rainwater harvesting and water-efficient fixtures, are aligned with national water conservation initiatives, as outlined by Mehta and Kapoor (2021).

GKVK has installed low-flow faucets and dual-flush toilets in 70 per cent of its hostels and administrative washrooms. These devices have led to a 15 per cent reduction in water usage per capita in the designated areas. As of 2025, the University has begun retrofitting the remaining units and aims to achieve full coverage by 2026, aligning with its mid-term sustainability roadmap by 2030, with further exploration of sensor-based urinals and waterless toilets in new constructions. These interventions contribute to demand-side efficiency and echo sustainability design benchmarks followed by campuses in Singapore and Australia (Bhatia & Nambiar, 2023).

The University operates a Wastewater Treatment Plant (WWTP) with a capacity of 80,000 liters, treating greywater and blackwater from hostel kitchens and bathrooms. The treated water is reused for irrigating gardens and lawns, contributing to circular water use. Regular quality monitoring ensures that reused water meets safety standards for non-potable applications. This closed-loop system reduces the burden on freshwater sources and supports campus ecological landscaping (Arora *et al.*, 2023).

Awareness campaigns are conducted annually, focusing on engaging students and staff in responsible water usage practices. These include workshops, posters, competitions and social media drives, with messages such as 'Use What You Need' and 'Think Before You Flush.' These campaigns have reportedly contributed to a 10 per cent drop in water consumptionin hostels and administrative offices, as departments adopt better usage etiquette., as evidenced by water meter readings from hostel and different blocks before and after the awareness drives, corroborated by maintenance records from 2023-2024. Such behavioural nudges play a crucial role in conservation efforts and are globally supported in institutional frameworks (Meena and Raju, 2023).

All five indicators scored in between 1-2 points, indicating a comprehensive and well managed water conservation program. GKVK's approach combines technical, behavioural and circular economy principles, positioning the University as a leader in sustainable campus water governance. These strategies not only reduce operating costs but also build climate resilience, aligning with SDG 6 (Clean Water and Sanitation) and India's National Water Mission objectives.

The Table 4 summarizes the structured assessment of waste management strategies implemented at GKVK Campus, using six key indicators that cover source segregation, composting, recycling, e-waste and hazardous waste disposal and awareness efforts. Each indicator is evaluated based on activity data, environmental impact (emission estimates) and scored under the Sustainable Practices Index (SPI).

GKVK achieves 80 per cent source segregation of campus waste into wet (organic) and dry (non-biodegradable) streams. Segregation is carried out across hostels, departments, laboratories and cafeterias. Color-coded bins and signage have been implemented, enabling streamlined down stream processing. However, the SPI score was 1 due to lack of full coverage and verification mechanisms. Studies have shown that source segregation is a fundamental requirement for successful institutional waste reduction (Sharma and Bose, 2022).

Table 4

Waste Management Practices and Sustainability Performance at GKVK Campus, UAS-B

Indicators	Activity Data	Emission Factor (Kg *Co, e*/kWh)	Estimated Emissions (kg *Co, e*)	SPI Score
Organic Farming Practices	50 per cent of farming areas are follows organic farming	Not applicable	Not applicable	1
Waterefficient Irrigation Systems	75 per cent of fields equipped with drip irrigation systems.	Not applicable	Not applicable	2
Sustainable Crop Rotation	Crop rotation implemented across 60 per cent of agricultural fields	Not applicable	Not applicable	1
Integrated Pest Management (IPM)	90 per cent of crops grown using IPM techniques	Not applicable	Not applicable	2
Agroforestry Systems	35 40 per cent of the agricultural land used for agroforestry	Not applicable	Not applicable	2
	Total			1.3

The University composts approximately 80,000 kg of organic waste annually, accounting for 52 per cent of all organic waste generated. Compost is derived from hostel kitchens, dining halls and landscape trimmings. A dedicated on-campus composting unit produces material that is then used for maintaining gardens and tree pits, reducing fertilizer demand. This has led to significant emissions avoidance from methane that would have been generated via anaerobic decomposition (Ramesh *et al.*, 2023).

Roughly 40 per cent of dry waste such as plastic, glass, paper and metals are segregated and recycled through authorized municipal vendors. Dry waste is collected daily and stored in centralized bins. The University has signed agreements with local urban waste recycling agencies to ensure that the collected material is redirected to processing plants. However, limited recycling of multi-layered plastic and low-value waste contributed to a SPI score of 1. Successful dry waste segregation requires continuous staff engagement and sorting infrastructure (Muralidharan and Jain, 2022).

GKVK has implemented a formal e-waste management system, collecting approximately 2.3 tonnes of electronic waste annually. This includes used computers, batteries, printers and lab electronics. E-waste is stored in a dedicated room and sent quarterly to CPCB-certified recyclers, as per India's E-Waste (Management) Rules, 2016. The emissions offset (11.5 kg *Co, e*) is calculated based on lifecycle estimates for e-waste recovery. These measures align with best practices from green campus certification systems globally (Yadav & Raj, 2023).

The University ensures the safe disposal of 3,700 kg of hazardous waste annually from laboratories, including solvents, acids and reagents. This waste is handed over to authorized TSDFs (Treatment, Storage and Disposal Facilities) and is recorded in laboratory-level chemical tracking systems. The emission factor (0.1 kg *Co, e*/kg) results in 370 kg *Co, e* of accounted emissions. Stringent safety procedures are followed during waste handling, aligning with CPCB norms (Banerjee *et al.*, 2023).

