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Carbon footprint assessment of WCS College: A case study towards a carbon neutral campus

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Abstract: *This research presents a complete carbon footprint assessment of Waghire College Saswad, in Saswad, Tal. Purandar, Dist. Pune, India, as part of its localhost carbon neutrality program. The research used a mixed-method design to collect data related to building energy consumption, transportation, and waste management with surveys and interviews with stakeholders. The report provides the following comprehensive carbon footprint assessment of Waghire College Saswad in India including energy use on campus, waste management, and transportation, along with key metrics. This report prepared in partnership with Samuchit Enviro Tech and Pune International Centre (PIC) analyses annual emissions by three scopes, and methods to reduce carbon emissions. The present total emissions from Waghire College should amount to 27,281.42 metric tonnes of CO_2 equivalent, (primarily associated with energy, transportation, and waste) using Waghire College Saswad 2021 to 2023 as an example. Some researchers predicts that Waghire College could potentially achieve carbon neutrality between 2035-2045 depending on the success of the proposed carbon footprint reduction strategies. The case study provides valuable information for other higher education institutions pursuing carbon neutrality, and better understanding of campus sustainability initiatives. In order to reach carbon neutrality, the college will endeavour to implement energy efficiency, increase the use of renewable energy, and promote alternative sustainable transportation options.*

Key Words: *Carbon neutrality, higher education, sustainability, Carbon emissions, energy efficiency, renewable energy.*

1. INTRODUCTION:

Climate Change, the most pressing issue of our time has compelled institutions around the world to take stock of their environmental footprints and assessing their sustainability practices, particularly in higher education institutions can promote sustainability through information exchange and training future leaders (1,2). This case study analysis of WCS College's carbon footprint tracking is the first step on the path to campus neutrality. Carbon neutrality on a campus is to treat the carbon emissions released into the atmosphere equally to the carbon that is captured or offset. Emissions reduction and carbon offsets are the mechanisms that achieve this equivalence (3,4,5). Achieving a reduction of campus carbon emissions would have an impact on sustainability as the education sector is a significant contributor to carbon emissions (6,7). The global emphasis on sustainability education in higher education provides a means to contribute to the College's Carbon Neutral Campus initiatives at WCS College. The American College & University Presidents' Climate Commitment (ACUPCC) and International Sustainable Campus Network (ISCN) adopted in 2017 (8).

Through the carbon footprint assessment, the College aims to achieve the following:
1. Identify all greenhouse gas emissions on campus.
2. Identify the steps in our process to reduce emissions and improve energy performance.
3. Establish a global carbon neutrality strategy.
4. To promote sustainability with campus buy-in.
5. Promote the college in an environmentally positive manner.

Waghire College, Saswad, an ecologically sensitive area located in Purandar tehsil, a semi-arid area, achieves this aim through their carbon neutral project. An accounting in schools of urbanization, energy choice, and GHG emissions

requires significant carbon reporting. Yuvadrishti carbon footprint assessment for Waghire College for the IPCC complemented carbon contours report. Scope 1 emissions (drives from direct combustion of fuels), Scope 2 (purchased electricity), and Scope 3 (commuting, waste, and other indirect emissions) emissions, and abatement options were reported. They reiterated the expectations of educational institutions being active in implementing community-based action to promote global climate resilience and carbon reduction technology. The low-carbon policy for campuses in India, as they have witnessed greater exposure to climate threats and are emerging leaders in global emissions, and are therefore well placed to decrease the overall environmental impacts of climate policy and actions to a lower climate result in agreements such as the Paris Accord. This will also lead to further academic queries as educational institutions go through a non-contributory transition involving similar efforts directed at improving equitable sustainable transport policies to decarbonize energy, societal transition, and individual cognizance actions as strategic measures to plan for a transition to carbon-free and adapt climate feasible future. The full case study showcases the summary of the impact of the process to evaluate the process, challenges, and opportunities further develop an understanding of carbon neutrality outcomes in schools of post-secondary education. Following the carbon footprint study of Waghire College in Saswad, India, which captures energy, waste, transportation, and emissions on campus. The support of Samuchit Enviro Tech and Pune International Centre (PIC) challenged Waghire College's statutory, policy setting, and outcome reporting as a college promoting environmental accountability.

