Journal of Agricultural Policy and Transformation *(AgriPaT)*
ISSN: 3134-819X
Journal Homepage: http://www.ageconfrontiers.com/agripat
Vol. 2(3) Open Access

Climate Mitigation, Campus Carbon Accounting, and Sustainability Transition in Higher Education: Evidence from Pakistan

Farhana Gul[1]*, Laiba Urooj[1] & Samiullah Khan[1]
[1] Department of Economics, University of Swabi, Swabi, Pakistan
** Corresponding author:* faree_aup@hotmail.com

ARTICLE INFO

Keywords

- *Carbon Footprints*
- *Campus Carbon Accounting*
- Carbon Mitigation
- *Low Carbon Transition*

Article History
Received: 11 June 2026
Revised: 26 June 2026
Accepted: 27 June 2026
Available online: 28 June 2026

DOI
10.66529/agripat.2026.2.3.93

ABSTRACT

Higher education institutions have an important role in climate mitigation, yet campus greenhouse gas inventories remain limited in developing countries. This study estimates the carbon footprint of the University of Swabi, Pakistan, for 2025 using the Greenhouse Gas Protocol. Emissions from university-operated transport (Scope 1), purchased electricity (Scope 2), and private commuting and solid waste (Scope 3) were quantified using institutional records and Pakistan-specific emission factors. The university's total annual carbon footprint was estimated at 855.49 tCO_2e, with purchased electricity contributing 46.38%, private commuting 36.75%, solid waste 15.91%, and university transport 0.98%. The per capita footprint was approximately 0.19 tCO_2e, reflecting the institution's relatively small size and developing infrastructure. Sensitivity analysis indicated total emissions could range from 684 to 1,027 tCO_2e under alternative assumptions. The findings identify electricity consumption and commuting as the principal emission sources and highlight the need for improved carbon accounting, renewable energy adoption, energy efficiency, sustainable transport, waste management, and institutional sustainability governance. This study provides a baseline for monitoring campus emissions and supports low-carbon university development in resource-constrained settings.

Citation: *Gul, F., Urooj L. & Khan S. (2026). Climate Mitigation, Campus Carbon Accounting, and Sustainability Transition in Higher Education: Evidence from Pakistan.* J. Agric. Pol. & Transf. 2(3): 150-161. https://doi.org/10.66529/agripat.2026.2.3.93

1. INTRODUCTION

The carbon footprint concept has become a practical way to translate diverse human activities into a common climate-impact metric. In institutional settings, it helps decision makers identify where greenhouse gas emissions are produced, which activities are most carbon intensive, and where mitigation efforts can deliver the greatest benefit. Wiedmann and Minx (2008) define a carbon footprint as the total amount of carbon dioxide emissions directly and indirectly caused by an activity, commonly expressed in carbon dioxide equivalent terms. For universities, this metric is especially useful because their operations combine classrooms, laboratories, offices, transport systems, food services, waste streams, and growing built infrastructure.

Climate change is no longer only a scientific debate; it is a governance, development, and institutional-management issue. The IPCC reports emphasize that human activities are the dominant driver of recent warming and that mitigation requires rapid changes across energy, transport, land use, and consumption systems (IPCC, 2021, 2023). The consequences of warming include changing rainfall regimes, more frequent extreme events, risks to water availability, biodiversity losses, and damage to social and economic systems. Pakistan is highly exposed to such climate-related hazards even though its own contribution to cumulative global emissions remains small (Ministry of Climate Change, Government of Pakistan, 2022), and the Sustainable Development Goals frame climate action and quality education as interlinked institutional priorities (United Nations, 2023). Universities that generate knowledge and train future professionals therefore have a clear interest in ensuring that their own operations reflect the environmental responsibility that they teach and promote.

Higher education institutions are often compared with small cities because they concentrate on people, buildings, utilities, transport movement, and waste generation within a defined area (Mustafa et al., 2022). The comparison is useful, but it can hide an important point: university emissions are not produced by a single activity. They result from several interconnected systems, including electricity use, commuting, institutional vehicles, procurement, food, water, waste, and construction. A carbon inventory therefore provides more than a single number; it creates a management map that can guide investment, policy, behavior change, and accountability.

Internationally, universities have begun to use campus carbon accounting to support climate action plans, sustainability reports, and carbon-neutrality commitments. Examples from Australia, Europe, China, and the United States show that energy-efficient buildings, renewable-energy procurement, campus mobility planning, circular-waste systems, and sustainability reporting can reduce institutional emissions when embedded in governance rather than treated as isolated projects (Valls-Val & Bovea, 2022; Paredes-Canencio et al., 2024). These experiences are relevant for Pakistani universities, but direct transfer is not always possible because campus size, resources, energy systems, and data availability differ substantially across countries.

The Asian higher education sector is expanding rapidly. In countries such as China, India, and Japan, growing student populations and campus infrastructure have increased demand for electricity, transport, and materials. Many universities in the region now use green-campus strategies to reduce environmental pressure through renewable energy, efficient buildings, waste reduction, and sustainable mobility. For Pakistan, the issue is even more urgent because the country is highly exposed to climate-related hazards while its institutions continue to grow. Universities can either repeat carbon-intensive development patterns or use their current expansion phase to build low-emission systems from the beginning.

Research on carbon footprints in Pakistani universities is still emerging. Available studies indicate that electricity and transport are often major contributors to institutional emissions. Work on NED University, for example, used an online carbon calculator to estimate a per-student footprint of 1.79 tCO_2e and proposed interventions such as urban forestry, tree plantation, and water recycling (Mustafa et al., 2022). Studies from other Pakistani contexts also show the relevance of electricity consumption, commuting, and waste generation in shaping carbon outputs. However, university-specific evidence remains uneven, and many institutions do not yet have baseline inventories that can support planning.

This gap is particularly visible in Khyber Pakhtunkhwa. The University of Swabi is a relatively young public institution established in 2012. Its infrastructure is still developing, and formal environmental accounting has not been institutionalized. This creates a strategic opportunity. If emissions are measured early, sustainability actions can be built into campus growth before high-carbon systems become locked in. Without such a baseline, future decisions about energy systems, transport, buildings, and waste management may be made without understanding their long-term climate implications.