The composting of organic waste at GKVK aligns with global practices that have successfully reduced landfill waste, as demonstrated in the study by Kumar and Yadav (2022).

Annual waste awareness programs are held across campus involving students, faculty and staff. These include interactive sessions, poster campaigns and digital outreach focusing on waste minimization, segregation and composting techniques. These initiatives have led to improved participation in recycling programs and increased reporting of improper disposal. Although qualitative in nature, such behavioural change plays a critical role in shaping long-term sustainability attitudes (Ravi and Mukherjee, 2022). Waste management practices at GKVK, such as composting and waste segregation, align with national trends in educational institutions (Singh & Garg, 2020).

The total SPI score for the campus is 1.3 out of a possible 2, indicating a moderately developed waste management system. While composting and hazardous waste disposal show strong performance, areas like dry waste recycling and universal awareness campaigns require further scaling. Moving forward, integration with smart waste tracking apps and student-led waste audit programs could enhance performance and reporting credibility.

A structured evaluation of green infrastructure and biodiversity conservation strategies implemented at GKVK Campus are described in Table 5. The assessment is based on five key indicators - green spaces, tree plantations, biodiversity zones, green buildings and sustainable landscaping - each scored under the Sustainable Practices Index (SPI), with a maximum score of 2 per indicator.

Nearly 90 per cent of the campus area (1,200 acres) is dedicated to green cover, including forests, gardens, arboretums and agricultural research plots. These areas serve not only as carbon sinks but also help reduce the urban heat island effect, improve air quality, and support native flora and fauna. According to the qualitative observations, there are plans to increase green space by 30 hectares by 2025, aligning

TABLE 5

Green Infrastructure and Biodiversity Conservation Strategies at GKVK Campus, UAS-B

Indicators	Activity Data	Emission Factor (Kg *Co, e*/kWh)	Estimated Emissions (kg *Co, e*)	SPI Score
Green Spaces	90 per cent of campus area dedicated to green spaces (1200 acres)	Not applicable	Not applicable	2
Tree Plantation	9,800 trees planted on campus in the last 2 years.	Not applicable	Not applicable	2
Biodiversity Conservation	14 biodiversity zones with 167 hectares identified and preserved.	Not applicable	Not applicable	2
Green Buildings	40 per cent of campus buildings certified for energy efficiency (LEED)	0.199	159,200	2
Sustainable Landscaping	Organic landscaping practices in all campus gardens.	Not applicable	Not applicable	2
Total				2

with India's National Mission for a Green India (MoEFCC, 2022). Similar initiatives in the University of Delhi's Ridge Forest zone have shown ecological and microclimatic benefits (Srivastava & Nair, 2021).

Over the past two years, GKVK has planted approximately 9,800 trees as part of its reforestation and enrichment planting initiatives. These include species selected for high carbon sequestration, native value and drought resistance. The plantation program follows a decentralized model involving student clubs, faculty departments and state forest officials. Tree cover expansion is a critical low-cost climate mitigation strategy, as also emphasized by Thomas *et al.,* (2021) in their evaluation of college-based agroforestry programs.

The University has identified and actively conserved 14 biodiversity heritage sites across 167 hectares. These zones contain native flora, avian habitats, pollinator corridors and wetland patches. These sites are protected from encroachment and are regularly used for field research. Monitoring of species diversity is conducted annually using quadrat and transect methods. This aligns with global practices as seen at the University of Cape Town and Chiang Mai University, where biodiversity zones are integral to carbon neutrality frameworks (Mendoza & Pillay, 2023). GKVK's green infrastructure, with 90 per cent of its campus dedicated to green spaces, is in line with international standards for eco-friendly campus designs, as outlined by Sharma and Patel (2021).

Approximately 40 per cent of buildings on campus are certified or designed as LEED-compliant or energy-efficient buildings, incorporating passive solar design, optimized insulation and natural ventilation. These buildings reduce the need for artificial heating and cooling and significantly cut down energy use. Green buildings on the GKVK campus have significantly contributed to energy savings and emissions reductions, aligning with global best practices in educational institutions (Yadav & Singh, 2020). Using the emission factor of 0.199 kg *Co, e*/kWh, the green building strategy alone accounts for a reduction of 159,200 kg *Co, e* annually. Similar findings were observed at IIT Madras and Ashoka University, where LEED and GRIHA-certified buildings significantly improved energy performance (Gupta and Sharma, 2022).

Landscaping across the campus adheres to organic principles, avoiding synthetic fertilizers and pesticides. Instead, compost produced on campus is used to maintain the soil health of lawns, medicinal gardens and floral zones. Rain gardens and infiltration

swales are used in some areas to enhance ground water recharge. This approach promotes local biodiversity, improves ecosystem services and contributes indirectly to carbon sequestration. Campus-wide organic landscaping is a key metric in international green campus rating systems (Tanaka and Wu, 2022).

Each of the five components scored the maximum of 2, indicating an exceptionally robust green infrastructure framework. These strategies are essential for GKVK's long-term vision to become a carbon-positive and biodiversity-rich campus, contributing to SDG 13 (Climate Action) and SDG 15 (Life on Land). The integration of ecological, infrastructural and behavioural approaches demonstrates an institutional commitment to holistic sustainability.

The Table 6 illustrates the sustainable mobility interventions undertaken by GKVK Campus to reduce transportation-related greenhouse gas (GHG) emissions. These efforts are structured around five main indicators: cycling infrastructure, public transport access, electric vehicles, carpooling and policy initiatives. Each component has been evaluated with an SPI score of 1, indicating effective yet improvable practices across categories.

Approximately 10 per cent of the campus population uses bicycles as a primary mode of transport. The university has developed a bicycle-friendly campus by installing dedicated cycling lanes and secure bicycle racks at major academic and hostel blocks. This shift to active transportation aligns with the findings of Pathania and Roy (2020), who observed that Universities with cycling infrastructure report significantly lower per capita emissions from student commuting. This mode not only reduces emissions but also promotes health and spatial efficiency. GKVK's transformation into a green campus aligns with broader institutional change processes described by Rathore and Sharma (2021), where sustainability is a key driver for academic institutions.

About 20 per cent of students and staff commute using public transportation, supported by subsidized bus passes and accessible public transport connections to Bengaluru city routes. Using an average emission factor of 0.12 kg *Co, e* per km, this initiative translates to an estimated 7,200 kg *Co, e* emissions based on kilometers commuted. Encouraging mass transit aligns with India's National Urban Transport Policy (MoHUA, 2023) and studies by Singh and Jain (2021), which show public transit adoption in campuses reduces Scope 3 emissions significantly.

Table 6

Sustainable Mobility and Transportation Practices at GKVK Campus, UAS-B

Indicators	Activity Data	Emission Factor (Kg *Co, e*/kWh)	Estimated Emissions (kg *Co, e*)	SPI Score
Cycling Infrastructure	About 10 per cent of campus population uses bicycles as a mode of transport	Not applicable	Not applicable	1
Public Transport Access	20 per cent of staff and students use public transport for commuting	0.12	7,200	1
Electric Vehicles (EVs)	10 electric vehicles (EVs) in the campus fleet.	0 kg *Co, e*/kWh	0	1
Carpooling	Carpooling program with 500 participants annually	0.12	3,000	1
Sustainable Transport Policy	Sustainability policy includes carbon footprint reduction for transport.	Not applicable	Not applicable	1
Total				1

The campus has deployed 10 electric vehicles for intra-campus mobility, including staff transportation, maintenance and food delivery operations. These EVs operate with zero tailpipe emissions and if powered by the campus's solar generation units, they contribute to a net reduction in indirect emissions. Saxena *et al.* (2021) have highlighted that early EV adoption in institutional fleets improves sustainability ratings and reduces fossil fuel dependency.

An annual carpooling program involving 500 participants has been initiated. Staff and students are encouraged to form ride-sharing groups, which has led to a 20 per cent reduction in single-occupancy vehicle trips. Based on an emission factor of 0.12 kg *Co, e*/km, the estimated savings are around 3,000 kg *Co, e*/year. This result aligns with the work of Chatterjee and Srinivasan (2022), who showed that structured carpooling programs in academic institutions reduced campus emissions by up to 25 per cent over three years. Sustainable transport initiatives, such as cycling infrastructure and carpooling, are crucial for reducing emissions, as seen in the study of Rajagopalan and Singh (2020). Sustainable mobility programs, such as the promotion of cycling and carpooling at GKVK, reflect global best practices for reducing campus-related emissions (Sharma and Luthra, 2022).

The campus has implemented a formal Sustainable Transport Policy aimed at reducing the transport-related carbon footprint. This includes promotion of EVs, incentives for bus usage and plans for installing e-bike stations. Policy-based interventions, as advocated by Hidalgo and Carruthers (2020), are crucial for long-term mobility planning and behaviour change in urban educational zones. GKVK's comprehensive carbon footprint reduction strategies reflect successful models implemented in other Indian Universities (Joshi & Patel, 2020).

The Sustainable Practices Index (SPI) score of 1 for each category reflects a solid baseline in eco-mobility. To further enhance performance, the campus may explore expanding EV fleets, integrating real-time bus tracking and implementing a bicycle-sharing program. The total estimated emission savings from transport-related actions exceed 10,000 kg *Co, e*/year, making this one of the most impactful categories under Scope 3 emissions. These initiatives contribute to SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action) and align with India's Green Mobility Mission and international best practices for low-emission campuses.

An overview of sustainable agricultural practices implemented at GKVK, University of Agricultural Sciences, Bangalore, across five key dimensions: organic farming, water efficient irrigation, crop rotation, integrated pest management (IPM) and agroforestry systems are described in Table 7. Each of these indicators has received a Sustainable Practice Index (SPI) score between 1-2, reflecting high performance levels with significant impact on soil health, emission reduction and biodiversity conservation. GKVK's commitment to biodiversity conservation is a strong example of how Universities can integrate ecological services into their sustainability strategies, as noted by Reddy & Rao (2021).

At GKVK, 50 per cent of the farming area is dedicated to organic farming, where no synthetic fertilizers or chemical pesticides are used. These areas are certified under the National Organic Program and multiple varieties of crops are cultivated for both academic trials and student training. This practice plays a crucial role in minimizing nitrous oxide emissions and improving long-term soil health. Similar trends were reported in the study by Mukherjee and Barman (2021) in organic farms of West Bengal, which documented reduced GHG emissions and improved soil microbial activity under certified organic management. Sustainable agriculture practices, including organic farming and water-efficient irrigation systems at GKVK, are key components of climate-smart agriculture, which has been recognized in several studies (Iyer & Verma, 2022).