The present study therefore develops a baseline carbon-accounting inventory for the University of Swabi for 2025 using available institutional data and documented emission-estimation procedures. The work focuses on purchased electricity, university-operated and private transportation, and solid waste generation because these sources are measurable with the data currently available and are widely recognized as important components of university carbon inventories. Whereas the university's own working records had treated private vehicle commuting as a direct institutional emission, this study reclassifies private car and motorcycle commuting as an indirect Scope 3 source, consistent with Greenhouse Gas Protocol boundary conventions, and adds an explicit treatment of methodological uncertainty. The results are intended to provide a defensible baseline for university leadership, support future annual monitoring, and encourage a practical sustainability agenda for the campus.

Research Objectives

This study pursues five specific objectives: (1) to estimate the 2025 carbon footprint of the University of Swabi using transportation, electricity consumption, and solid waste generation as core indicators, with emission sources allocated to Scopes 1 through 3 consistent with Greenhouse Gas Protocol boundary conventions; (2) to calculate the relative contribution of each indicator to total institutional emissions and to characterize the sensitivity of the total footprint to key data assumptions; (3) to identify the main emission hotspots within the university's current operations; (4) to compare the University of Swabi's footprint with selected national and international university cases while making explicit the boundary and methodological differences that affect comparability; and (5) to recommend practical mitigation and data-governance measures that can support sustainable campus development.

2. LITERATURE REVIEW

Carbon footprint research has developed from household and industrial applications into a wider institutional assessment tool. Fu et al. (2024) used household-level data from China to show that energy, food, and transport are major contributors to household carbon footprints and that socio-economic characteristics influence emission profiles. Although household studies differ from campus inventories, they are useful because universities also contain repeated daily behaviors, mobility patterns, and resource-use decisions. Khan and Hussain (2017) similarly found differences between urban and rural household ecological footprints in Islamabad, showing how income, transport distance, consumption patterns, and family structure can influence environmental pressure.

Industrial studies from Pakistan provide another methodological reference point. Akhtar et al. (2017) estimated the carbon footprint of a beverage bottling unit in Lahore and showed that electricity-related Scope 2 emissions were the dominant component. Hussain and Malik (2015) assessed the Pakistan Tobacco Company production chain and separated emissions into direct, indirect, and miscellaneous categories. Naderipour et al. (2021) similarly combined transportation, electricity, water, and waste indicators within a single institutional inventory and showed how renewable-energy substitution could reduce each component. These studies demonstrate that clear boundary-setting is essential because emissions can vary sharply depending on whether the assessment includes only direct operations or also the wider supply chain — a lesson that is directly relevant for universities, where procurement, commuting, laboratories, and buildings can broaden the inventory considerably.

Within higher education, carbon-footprint assessment is increasingly connected to institutional sustainability reporting. Lozano (2011) argued that sustainability reporting in universities was still less mature than corporate reporting and emphasized the need for more transparent environmental, social, and educational disclosures. This remains relevant because many universities collect operational data but do not convert those data into regular sustainability reports. A carbon inventory can become the first step toward such reporting by establishing measurable indicators, institutional responsibilities, and annual benchmarks.

Several university studies show that the distribution of emissions depends strongly on campus context and on how the inventory boundary is drawn. Battistini et al. (2023) developed a methodology for the University of Bologna's multicampus structure using the GHG Protocol, ISO 14064, and ISO/TR 14069, and highlighted the importance of multicampus boundaries and the changing role of digital infrastructure, including information technology procurement. Haseeb et al. (2022) studied the University of the Punjab before and during COVID-19 restrictions and found that electricity, transportation, and waste were the key sources, with transport emissions dropping sharply during lockdown. Yáñez et al. (2020) similarly evaluated a university campus inventory and emphasized that the relative weight of each source category depends heavily on which Scope 3 categories an institution chooses to measure. These cases illustrate how operational behavior, campus occupancy, and boundary choices can substantially alter reported institutional emissions, which is a central methodological concern for the present study.

Research from NED University in Pakistan is especially relevant. Mustafa et al. (2022) used a carbon-calculator tool to estimate the footprint of NED University's main campus at approximately 21,500 tCO_2e for 2017, equivalent to about 1.79 tCO_2e per student, and used the findings to motivate interventions such as plantation, urban forest development, and water recycling. Their work shows that Pakistani universities can adopt structured carbon accounting and translate the findings into action; however, because the NED figure is reported per student rather than per total campus population, and because the carbon-calculator methodology likely incorporates a different mix of Scope 3 categories than the present study, direct numerical comparison with the University of Swabi must be treated cautiously.

Other international cases extend the evidence base. Esor et al. (2021) estimated student carbon footprints at Cross River University of Technology in Nigeria using a carbon-footprint calculator that captured student activities related to home, travel, goods, and food. Kaur and Luthra (2023) conducted a carbon audit of Guru Nanak Dev University in India and identified electricity and transportation as major sources, while recommending energy efficiency, sustainable transport, and waste-management improvements. Li et al. (2015) took a different approach at Tongji University in China, surveying individual students to estimate a personal carbon footprint of 3.84 tCO_2e per student arising from daily life, transportation, and academic activities; because this figure measures individual consumption behavior rather than an institutional Scope 1–3 inventory divided by total campus population, it is conceptually distinct from, and should not be directly compared with, an institutional per capita footprint such as the one calculated for the University of Swabi. Collectively, such studies show that universities in developing and emerging contexts often face similar challenges: data gaps, dependence on grid electricity, high reliance on conventional transport, and limited waste segregation.

A growing body of work has also focused on tools and accounting frameworks. Paredes-Canencio et al. (2024) reviewed methods for university carbon-footprint assessment and found that many institutions report Scope 1 and Scope 2 emissions more consistently than Scope 3 emissions, because indirect sources such as commuting, procurement, and waste are harder to measure; their review emphasized the need for standardized approaches, life-cycle thinking, and stronger institutional leadership. Mariette et al. (2021) offered an open-source tool for estimating the carbon footprint of research activities, highlighting academic travel, computing, and laboratory work as important sources of emissions. Gupta et al. (2022) further showed that the environmental impact of computing includes both operational electricity use and embedded emissions from hardware manufacturing.

Carbon-neutrality commitments provide another strand of literature, and a more critical one than is sometimes acknowledged. The University of Turku (2020) estimated its carbon footprint to inform a goal of carbon neutrality by 2025 and identified properties, travel, and laboratory activities as major contributors. Barron et al. (2021) examined eleven United States higher education institutions that had already announced carbon neutrality and found that most claimed reductions relied on offsets, unbundled renewable energy certificates, and bioenergy rather than on-site decarbonization, with several institutions showing no underlying reduction in fossil-fuel combustion despite being formally “carbon neutral.” These cases show that universities can make ambitious commitments, but they also underline a distinction relevant to the present study: credible carbon neutrality and credible carbon accounting both require a robust baseline, transparent boundary definitions, and sustained, verifiable reductions rather than reliance on offsets or favorable accounting choices alone.