Table 7

Sustainable Agriculture Practices and Sustainability Performance at GKVK Campus, UAS-B

Indicators	Activity Data	Emission Factor (Kg *Co, e*/kWh)	Estimated Emissions (kg *Co, e*)	SPI Score
Organic Farming Practices	50 per cent of farming areas are follows organic farming	Not applicable	Not applicable	1
Water efficient Irrigation Systems	75 per cent of fields equipped with drip irrigation systems.	Not applicable	Not applicable	2
Sustainable Crop Rotation	Crop rotation implemented across 60 per cent of agricultural fields	Not applicable	Not applicable	1
Integrated Pest Management (IPM)	90 per cent of crops grown using IPM techniques	Not applicable	Not applicable	2
Agroforestry Systems	35 40 per cent of the agricultural land used for agroforestry	Not applicable	Not applicable	2
Total				1.3

Drip irrigation systems have been installed in 75 per cent of campus fields, significantly reducing water wastage and promoting targeted nutrient delivery. This technique ensures that water reaches the root zone directly, reducing evaporation losses and runoff. Tripathi and Agarwal (2020) found that drip irrigation improved water-use efficiency by over 50 per cent in semi-arid regions of Karnataka, corroborating the water-conservation benefits seen at GKVK. Efficient irrigation further contributes indirectly to emission reduction by reducing the energy used in water pumping.

Crop rotation practices are followed on 60 per cent of the cultivated land, focusing on alternating legumes, cereals and vegetables to replenish nutrients naturally. This significantly reduces the dependence on chemical fertilizers and helps control pest cycles. According to Das *et al.* (2019), crop rotation across Indian agricultural Universities improved nitrogen fixation, boosted productivity and led to measurable declines in soil degradation and input emissions.

IPM techniques are applied to 90 per cent of all crop plots, integrating mechanical, biological and botanical methods of pest control. This reduces pesticide use and promotes ecosystem-based pest regulation. Sharma *et al.* (2020) noted that IPM reduced pesticide-related emissions by 30 per cent in similar university settings while improving crop yield stability. At GKVK, this has become a key part of the academic demonstration plots and is widely adopted by local extension centers.

Agroforestry is practiced on 35-40 per cent of agricultural land, integrating trees like neem, tamarind and Gliricidia with cropping systems. These systems enhance carbon sequestration, enrich soil organic carbon, and provide climate resilience. As observed by Pandey *et al.,* (2022) in the Central Plateau of India, agroforestry systems had up to 50 per cent higher carbon storage compared to monocrop plots. At GKVK, this land-use synergy is employed in both experimental research farms and teaching blocks, offering ecological and economic co-benefits.

Each indicator scoring a 2 reflects the strong alignment of GKVK's farming systems with international sustainability benchmarks such as the FAO's Climate-Smart Agriculture Framework. The integration of these practices not only reduces the carbon footprint but also contributes to soil regeneration, biodiversity and resilience to climate stress.The observed results also align with India's National Mission on Sustainable Agriculture (NMSA) and support multiple SDGs - SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action).

TABLE 8

Sustainable Education, Research and Engagement at GKVK Campus, UAS-B

Indicators	Activity Data	Emission Factor (Kg *Co, e*/kWh)	Estimated Emissions (kg *Co, e*)	SPI Score
Sustainability in Curriculum	More than 10 courses related to sustainability offered annually	Not applicable	Not applicable	2
Sustainability Research	More than 5 ongoing sustainability-related research projects	Not applicable	Not applicable	2
Student Engagement in Sustainability	30 per cent of students participate in sustainability-related activities	Not applicable	Not applicable	2
Partnerships for Sustainability	3 partnerships with external organizations for sustainable development	Not applicable	Not applicable	2
Sustainability Workshops and Events	10 workshops held annually focusing on sustainable practices	Not applicable	Not applicable	2
Total				2

The Table 8 outlines the academic, research and participatory engagement dimensions of sustainability at GKVK, highlighting the role of education in institutionalizing sustainable practices. The table presents five indicators - curriculum, research, student engagement, partnerships and workshops - that have collectively earned a maximum Sustainability Practice Index (SPI) score of 2. These initiatives represent the university's effort to embed sustainability into its core academic functions and campus life.

The GKVK offers over 10 courses annually that directly address sustainability themes, including environmental science, sustainable agriculture, natural resource economics, renewable energy and agroecology. These are included at both undergraduate and postgraduate levels, ensuring that sustainability education is not peripheral but integrated into core learning outcomes. Studies such as Tilbury and Wortman (2008) emphasize the role of curriculum in shaping student mindsets toward sustainable behaviour, while Desha and Hargroves (2014) suggest that institutionalizing sustainability in education leads to long-term cultural shifts in campuses. GKVK's sustainability education initiatives have had a measurable impact on student engagement, reflecting findings by Deshmukh and Roy (2021) on the role of environmental education in promoting sustainable behaviour.

The University currently supports more than five funded research projects focusing on themes like carbon sequestration in agroforestry, water-saving agricultural methods and renewable energy applications in rural settings. These projects are often funded by agencies such as the DST, ICAR and international collaborations, reflecting GKVK's strong orientation towards research-based sustainability leadership. Similar university-led research practices have been documented by Lozano *et al*. (2015) and Kagawa (2007) as critical for translating sustainability from concept to practice. Educational institutions are increasingly viewed as vital contributors to climate action, as highlighted by Gupta and Mehta (2020), especially through their green campus initiatives. Green campus certifications, such as those pursued by GKVK, have proven to be effective tools in driving sustainability in educational institutions (Gupta and Joshi, 2020).

An estimated 30 per cent of students participate in sustainability-related events, such as campus clean-ups, plantation drives, biodiversity walks and NSS-led awareness campaigns. The university

promotes experiential learning through community engagement and volunteering, thereby aligning co-curricular activities with the broader sustainability goals. A comparable engagement rate was reported by Velazquez *et al.* (2006) in Mexican Universities, where student participation in environmental activities correlated with reduced institutional GHG emissions.

GKVK has established three formal partnerships with NGOs and government departments to strengthen sustainability projects, ranging from waste management to community afforestation and biodiversity restoration. These partnerships have enabled access to external funds, technical expertise, and participatory knowledge creation. According to Stephens and Graham (2010), University partnerships in sustainability accelerate implementation of SDG-aligned projects by creating synergistic opportunities beyond the academic sphere. The integration of smart energy monitoring systems at GKVK is in line with the technological advances that have been found to enhance sustainability efforts in Universities (Singh & Desai, 2021).

The campus hosts at least 10 annual workshops or awareness events related to sustainability. These include training programs on waste segregation, green building awareness, composting techniques, energy conservation and field visits to model sustainable farms. Hands-on engagement improves the effectiveness of sustainability communication, as supported by Filho *et al.,* (2018) who demonstrated that workshops are among the most effective formats for sustainability skill development in university settings.

Each indicator receives a maximum SPI score, signifying deep institutional commitment to education for sustainable development (ESD). These efforts align with the UNESCO ESD 2030 frame work and support SDG 4 (Quality Education), SDG 13 (Climate Action) and SDG 17 (Partnerships for the Goals). Notably, the emphasis on research and experiential learning enhances the university's ability to serve as a living lab for climate-smart innovations.

A structured overview of sustainable practices adopted within the hostel and food service operations at the GKVK campus provided in the Table 9. These practices contribute significantly to reducing Scope 3 emissions and enhancing sustainability performance. All five indicators score a maximum SPI score of 1, reflecting comprehensive implementation and active improvement plans.

Approximately 50 per cent of the food served in hostels is sourced locally and organically,

Table 9

Sustainable Hostel and Food Service Practices at GKVK Campus, UAS-B

Indicators	Activity Data	Emission Factor (Kg *Co, e*/kWh)	Estimated Emissions (kg *Co, e*)	SPI Score
Sustainable Food Sourcing	50 per cent of food sourced locally and organically	Not applicable	Not applicable	1
Waste Reduction in Hostels	100 per cent of hostel kitchens segregate food waste for composting and local animal breeders	Not applicable	c	1
Water Conservation in Hostels	70 per cent of hostels equipped with low-flow faucets and dual flush toilets	Not applicable	Not applicable	1
Energy Efficient Food Service Operations	Energy-efficient kitchens with energy-saving appliances	0.199	3,960	1
Sustainable Packaging	40 per cent of food packaging is biodegradable or reusable	Not applicable	Not applicable	1
Total				1

reducing emissions from long-distance transport and supporting sustainable agriculture. GKVK's practice of sourcing 50 per cent of food locally and organically is supported by studies indicating significant reductions in food-related emissions (Gupta & Pandey, 2022). Locally sourced food contributes to community resilience and minimizes packaging waste and storage requirements. A similar benefit was highlighted by Edwards-Jones *et al.,* (2008), who demonstrated that local sourcing reduces food miles and associated greenhouse gas (GHG) emissions. Additionally, Heller and Keoleian (2015) showed that plant-based and locally produced diets significantly lower food-related emissions.

All hostel kitchens (100%) segregate food waste, which is either composted or sent to local animal breeders. This prevents organic waste from reaching landfills and promotes nutrient cycling within campus gardens. While GKVK's composting efforts are commendable, the university could explore waste-to-energy technologies as seen in other Indian institutions (Banerjee & Thomas, 2021). According to Papargyropoulou *et al.,* (2014), food waste segregation and composting systems significantly reduce methane emissions in institutional settings. This initiative also supports the goals of circular bioeconomy discussed in Fanzo *et al.,* (2021).

Around 70 per cent of hostel facilities are equipped with low-flow taps and dual flush toilets, leading to a 15 per cent reduction in water use. These fixtures are known to save both water and the energy required for heating or pumping water. The university plans to complete full retrofitting by 2026, aligning with sustainable campus infrastructure frameworks. This intervention is consistent with findings by Gleick (2003) and Lee *et al.,* (2011), which validate the effectiveness of water-efficient infrastructure in institutional buildings. The university plans to complete full retrofitting by 2024, aligning with sustainable campus infrastructure frameworks. National policies on sustainable campus development, such as those suggested by Bhatia and Sharma (2021), should be adopted at GKVK to further enhance its sustainability efforts.

Cafeterias and hostel kitchens have transitioned to energy-efficient appliances, including refrigerators, ovens and dish washers, leading to a 10 per cent reduction in kitchen energy demand, with estimated emissions reduced by 3,960 kg *Co,e*/year. The emission factor used (0.199 kg *Co, e*/kWh) aligns with national averages. Research by Gustafson *et al.* (2013) emphasizes that kitchen operations are high-energy zones in university campuses and energy-efficient retrofits yield significant savings.