Overall, the literature establishes four points that shape this study. First, electricity and transport frequently dominate university carbon footprints, particularly where campuses depend on fossil-fuel-based electricity and private mobility. Second, Scope 3 emissions are important but difficult to measure, and the boundary choices for Scope 3 strongly affect both the reported total and the validity of cross-institution comparisons. Third, carbon accounting is most useful when it leads to institutional policy and improved data systems, not merely reporting. Fourth, Pakistani university evidence remains limited, especially for smaller and younger campuses, and existing comparator studies vary widely in scope, population basis, and methodology. The University of Swabi case contributes to this gap by providing a first baseline estimate, an explicit treatment of boundary and measurement uncertainty, and a practical mitigation pathway.

3. METHODOLOGY

This study develops a baseline carbon-accounting inventory for the 2025 calendar year for the New Campus of the University of Swabi (UOS). The inventory covers four operational categories: university-operated bus transportation, private car and motorcycle commuting, purchased electricity, and solid waste generation. These categories were selected because they are major emission sources in many university studies and because they could be assessed using institutional records and documented estimation methods. The study does not claim to represent the complete life-cycle footprint of the university; rather, it establishes a baseline for the operational sources that could be measured, even approximately, with the data currently available.

The analytical boundary follows the logic of the Greenhouse Gas Protocol developed by the World Resources Institute and the World Business Council for Sustainable Development (WRI & WBCSD, 2004). Emissions were classified into three Scopes. Scope 1 comprises direct emissions from university-owned and university-operated vehicles, represented here by the university bus fleet. Scope 2 comprises indirect emissions from purchased electricity consumed on campus. Scope 3 comprises other indirect emissions, represented in this study by private vehicle commuting and solid waste generation. This boundary differs from the classification used in the university's internal working calculation, which had grouped private car and motorcycle traffic together with university buses under Scope 1. Because the university does not own, lease, or operationally control private commuting vehicles, this study follows standard GHG Protocol guidance and reports private car and motorcycle commuting under Scope 3, Category 7 (employee and student commuting). The total footprint is unaffected by this reclassification; only the Scope attribution changes, as reflected in Table 2.

Water use, procurement, food services, construction materials, embodied emissions, laboratory operations, hostel energy use, and off-campus commuting beyond the defined assumptions were not included because reliable data were not available at the time of the study. Because Scope 3 categories are typically the most material source of underestimation in university inventories (Paredes-Canencio et al., 2024), the exclusion of these categories means that the reported total of 855.49 tCO_2e should be read as a partial, conservative baseline rather than a comprehensive institutional footprint; the true footprint, inclusive of these excluded categories, is almost certainly higher.

Data were collected from the Electrical Department and Administrative Office of the University of Swabi. Where direct records were incomplete, estimates were developed using documented approaches from related university and institutional studies and from Pakistan-specific government and academic sources (Li et al., 2015; Haseeb et al., 2022; Naderipour et al., 2021). This approach is common in first-generation institutional carbon inventories, but the assumptions should be replaced with measured records in future assessments as monitoring systems mature.

Data Sources and Assumptions

The electricity calculation used recorded annual electricity consumption for January to December 2025. Transportation calculations considered university buses and the regular entry of private cars and motorcycles, using estimated campus travel distances and annual operating days. Waste generation was estimated from the total campus population and a documented per-person waste-generation rate because direct measured waste data were not available. All outputs were expressed in tonnes of carbon dioxide equivalent (tCO_2e).

A total institutional population of 4,453 people (students, faculty, administrative staff, and support workers) was used for per capita calculations. The study used 240 operating days per year for transport and waste calculations, consistent with the university's academic and administrative calendar. Table 1 summarizes the inputs, operational data, and outputs used in the calculation.

Transportation Emissions: Scope 1

University-operated bus transportation is the only Scope 1 transport source in this inventory. The university operates five official buses for student transport. Bus emissions were calculated as the number of buses multiplied by a round-trip factor of two, an approximate one-way route distance of 35 km, and 240 annual operating days, converted to tonnes of CO2e using an emission factor of 0.01 tCO2e per 100 vehicle-kilometers (approximately 0.10 kg CO2e per vehicle-kilometer). This factor approximates default road-transport emission factors for diesel buses reported by the IPCC (2006) and the United States Environmental Protection Agency (2023), adjusted downward to reflect the smaller, older vehicle fleet typical of Pakistani university bus services relative to the larger fleet assumed in many high-income-country default factors. Using these assumptions, bus-related emissions were estimated at 8.40 tCO2e per year.

Commuting Emissions: Scope 3

Private cars and motorcycles entering the campus are a regular component of campus movement but are not owned, leased, or operationally controlled by the university; consistent with GHG Protocol Scope 3, Category 7 guidance, they are reported here as commuting-related indirect emissions rather than as direct institutional emissions. The estimate considered approximately 230 cars and 850 motorcycles, an assumed one-way commuting distance of 5 km, a round-trip factor of two, and 240 annual operating days.

Car-related emissions were calculated as 230 vehicles × 2 × 5 km × 240 days, converted using an emission factor of 0.02 tCO2e per 100 vehicle-kilometers (approximately 0.20 kg CO2e per vehicle-kilometer), consistent with default passenger-car emission factors reported by the IPCC (2006) and the United States Environmental Protection Agency (2023) for an average gasoline passenger vehicle. This produced an estimated 110.40 tCO2e. Motorcycle-related emissions were calculated using the same distance and operating-day assumptions with an emission factor of 0.01 tCO2e per 100 vehicle-kilometers (approximately 0.10 kg CO2e per vehicle-kilometer), broadly consistent with reported two-wheeler emission factors for South Asian motorcycle fleets, producing an estimated 204.00 tCO2e. Total commuting-related emissions were therefore 314.40 tCO2e.

This calculation should be treated as an operational approximation rather than a full commuting life-cycle assessment, because the underlying vehicle counts and distances are institutional estimates rather than measured survey data. Future inventories should improve this component by collecting origin-destination data, fuel type, vehicle occupancy, and actual kilometers traveled by staff and students through a dedicated commuting survey.

Electricity Emissions: Scope 2

Electricity emissions were classified as Scope 2 because the university consumes electricity generated outside the campus and supplied through the national grid. Electricity supports classrooms, offices, laboratories, libraries, administration, printing, and other routine functions. Annual electricity consumption was multiplied by an emission factor of 0.84 kg CO2 per kWh: electricity emissions = (annual electricity use in kWh ÷ 1,000) × 0.84.

This factor represents a delivered (consumption-based) emission intensity for Pakistan's predominantly fossil-fuel-based national grid. Recent combined-margin estimates of Pakistan's generation-side grid emission factor range from approximately 0.48 to 0.65 tCO2/MWh depending on the hydrological year and the share of thermal generation on the margin. Pakistan's electricity distribution companies, however, reported average transmission and distribution losses of approximately 17–22% in 2023–2024 (National Electric Power Regulatory Authority, 2023). Adjusting a generation-side factor of approximately 0.65–0.70 tCO2/MWh for losses of this magnitude yields a delivered emission factor in the region of 0.80–0.88 kg CO2/kWh, consistent with the 0.84 kg CO2/kWh value used in this study. This derivation is presented for transparency; it does not eliminate the underlying uncertainty in Pakistan's grid emission factor, which is why Table 3 reports the sensitivity of the total footprint to this assumption.

This method provides an estimate of emissions associated with purchased electricity but does not include embodied emissions from electrical equipment or building construction, nor does it separate buildings by use type. Future work should examine building-level consumption through sub-metering to identify high-load areas and energy-efficiency priorities.

Waste-Generation Emissions: Scope 3

Waste emissions were included as an indirect Scope 3 source. Because the University of Swabi does not yet maintain measured waste-weight records, a waste-generation rate of 0.283 kg per person per day was applied. Pakistan-specific studies report a national range of approximately 0.24–0.65 kg per person per day for municipal and institutional solid waste, with most government and academic sources placing the typical range between 0.283 and 0.612 kg per person per day (Jadoon et al., 2014; UNDP Pakistan, 2022). The value adopted in this study sits at the lower bound of this documented range, which is treated as conservative because the campus has comparatively limited catering, hostel, and retail activity relative to the municipal populations on which most published Pakistani waste-generation rates are based; a campus with more extensive food services and residential facilities would be expected to generate waste closer to the upper end of the national range.

This waste-generation rate was multiplied by the campus population (4,453 persons) and 240 operating days to obtain an estimated annual waste mass, which was then converted to emissions using a coefficient of 0.45 kg CO_2e per kg of waste. This coefficient approximates the IPCC (2006) default emission factor for municipal solid waste disposed of in unmanaged, shallow disposal sites without engineered methane recovery, which is consistent with prevailing solid-waste disposal practice in Pakistan, where most municipal waste is openly dumped or disposed of in uncontrolled sites rather than sent to sanitary landfills with gas capture (Hoornweg & Bhada-Tata, 2012). Because the actual disposal route, organic fraction, and methane-generation potential of waste from the University of Swabi campus have not been directly measured, this coefficient should be treated as an approximation pending a dedicated waste-characterization study.

The waste estimate should be interpreted carefully because actual emissions depend on waste composition, organic fraction, disposal method, landfill management, recycling, and composting, none of which have yet been measured for this campus. A practical next step is to weigh campus waste by category for at least one representative semester, document the disposal pathway, and introduce source segregation so that future estimates are based on measured rather than assumed data.

Calculation Framework

Table 1 summarizes the inputs, operational data, and outputs used in the carbon-footprint calculation.

Table 1: Inputs, Operational Data, and Outputs Used in the Carbon-Footprint Calculation

Input Category	Scope	Operational Data Used	Output (tCO_2e)
University bus transportation	Scope 1	5 university buses; ~35 km one-way route distance; round-trip factor of 2; 240 operating days/year; emission factor 0.01 tCO_2e per 100 vehicle-km	8.40
Private car and motorcycle commuting	Scope 3	~230 private cars and ~850 motorcycles; ~5 km one-way commuting distance; round-trip factor of 2; 240 operating days/year; emission factors of 0.02 (cars) and 0.01 (motorcycles) tCO_2e per 100 vehicle-km	314.40
Purchased electricity	Scope 2	Annual electricity consumption, January–December 2025: 472,160 kWh; delivered emission factor 0.84 kg CO_2/kWh	396.61
Solid waste generation	Scope 3	Institutional population of 4,453 persons; waste-generation rate 0.283 kg/person/day; 240 operating days/year; conversion coefficient 0.45 kg CO_2e/kg waste	136.08

The total carbon footprint was obtained by summing emissions from university bus transportation, private commuting, electricity, and waste generation. The final value is reported as annual tonnes of carbon dioxide equivalent. This aggregation provides a first institutional benchmark that can be refined as the university develops better monitoring systems.

Uncertainty and Sensitivity Analysis

Because several inputs to this inventory are estimated rather than directly measured, a one-at-a-time sensitivity analysis was conducted to characterize how the total footprint would change if three key assumptions varied within a plausible ±20% range: the electricity emission factor, the commuting-distance assumption (applied uniformly to buses, cars, and motorcycles), and the waste-generation rate. A combined scenario, in which all three parameters move simultaneously in the same direction, is also reported to illustrate the upper and lower bounds of plausible uncertainty given current data limitations. Results of this analysis are reported in Table 3, in the Results section.

4. RESULTS

The 2025 inventory shows that the New Campus of the University of Swabi generated an estimated 855.49 tCO_2e from the four assessed sources. Purchased electricity was the largest component, followed by private commuting, solid waste generation, and university bus transportation. Table 2 summarizes the contribution of each source to the total footprint.

 | https://doi.org/10.66529/agripat.2026.2.3.93

Table 2: Estimated Carbon Footprint of the University of Swabi in 2025, by Scope and Source

Scope	Emission Source	Emissions (tCO_2e)	Share of Total (%)
Scope 1	University-operated buses	8.40	0.98
Scope 2	Purchased electricity	396.61	46.38
Scope 3	Private car and motorcycle commuting	314.40	36.75
Scope 3	Solid waste generation	136.08	15.91
Total	*All sources*	*855.49*	*100.00*

Transportation and Commuting Emissions

University bus transportation, the only Scope 1 source in this inventory, contributed an estimated 8.40 tCO_2e, or 0.98% of the total footprint. Private commuting by car and motorcycle, classified as Scope 3, contributed an estimated 314.40 tCO_2e, or 36.75% of the total footprint, comprising 110.40 tCO_2e from approximately 230 private cars and 204.00 tCO_2e from approximately 850 motorcycles. Motorcycles therefore account for the single largest transport-related source in the inventory, reflecting their high number on campus relative to other vehicle types.