Approximately 40 per cent of the food packaging used in hostels is biodegradable or reusable, encompassing compostable containers, bamboo cutlery and reusable trays. This effort reduces dependence on single-use plastics and aligns with India's EPR (Extended Producer Responsibility) rules and global plastic reduction targets. According to Hopewell *et al.,* (2009) and Van Eygen *et al.,* (2018), replacing plastic packaging with compostables significantly lowers life-cycle emissions and microplastic generation in campus ecosystems.

Overall SPI Score and Strategic Relevance of GKVK Campus, UASB

Each of the five indicators in Table 10 scores 2 out of 2, confirming best-practice implementation across hostel and food service operations. These interventions contribute to reducing both direct and indirect emissions (Scope 1 and 3) and strengthen the university's case for carbon neutrality. Additionally, these practices enhance student wellbeing, environmental literacy and food-system sustainability.

The Table 10 provides a consolidated view of the Sustainability Practice Index (SPI) across eight major functional categories of the GKVK campus, aggregating performance scores based on implementation scale, environmental benefits and emission reductions. The SPI score (ranging from 0-3) reflects the degree to which each practice is adopted and its contribution to emission mitigation and sustainable development goals (SDGs). Similar

TABLE 10

Overall Sustainability Practice Index (SPI) of GKVK Campus, UAS-B

Category	Indicators	Total Activity Data	Total Emissions (kg *Co, e*/year)	SPI Score (0-2)
Energy Management	Use of Solar Panels	78,20,000 kWh	15,57,180 kg *Co, e*	2
Water Conservation	Rainwater Harvesting	1.5 million liters /month	Not applicable	1.2
Waste Management	Waste to Landfill	1,50,000 kg/year (which include all the waste)	Not applicable	1.6
Green Infrastructure and Biodiversity	Green Buildings	1200 hectares of green space	Not applicable	2
Sustainable Mobility	Electric Vehicles	100 vehicles, 500 participants in carpooling	30,000 kg *Co, e*	1
Sustainable Agriculture	Organic Farming	50 per cent organic farming area	Not applicable	1.3
Education/Research/Engagement	Sustainability in Curriculum	10 courses on sustainability	Not applicable	2
Hostel and Food Services	Energy Efficiency in Hostels	50per cent local food sourcing	5,000 kg *Co, e*	1

findings have been observed in the study of Kishor *et. al.,* (2023).

GKVK has achieved 20 per cent solar energy substitution, producing approximately 15,57,180 kg *Co, e*/year of equivalent reductions. The installation of 1 M W solar PV systems has offset conventional grid emissions significantly. Solar PV systems are monitored *via.,* a central dashboard and undergo quarterly maintenance by a third-party service provider. Annual performance audits ensure the systems meet efficiency targets and comply with MNRE maintenance guidelines. According to Byrne *et al.,* (2017), university campuses transitioning to solar energy can reduce their GHG emissions by 18-30 per cent. GKVK's 2/3 score is justified as it hasn't yet crossed the 50 per cent renewable mark. Future expansion may push this closer to a full score. Energy efficiency initiatives at GKVK, particularly the integration of solar energy, are consistent with findings from Kaur and Bhullar (2020) on successful renewable energy integration in academic settings.

with 1.5 million litres/month harvested through campus-wide rainwater harvesting systems, GKVK reduces reliance on municipal water supply for irrigation and sanitation. Palla *et al.* (2011) reported that integrated rainwater harvesting systems can reduce water demand by up to 35 per cent in urban institutional campuses. This effort, coupled with STP reuse and low-flow fixtures, earns GKVK a solid sustainability score. The rainwater harvesting systems undergo annual desilting and inspection, coordinated by the Estate Maintenance Division. Maintenance logs are maintained for each building, and gutters and filters are cleaned prior to monsoon onset to ensure optimal collection efficiency.

Despite significant efforts in composting and e-waste collection, 50 per cent of total campus waste still goes to landfills-a concern highlighted in Scope 3 emissions. Only partial waste diversion practices are in place. Composting units are managed daily by trained estate workers, with periodic checks for temperature, moisture and turnover. E-waste and hazardous waste storage areas are audited quarterly, and vendors are required to provide recycling and disposal certificates after each pickup. Wilson *et al.* (2012) emphasized the importance of a zero-waste

goal in educational institutions to minimize landfill emissions and leachate risks. The low SPI reflects room for systemic improvements.

With 1,200 hectares of green space, including agroforestry zones and biodiversity reserves, GKVK integrates built and natural infrastructure. Moreover, 70 per cent of buildings include green features such as LEED design elements. Li and Weng (2007) confirmed that such green infrastructure contributes to heat island mitigation and carbon sequestration. Thus, a high SPI is justified. Biodiversity conservation zones at GKVK, which cover 167 hectares (Biodiversity Heritage site), align with best practices for campus biodiversity preservation, as demonstrated by Sen and Roy (2021).

Although the university has introduced 10 electric vehicles (EVs) and runs a carpooling program with 500 participants, the emission reduction remains limited (30,000 kg *Co, e*/year). Creutzig *et al.* (2015) reported that urban transport interventions need broad modal shifts to realize deeper climate benefits. Hence, GKVK scores modestly here due to limited impact and low user penetration.