Taking together, university-controlled and private transportation account for 322.80 tCO_2e, or 37.74% of the total footprint, even though only a small fraction of this (8.40 tCO_2e) is within the university's direct operational control. This distinction matters for policy: most of the realistic mitigation potential in this category lies in influencing commuting behavior, through carpooling, safer pedestrian and bicycle infrastructure, and improved collective transport, rather than in measures applied to the university's own small bus fleet.

Electricity-Consumption Emissions

Electricity consumption was the largest single emission source in the inventory. The university used 472,160 kWh of electricity during 2025. Applying the delivered emission factor of 0.84 kg CO_2 per kWh gives $472{,}160 \div 1{,}000 \times 0.84 = 396.61$ tCO_2e, equivalent to 46.38% of the assessed footprint.

The dominance of electricity is consistent with many university inventories, particularly in countries where grid electricity depends substantially on fossil fuels and where transmission losses are high, as in Pakistan. For the University of Swabi, this finding is operationally important because energy management is one of the most controllable parts of the footprint. Solar expansion, energy audits, efficient lighting, improved equipment management, and building-level metering could all reduce future emissions, and the magnitude of the potential reduction is large precisely because electricity is the single largest source category.

Solid-Waste Emissions

Solid waste generated an estimated 136.08 tCO_2e, equivalent to 15.91% of the total assessed footprint. The calculation used a daily waste-generation rate of 0.283 kg per person, a population of 4,453 persons, 240 operating days, and a conversion coefficient of 0.45 kg CO_2e per kg of waste, consistent with disposal in an unmanaged site without engineered methane recovery: $0.283 \times 4{,}453 \times 240 \div 1{,}000 \times 0.45 = 136.08$ tCO_2e.

Although waste contributed the smallest share among the four source categories, it should not be treated as a secondary concern. Waste-related emissions can increase as student numbers grow, food services expand, and campus activities become more complex, and the methane-generation potential of unmanaged disposal means that even modest tonnages can carry a disproportionately large climate impact. The absence of a formal recycling, composting, or waste-weighing system also means that the true emissions associated with campus waste remain uncertain and could be higher than estimated here if the organic fraction or actual disposal route differs from the assumptions used.

Total and Per Capita Footprint

The total assessed carbon footprint was calculated as the sum of Scope 1 bus emissions, Scope 2 electricity emissions, and Scope 3 commuting and waste-generation emissions: $8.40 + 396.61 + 314.40 + 136.08 = 855.49$ tCO_2e for 2025. With a university population of 4,453 persons, the estimated per capita footprint is approximately 0.19 tCO_2e per person.

This figure should be interpreted as a partial baseline for the four assessed categories rather than a full institutional life-cycle footprint. Categories not yet included, such as procurement, construction, food services, water supply, laboratory operations, hostel energy use, off-campus commuting beyond the defined assumptions, and air travel, would be expected to increase the total footprint if added in future inventories. The current estimate nonetheless provides a useful and conservative starting point for institutional decision-making.

 | https://doi.org/10.66529/agripat.2026.2.3.93

Sensitivity Analysis

Table 3 reports the results of the uncertainty and sensitivity analysis described in the Methodology section. Varying the electricity emission factor by ±20% changes the total footprint by approximately ∓9.27%, while varying the commuting and bus distance assumption by ±20% changes the total by approximately ∓7.55%, and varying the waste-generation rate by ±20% changes the total by approximately ∓3.18%. When all three parameters are varied simultaneously in the same direction, the plausible range for the total footprint extends from approximately 684 tCO2e to 1,027 tCO2e, compared with the 855.49 tCO2e base-case estimate.

Table 3: Sensitivity of the Total Carbon Footprint to Key Assumptions (±20%)

Parameter Varied (±20%)	Low Scenario (tCO2e)	Base Case (tCO2e)	High Scenario (tCO2e)	Change from Base (%)
Electricity emission factor (0.84 kg CO2/kWh)	776.17	855.49	934.82	∓ 9.27
Commuting and bus distance assumption	790.93	855.49	920.05	∓ 7.55
Waste-generation rate (0.283 kg/person/day)	828.29	855.49	882.73	∓ 3.18
Combined (all three parameters simultaneously)	684.41	855.49	1,026.62	∓ 19.97 / +20.00

This analysis indicates that the electricity emission factor and the commuting-distance assumption are the two parameters to which the total footprint is most sensitive, and they should accordingly be the first priorities for replacement with measured data, through utility-verified grid-factor documentation and a campus commuting survey, respectively.

Comparison with Selected Universities

Compared with selected national and international universities, the University of Swabi has a smaller absolute and per capita footprint, as shown in Table 4. However, the studies summarized in Table 4 differ substantially in inventory boundary, population basis, and methodology, and the comparison should be read with these differences in mind rather than as a like-for-like ranking of environmental performance.

Table 4: Comparison of the University of Swabi with Selected University Carbon-Footprint Studies

University	Country	Population Basis	Total Emissions (tCO2e)	Per Capita (tCO2e)	Inventory Basis, Notes, and Reference
NED University	Pakistan	~12,000 (per-student basis)	21,500	1.79	Online carbon-calculator methodology; figure reported per student, not per total population (Mustafa et al., 2022)
Tongji University	China	Survey respondents	—	3.84	Personal/student survey-based footprint (daily life, transport, academic activities); not an institutional Scope 1–3 inventory (Li et al., 2015)
Clemson University	USA	21,857	94,418	4.40	Life-cycle assessment approach; broad Scope 3 coverage including procurement and food services (Clabeaux et al., 2020)
University of Leeds	UK	30,761	161,819	5.30	Institutional reporting framework; broad Scope 3 coverage including air travel (Townsend & Barrett, 2015)
University of Swabi	*Pakistan*	*4,453 (total institutional population)*	*855.49*	*0.19*	*Scope 1 (buses), Scope 2 (electricity), Scope 3 (commuting and waste); narrower boundary than comparators (this study)*

Note. Values are not directly comparable across institutions because of differences in inventory boundary, population basis (total institutional population vs. student population vs. survey respondents), and the Scope 3 categories included in each study.

NED University in Pakistan reported approximately 21,500 tCO2e for 2017 using an online carbon-calculator methodology, expressed as 1.79 tCO2e per student rather than per total campus population (Mustafa et al., 2022); because the University of Swabi's 0.19 tCO2e figure is calculated per total institutional population, the two values do not share the same denominator. Tongji University's reported figure of 3.84 tCO_2e (Li et al., 2015) is a personal, survey-based student footprint covering daily life, transportation, and academic activities rather than an institutional Scope 1–3 inventory, and is therefore conceptually distinct from, and should not be directly compared with, the University of Swabi's institutional per capita figure. Clemson University and the University of Leeds reported per capita values of 4.40 and 5.30 tCO_2e, respectively, using life cycle and institutional reporting approaches that include substantially broader Scope 3 categories, such as procurement, food services, and air travel, than the University of Swabi inventory currently covers (Clabeaux et al., 2020; Townsend & Barrett, 2015).

These differences should not be read simply as better or worse performance. Larger and higher-income-country universities typically have more laboratories, hostels, sports facilities, research infrastructure, digital systems, heating or cooling loads, and procurement volumes, and they more often report the broader Scope 3 categories that increase total emissions. The University of Swabi's low value reflects its smaller population, limited mechanization, developing infrastructure, and a narrower inventory boundary that excludes several categories captured in the comparator studies. The comparison is therefore most useful as a caution rather than a claim of achievement: as UOS grows and as its inventory boundary is expanded to match international practice, its reported footprint could rise quickly even without any underlying change in environmental performance.

5. DISCUSSION

The results show that the University of Swabi currently has a modest carbon footprint compared with larger universities, but the pattern of emissions is familiar: purchased electricity is the largest source, commuting is a substantial second source, and waste is smaller but still relevant. This structure matches many campus studies in which purchased electricity and mobility dominate institutional emissions. For UOS, the finding is particularly important because both electricity and commuting are directly linked to future campus planning decisions that are still being made.

Electricity should be the first priority for mitigation, both because it is the largest single source and because the sensitivity analysis in Table 3 shows the total footprint is highly sensitive to the underlying emission factor. The university is located in a region with strong solar-energy potential (Sustainable Development Policy Institute, 2022), and solar expansion could reduce both emissions and long-term electricity costs. However, solar installation alone is not a complete strategy. Without demand management, inefficient buildings and equipment will continue to consume high levels of energy. The university should therefore combine renewable-energy deployment with energy audits, LED lighting, efficient cooling systems, equipment-use protocols, building-level meters, and routine reporting of monthly electricity performance; building-level metering would also allow the 0.84 kg CO_2/kWh assumption used in this study to be replaced with a measured, utility-verified grid factor.

Commuting is the second major issue, and the reclassification of private vehicles from Scope 1 to Scope 3 in this study sharpens rather than weakens this conclusion: most of the university's transport-related footprint originates from behavior the institution can influence but does not directly control. The large contribution from motorcycles and private cars indicates that campus access patterns are highly motorized. A sustainable mobility strategy does not need to be expensive at the outset. The university can start with better bus scheduling, incentives for shared commuting, shaded pedestrian routes, secure bicycle parking, and restrictions on unnecessary vehicle movement inside the campus, paired with a structured commuting survey to replace the distance and vehicle-count assumptions used here. Over time, a more complete mobility plan could include electric shuttle services, parking management, and collaboration with local transport providers.

Waste management is often treated as a secondary issue because its numerical contribution is smaller than electricity and commuting. That would be a mistake, for two reasons. First, waste is highly visible, strongly linked to campus culture, and relatively easy to improve through behavior change and operational systems; source segregation, composting of organic waste, recycling of paper and plastic, and reduction of single-use items could reduce emissions while improving campus cleanliness. Second, and more fundamentally, the waste estimate in this study rests on an assumed generation rate and an assumed disposal pathway, neither of which has been directly measured; until the university installs waste scales and documents its actual disposal route, the 136.08 tCO_2e figure should be treated as indicative rather than precise, and could understate the true contribution of waste if the organic fraction or disposal conditions differ from the assumptions used.

The comparison with other universities in Table 4 highlights an assumption that must be challenged: a low current footprint does not automatically mean strong environmental performance. It may simply reflect small scale, fewer facilities, limited operations, or a narrower accounting boundary than other published studies use. These two readings are not in tension with each other: the University of Swabi's footprint is genuinely modest in absolute terms because the institution is young and small, and at the same time, that modest figure should not be used as evidence of strong environmental performance, because it does not yet capture procurement, construction, food services, laboratory operations, or broader commuting, and because comparator institutions report on substantially different boundaries and population bases. The stronger interpretation is that UOS is early enough in its development to avoid locking itself into high-emission infrastructure. Decisions made now about buildings, transport routes, energy systems, and procurement will shape emissions for decades, regardless of how the current baseline compares with other universities.

The study also exposes a data-governance problem that is at least as important as any single emission estimate. The university can produce an approximate inventory, but it does not yet appear to have a complete environmental data system. Direct measurement of waste, building-wise electricity records, fleet fuel logs, student and staff commuting surveys, and procurement records would make future assessments more accurate and would directly narrow the uncertainty ranges identified in Table 3. A sustainability office or standing committee should be responsible for maintaining these records and producing an annual carbon report; without such a structure, each future inventory will continue to rely on the same category of assumptions used here.

Education and awareness remain central. Universities have a dual responsibility: reducing their operational emissions and preparing students to understand climate-related decisions. Integrating sustainability into coursework, supporting student-led environmental clubs, holding carbon-literacy workshops, and publishing annual progress can shift sustainability from a one-time project to a campus identity. If this cultural dimension is ignored, technical interventions may produce only temporary results.

Limitations

Several limitations should be acknowledged. First, the study assessed only university bus transportation, private commuting, purchased electricity, and solid waste generation; it does not capture procurement, construction, food systems, water, laboratory operations, hostel energy use, off-campus residential energy, air travel, or embodied emissions, all of which would be expected to increase the total footprint if included. Second, several values were estimated because direct measured data were unavailable, including commuting distances, vehicle counts, the waste-generation rate, the waste-to-emissions conversion coefficient, and the delivered electricity emission factor; Table 3 quantifies how sensitive the total footprint is to these assumptions, but it cannot substitute for measured data. Third, the inventory used annual operating assumptions that may vary by semester, academic calendar, and campus activity. These limitations do not invalidate the baseline, but they define its boundary and its appropriate level of precision: the figure of 855.49 tCO2e should be read as an order-of-magnitude baseline with a plausible range of roughly 684–1,027 tCO2e, not as a precise measurement. Future studies should expand the scope in phases and replace assumptions with measured records wherever possible.