With 50 per cent of agricultural area under organic practices with 54 ha and widespread use of drip irrigation and crop rotation, GKVK's farming system is climate-smart and soil-friendly. Scialabba and Müller-Lindenlauf (2010) argue that organic farming sequesters more carbon and uses fewer fossil inputs. This indicator thus justifies a high SPI.

More than 10 sustainability-linked courses, multiple research grants and active student engagement through NSS and community forestry initiatives show academic commitment to the SDGs. Stephens and Graham (2010) suggest that integration of sustainability in curriculum amplifies behavioural change and system-wide adoption.

GKVK has adopted energy-efficient hostel kitchens, food waste composting and 50 per cent local sourcing, reducing *Co, e* emissions by over 5,000 kg/year. These actions contribute to local food resilience and reduced supply chain emissions. Studies such as Vermeulen *et al.* (2012) support the efficacy of local sustainable food systems in campus settings.

This SPI table provides a multi-dimensional lens for benchmarking campus sustainability performance. The scores illustrate strengths in water conservation, green infrastructure, agriculture and education, while revealing improvement areas in waste and transport sectors. With targeted interventions, GKVK can aim for a carbon net-negative campus.

The Table 11 provides a comparative analysis of the Sustainability Practice Index (SPI) scores of GKVK

Table 11

Comparative Analysis of SPI Scores across Global and National Averages

Category	GKVK Campus (SPI Score 0-2)	National Average (SPI Score 0-2)	Global Average (SPI Score 0-2)
Energy Management	2	1	2
Water Conservation	1.2	1	2
Waste Management	1.6	1	1
Green Infrastructure and Biodiversity	2	2	2
Sustainable Mobility	1	1	2
Sustainable Agriculture	1.3	1	2
Education/Research/Engagement	2	1	2
Hostel and Food Services	1	1	2

Note : National SPI averages are derived from TERI (2020), UGC Green Campus Guidelines (2021) and AICTE (2022). Global averages are synthesized from AASHE STARS category-level reports (2023), UI GreenMetric methodology (2022) and peer-reviewed cross-institutional benchmarking studies (e.g., Leal Filho *et al..,* 2019)

Campus across eight major sustainability domains, benchmarked against national and global SPI standards. The SPI score (0 - 2) reflects the extent of implementation, impact on emissions and alignment with best practices. The results illustrate GKVK's leadership in several domains while also highlighting key gaps requiring policy or operational focus.

GKVK scores a full 2, outperforming the Indian average (1) and matching the global average (2). With 20 per cent of energy sourced from solar PV, the campus demonstrates proactive investment in renewable infrastructure. While most Indian Universities still rely on conventional energy due to policy and budget limitations (Anupam *et al.*, 2021), GKVK reflects progress toward India's National Solar Mission targets. The success of solar energy adoption at GKVK is reflective of national policies supporting renewable energy in educational institutions (Rajput & Gupta, 2020).

Both national and global benchmarks score 1.2, which GKVK matches with strong rainwater harvesting, low-flow fixtures and 80,000 liters/day of wastewater reuse. According to Kundzewicz *et al.* (2008), effective water conservation practices are key to institutional climate resilience. GKVK's SPI score reflects high water-use efficiency aligned with SDG 6 (Clean Water and Sanitation).

GKVK scores 1.6, consistent with the national average, but below the global average (2). This moderate rating is due to 50 per cent waste still going to landfill, despite composting and recycling programs. Hoornweg and Bhada-Tata (2012) report that world-class Universities aim for more than 80 per cent landfill diversion. Therefore, GKVK has scope to improve through zero-waste policies and digitized waste audits.

With 90 per cent green space coverage and several protected biodiversity blocks, GKVK scores 2, aligning with both national and global averages. Gill *et al.* (2007) showed that integrated urban biodiversity systems significantly mitigate heat island effects and enhance ecological value in campuses. GKVK's conservation and green building initiatives demonstrate climate responsiveness.

GKVK scores 1, matching the national average but lagging behind the global best (2). Although initiatives like EV fleets and carpooling exist, low modal shift from two-wheelers and limited public transit access constrain this sector. Global campuses achieving higher scores typically implement cycling highways, on-campus bus loops and carbon-neutral shuttle services (Banister, 2008).

GKVK achieves 1.3, leading over the national average of 1 and on par with global institutions. Its 50 per cent organic conversion, drip irrigation, crop rotation and agroforestry are exemplary. Seufert *et al.* (2012) highlight the role of institutional farms in modelling climate-smart agriculture. The campus showcases scalable models for other Universities in India.

GKVK attains a full 2, again ahead of the national average (1) and aligned globally. Over 10 sustainability courses, more than five research projects and active NSS engagement foster campus-wide awareness. Barth and Rieckmann (2012) argue that integrating sustainability in the curriculum is key to fostering behavioural transformation. GKVK reflects best practice in this domain.

The campus matches global and exceeds national SPI scores with a score of 1. Sustainable sourcing (50%), energy-efficient kitchens and food waste composting are strong indicators of operational sustainability. Studies by Springmann *et al.* (2016) suggest food systems must be addressed for both emission reductions and health benefits - GKVK's hostel operations are an emerging model.

GKVK exceeds the national average in six out of six categories and is on par with global standards in five categories. The campus serves as a high-impact demonstration site for sustainable university governance in India. Similar practices were observed in other top Indian institutions, reinforcing the potential of Universities as hubs for sustainability (Bedi and Singhal, 2021). However, waste management and transport remain priority areas for reform. Targeted investments in electric mobility,

biogas recovery and zero-waste frameworks can bridge the remaining gaps.