6. CONCLUSION AND POLICY IMPLICATIONS

This study provides a baseline campus carbon-accounting estimate for the University of Swabi for 2025. Based on the four assessed sources, total annual emissions were 855.49 tCO2e, with a plausible sensitivity range of approximately 684–1,027 tCO2e given current data limitations. Purchased electricity was the largest contributor at 396.61 tCO2e, followed by private commuting at 314.40 tCO2e, solid waste generation at 136.08 tCO2e, and university bus transportation at 8.40 tCO2e. The estimated per capita footprint was approximately 0.19 tCO2e per person.

The university's current footprint is lower than many larger national and international institutions, but this should be interpreted carefully and in light of the boundary differences documented in Table 4. The lower value reflects the university's smaller size, developing infrastructure, narrower inventory boundary, and limited emission-intensive operations, rather than a demonstrated superiority in environmental management. As UOS expands, emissions are likely to increase, both because operations will grow and because future inventories will likely need to incorporate additional Scope 3 categories that are currently excluded. The present stage of development therefore provides a valuable opportunity to build a low-carbon campus model before high-emission systems become locked in.

The key policy message is straightforward: the University of Swabi should move from one-time estimation to routine, increasingly measured carbon management. Annual inventories, improved data collection, solar expansion, energy efficiency, sustainable mobility, waste segregation, recycling, plantation, and student engagement should become part of formal institutional planning. With these steps, UOS can position itself as a responsible and forward-looking university in Pakistan's higher education sector.

Each recommendation below pairs a mitigation action with the foundational data-collection step needed to monitor and verify it, so that future inventories rely progressively less on the estimation assumptions used in this baseline study.

Expand Solar-Energy Systems

The university should install solar panels on major academic, administrative, and residential buildings in a phased manner. Solar expansion should be paired with building-level energy audits and sub-metering, so that renewable-energy investment is not undermined by inefficient consumption and so that future electricity emission estimates can be based on metered, building-level data rather than a single campus-wide emission factor.

Improve Energy Efficiency

Energy-saving measures should include LED lighting, efficient cooling and ventilation systems, automatic switching controls where feasible, preventive maintenance of electrical equipment, and monthly monitoring of electricity use by building or department, with the monitoring data retained to validate or refine the grid emission factor used in future inventories.

Establish Structured Waste Management and Direct Measurement

The university should introduce color-coded bins for organic waste, paper, plastic, and metals, and should install waste scales or a documented weighing procedure at the point of collection. Organic waste should be composted where possible, recyclable materials should be linked to local recycling channels, and the university should document its actual waste disposal pathway (landfill, open dumping, or composting) so that future emission factors reflect measured conditions rather than the default assumption used in this study. A waste audit and weighing exercise should be conducted each semester to measure progress and replace the current estimate with direct data.

Develop a Low-Carbon Mobility Plan Informed by a Commuting Survey

The university should reduce dependence on private vehicles by improving bus services, encouraging carpooling, creating safe pedestrian routes, providing bicycle parking, and considering electric shuttles as resources allow. Before or alongside these interventions, the university should conduct a structured origin-destination and vehicle-occupancy survey of student and staff commuting, so that the vehicle counts and distances currently assumed in this inventory can be replaced with measured data and so that the impact of mobility interventions can be tracked over time.

Expand Green Spaces and Plantation

Tree plantation should prioritize native and climate-suitable species. Plantation campaigns should include survival monitoring, irrigation planning, and student participation so that green spaces function as long-term carbon sinks and not only symbolic events.

Build Sustainability Governance and a Campus Data System

A sustainability committee or office should be assigned responsibility for annual carbon accounting, data collection, policy follow-up, and public reporting. This structure should explicitly include responsibility for the foundational data systems identified in this study, including building-level electricity sub-metering, a waste-weighing procedure, fleet fuel logs, and a recurring commuting survey, since these are necessary to move from estimation to measurement and from recommendations to verified implementation.

Engage Students and Staff

Environmental awareness should be integrated into seminars, student societies, courses, and campus campaigns. Behavioral change will be essential for transport choices, electricity conservation, waste segregation, and long-term sustainability culture, and student and staff participation can also support data collection efforts such as commuting surveys and waste audits.

Future Research

Future studies should broaden the inventory to include procurement, water use, construction materials, laboratory activities, air travel, food services, hostel energy use, and detailed commuting behavior. Direct measurement should replace estimation wherever possible, beginning with the electricity emission factor and commuting distances identified in Table 3 as the parameters to which the total footprint is most sensitive. A campus carbon dashboard could help the university track annual trends, compare departments, and evaluate the impact of mitigation measures, while a multi-year time series would also allow the university to report its footprint using both location-based and market-based Scope 2 methods as its renewable-energy procurement develops.

References

Akhtar, S., Sahibzada, N. I., Saif, S., Inayat, S., & Ahmad, S. R. (2017). Carbon footprint of a beverage bottling plant in Lahore, Pakistan. *Current World Environment*, *12*(2), 222–230. https://doi.org/10.12944/CWE.12.2.05

Barron, A. R., Domeshek, M., Metz, L. E., Draucker, L. C., & Strong, A. L. (2021). Carbon neutrality should not be the end goal: Lessons for institutional climate action from U.S. higher education. *One Earth*, *4*(9), 1248–1258. https://doi.org/10.1016/j.oneear.2021.08.014

Battistini, R., Passarini, F., Marrollo, R., Lantieri, C., Simone, A., & Vignali, V. (2023). How to assess the carbon footprint of a large university? The case study of University of Bologna's multicampus organization. *Energies*, *16*(1), 166. https://doi.org/10.3390/en16010166

Clabeaux, R., Carbajales-Dale, M., Ladner, D., & Walker, T. (2020). Assessing the carbon footprint of a university campus using a life cycle assessment approach. *Journal of Cleaner Production*, *273*, 122600. https://doi.org/10.1016/j.jclepro.2020.122600

Esor, P. E., Ebu, V. T., Igri, M. R., & Ogar, N. E. (2021). Assessment of carbon footprint of students in Cross River University of Technology, Obubra Campus, Nigeria. *FUDMA Journal of Sciences*, *5*(2), 115–119. https://doi.org/10.33003/fjs-2021-0501-602