This research highlights the significant strides made by the GKVK campus of the University of Agricultural Sciences, Bangalore, in adopting eco-friendly practices, positioning it as a leader in sustainable campus operations in India. The comprehensive evaluation of GKVK's sustainability initiatives reveals a well-integrated approach to reducing environmental impact across multiple sectors, including energy, water, waste and agriculture. The campus's energy management system, particularly the installation of solar panels that generate approximately 1.5 million kWh per year, is aligned with national and global objectives, such as India's National Solar Mission, aiming for a substantial increase in renewable energy capacity. The integration of renewable energy in GKVK's energy management strategy is in line with findings from Sinha and Tripathi (2022), who highlighted its importance in reducing campus carbon footprints. Similarly, water conservation efforts, including rainwater harvesting and the use of low-flow devices in 70 per cent of the hostels, contribute to substantial reductions in water consumption, promoting sustainable use of this critical resource.

In waste management, GKVK segregates 80 per cent of its waste, with 52 per cent of organic waste being composted. Although the university has made impressive progress in composting, recycling and e-waste management, further improvements are needed in ensuring that more waste is diverted from landfills. This aligns with global best practices, where zero-waste goals are being pursued by leading academic institutions. The university also leads by example in sustainable agriculture, with 50 per cent of its agricultural land dedicated to organic farming and widespread implementation of water-efficient irrigation practices.

One of the standout features of GKVK's approach is the focus on green infrastructure. With 90 per cent of its campus area dedicated to green spaces, the university not only sequesters carbon but also improves air quality, enhances biodiversity and mitigates the urban heat island effect. The university's commitment to enhancing biodiversity through conservation zones and tree plantations, with over 9,800 trees planted in the last two years, under scores its dedication to long-term ecological sustainability.

Sustainable mobility, although less advanced than other sectors, is an area with room for improvement. While cycling infrastructure and public transport access are promoted, the campus's electric vehicle (EV) program and carpooling initiatives contribute only modestly to emission reductions. Future improvements could involve the expansion of EV fleets and enhanced public transport connectivity.

Educational engagement is another strong pillar of GKVK's sustainability efforts. Over 30 per cent of students participate in sustainability-related activities, and the campus offers a variety of courses focused on environmental conservation and climate action. These educational programs, combined with research initiatives, ensure that sustainability is ingrained in the academic culture of the institution.

Overall, the GKVK campus has made significant progress towards becoming a model of sustainable development. However, there are areas, particularly in waste management and sustainable mobility, where targeted interventions can help GKVK meet its long-term sustainability goals. The university's commitment to carbon neutrality, biodiversity preservation and climate resilience sets an example for other educational institutions in India and globally.

To bridge the remaining gaps in sustainable mobility and waste management, GKVK plans to scale up electric vehicle adoption by adding 20 more EVs by 2026, implement a smart bicycle-sharing system and integrate real-time public transport tracking. In waste management, the University aims to reduce landfill contributions to below 20 per cent by 2027 through increased recycling, biogas generation from food waste, and smart bin monitoring. These forward-looking initiatives are intended to bring GKVK on par with global best practices and achieve a higher landfill diversion rate and lower transport emissions.

The research study not only contributes to understanding the current state of sustainability in Indian Universities but also provides a roadmap for future enhancements. As GKVK continues to refine its practices, it has the potential to become a carbon-negative campus, setting a new benchmark for higher education institutions in India.

Policy Implications

The findings of this study on eco-friendly practices at GKVK campus provide key policy implications for higher education institutions, state governments and national bodies in India.

Incentivizing Green Campus Initiatives : The successful integration of renewable energy, particularly solar power, highlights the need for policies that incentivize solar adoption in educational institutions. State and national governments could offer financial support, tax rebates and technical assistance to encourage Universities to install renewable energy systems.

Strengthening Waste Management Frameworks : GKVK's waste management efforts, including composting and e-waste recycling, demonstrate the importance of policy frameworks that promote zero-waste practices. Policymakers should establish clear guidelines for waste segregation, recycling and composting in educational institutions to reduce landfill waste and encourage sustainable practices.

Promoting Sustainable Agriculture and Education : GKVK's focus on organic farming, water-efficient irrigation and agroforestry presents a model for integrating sustainability into academic curricula and research. Policymakers should support the inclusion of sustainable agricultural practices in university programs and provide funding for related research projects, aligning with India's National Mission on Sustainable Agriculture.

Encouraging Sustainable Mobility Programs : While GKVK has made strides in promoting cycling and carpooling, there is room for improvement in sustainable transport. National and state policies could encourage Universities to expand electric vehicle (EV) fleets and invest in cycling infrastructure, reducing the carbon footprint of campus mobility.

Enhancing Water Conservation Policies : GKVK's rainwater harvesting and water-saving devices showcase the potential for water conservation on campuses. State-level policies could mandate similar initiatives, especially in water-scarce regions, to promote efficient water use in educational institutions.

Building Awareness : Integrating sustainability into curricula, workshops and campus-wide campaigns is essential for fostering a culture of environmental responsibility. Policymakers should incentivize Universities to adopt comprehensive sustainability education programs, contributing to long-term behaviour change. These policy actions can support the scaling of eco-friendly practices across higher education institutions, contributing to broader sustainability goals in India.

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