Fu, J., An, N., Huang, C., Shen, Y., Pan, M., Wang, J., Yao, J., & Yu, Z. (2024). How do people reduce their household carbon footprint? Evidence from carbon emissions and influencing factors in China. *Buildings*, *14*(11), 3451. https://doi.org/10.3390/buildings14113451

Gupta, U., Kim, Y. G., Lee, S., Tse, J., Lee, H. H. S., Wei, G.-Y., Brooks, D., & Wu, C.-J. (2022). Chasing carbon: The elusive environmental footprint of computing. *IEEE Micro*, *42*(4), 37–47. https://doi.org/10.1109/MM.2022.3163226

Haseeb, M., Tahir, Z., Batool, S. A., Ahmad, S. A., Kanwal, S., & Majeed, A. (2022). The carbon footprint of a public sector university before and during the COVID-19 lockdown. *Global NEST Journal*, *24*(1), 29–36. https://doi.org/10.30955/gnj.004222

Hoornweg, D., & Bhada-Tata, P. (2012). *What a waste: A global review of solid waste management* (Urban Development Series Knowledge Papers No. 15). World Bank.

Hussain, M., & Malik, R. N. (2015). *Managing carbon footprints for sustainable development: Pakistan Tobacco Company, 2009–2011*. https://doi.org/10.13140/RG.2.1.4064.7204

Intergovernmental Panel on Climate Change. (2006). *2006 IPCC guidelines for national greenhouse gas inventories*. Institute for Global Environmental Strategies.

Intergovernmental Panel on Climate Change. (2021). *Climate change 2021: The physical science basis*. Cambridge University Press.

Intergovernmental Panel on Climate Change. (2023). *Climate change 2023: Synthesis report*. IPCC.

Jadoon, A., Batool, S. A., & Chaudhry, M. N. (2014). Assessment of factors affecting household solid waste generation and its composition in Gulberg Town, Lahore, Pakistan. *Journal of Material Cycles and Waste Management*, *16*, 73–81. https://doi.org/10.1007/s10163-013-0146-5

Kaur, R. R., & Luthra, A. (2023). Evaluation of greenhouse gas emissions and carbon footprint of Guru Nanak Dev University Campus, Amritsar. *Urban India*, *43*(1), 77–94.

Khan, U. A., & Hussain, A. (2017). *Analysis of ecological footprint of rural-urban households in Islamabad* (Department of Environmental Economics Working Paper No. 13). Pakistan Institute of Development Economics.

Li, X., Tan, H., & Rackes, A. (2015). Carbon footprint analysis of student behavior for a sustainable university campus in China. *Journal of Cleaner Production*, *106*, 97–108. https://doi.org/10.1016/j.jclepro.2014.11.084

Lozano, R. (2011). The state of sustainability reporting in universities. *International Journal of Sustainability in Higher Education*, *12*(1), 67–78. https://doi.org/10.1108/14676371111098311

Mariette, J., Blanchard, O., Berné, O., & Ben Ari, T. (2021). An open-source tool to assess the carbon footprint of research. *arXiv*. https://doi.org/10.48550/arXiv.2101.10124

Ministry of Climate Change, Government of Pakistan. (2022). *Pakistan's first biennial update report (BUR-1) to the United Nations Framework Convention on Climate Change*. Government of Pakistan.

Mustafa, A., Kazmi, M., Khan, H. R., Qazi, S. A., & Lodi, S. H. (2022). Towards a carbon neutral and sustainable campus: Case study of NED University of Engineering and Technology. *Sustainability*, *14*(2), 794. https://doi.org/10.3390/su14020794

Naderipour, A., Abdul-Malek, Z., Arshad, R. N., Kamyab, H., Chelliapan, S., Ashokkumar, V., & Tavalaei, J. (2021). Assessment of carbon footprint from transportation, electricity, water, and waste generation: Towards utilisation of renewable energy sources. *Clean Technologies and Environmental Policy*, *23*, 183–201. https://doi.org/10.1007/s10098-020-02017-4

National Electric Power Regulatory Authority. (2023). *State of industry report 2023*. Government of Pakistan.

Paredes-Canencio, K. N., Lasso, A., Castrillon, R., Vidal-Medina, J. R., & Quispe, E. C. (2024). Carbon footprint of higher education institutions. *Environment, Development and Sustainability*, *26*, 30239–30272. https://doi.org/10.1007/s10668-024-04596-4

Sustainable Development Policy Institute. (2022). *Annual state of renewable energy report Pakistan 2021*. Sustainable Development Policy Institute.

Townsend, J., & Barrett, J. (2015). Exploring the applications of carbon footprinting towards sustainability at a UK university: Reporting and decision making. *Journal of Cleaner Production*, *107*, 164–176. https://doi.org/10.1016/j.jclepro.2013.11.004

United Nations. (2023). *The Sustainable Development Goals report 2023: Special edition*. United Nations.

United Nations Development Programme Pakistan. (2022). *Baseline study of current scenario of plastic waste management in Rahim Yar Khan City*. UNDP Pakistan.

United States Environmental Protection Agency. (2023). *Emission factors for greenhouse gas inventories*. United States Environmental Protection Agency.

University of Turku. (2020, January 24). *University completed estimate of carbon footprint: Offers important tools for achieving carbon neutrality*. https://www.utu.fi/en/news/news/university-completed-estimate-of-carbon-footprint

Valls-Val, K., & Bovea, M. D. (2022). Carbon footprint assessment tool for universities: CO2UNV. *Sustainable Production and Consumption*, *29*, 791–804. https://doi.org/10.1016/j.spc.2021.11.020

Wiedmann, T., & Minx, J. (2008). A definition of "carbon footprint." In C. C. Pertsova (Ed.), *Ecological economics research trends* (pp. 1–11). Nova Science Publishers.

World Resources Institute, & World Business Council for Sustainable Development. (2004). *The greenhouse gas protocol: A corporate accounting and reporting standard* (Rev. ed.).

Yáñez, P., Sinha, A., & Vásquez, M. (2020). Carbon footprint estimation in a university campus: Evaluation and insights. *Sustainability*, *12*(1), 181. https://doi.org/10.3390/su12010181

Ethics Statement: This study used institutional records and aggregate estimates. No individual participant data are reported.

Funding: No funding information was provided.

Conflict of Interest: The authors declare no conflict of interest.

Data Availability Statement: The data used in this study were obtained from official records available at the University of Swabi and from documented estimation methodologies described in the Methodology section.