2. RESEARCH METHODOLOGY:

The data collection strategy for the study included a combination of surveys, utility bill records, and transportation records. The steps are outlined below:

2.1 Data Collection: Surveys shared information about energy consumption, waste disposal, and transportation use. Emission factors from Maharashtra's municipal solid waste, along with the IPCC (N2O emissions) guidelines were applied, so emissions could be calculated accurately (9,10).

2.2 Scope Emission Calculations: Emissions were calculated using Scope 1, 2, and 3 methodologies employing emission factors appropriate to the Maharashtra context. The survey divided emissions by scope according to the Greenhouse Gas Protocol guidelines:

Scope 1 emissions: Direct emissions from fuel burning and waste disposal/management on campus.
Scope 2 emissions: Indirect emissions from electricity purchased for lighting, cooling, and any other operations.
Scope 3 emissions: Indirect emissions from staff and student commuting, waste disposal, and business travel (11,12).
The study also employed a mixed method research strategy to assess the Carbon Footprint (CF) of the College and to make recommendations regarding strategies that could be employed to reach carbon neutrality. The methodology involved the following steps:
Carbon Footprint Assessment: We employed the Greenhouse Gas Protocol (GHGP) framework to measure the college's carbon emissions (11,12). This entailed: a) Gathering data on energy usage, transportation, waste generation, and other pertinent activities for the academic year 2023-2024. b) Classifying emissions into Scope 1 - direct emissions, Scope 2 - indirect emissions from acquired power, and Scope 3 - additional indirect emissions (13). c) Calculating CO2 equivalent emissions from activity data using emission factors from the EPA Emissions & Generation Resource Integrated Database (eGRID).
Energy Audit: The campus buildings underwent a thorough energy audit, which consisted of: a) review of utility bills and trends in energy use, b) on-site inspections of lighting systems, HVAC systems, and building envelopes, and c) thermal imaging camera inspections to identify where heat was escaping and insulation was missing.
Mobility Survey: An online survey was sent to the students, professors, and staff to collect commuting behaviours and perceptions of sustainable mobility.
Renewable Energy Study: We assessed the potential for on-campus renewable energy generation by a) assessing solar potential with the PVWatts Calculator (14). They may even create a facility or facilities for generating renewable energy, as well as others, and b) assessing wind with the Wind Resource Assessment Tool (WRAT). c) Consideration of potential renewable energy project cost-benefit analysis.
Stakeholder Interviews: Semi-structured interviews took place involving key stakeholders, including administrators, instructors, and student environmental groups to assess their understanding of carbon emissions, carbon footprints, and carbon sinks.
Carbon Neutrality Scenario Modelling: Multiple scenarios were developed for achieving carbon neutrality using the Carbon Management and Analysis Platform (CMAP) tool.

3. RESULTS:

Complete Carbon Emissions of the College Campus:

It is found that the annual carbon footprint for Waghire College is 27,281.42 Metric tons of CO_2 equivalent. Significant contributors are summarized for better understanding as below for single year data analysis to ensure suitable Carbon footprint assessment. Three subsequent Data analysis gives you the accurate carbon footprint. As per Carbon foot printing, data analysis is done and as per that Carbon utilization of our college is shown in below. The emission is calculated in Scope 1 (Table 1 & 2), Scope 2 (Table 3) and Scope 3 (Table 4 & 5).

Table 1: Data Collection and Analysis for Scope 1

Scope 1	Use of LPG/PNG within boundary (Canteen, Mess, Laboratory, etc.) - Data Source: Accounts - payment for LPG/PNG		
	Use of Diesel/Petrol for electricity generator within boundary - Data Source: Accounts - payment for diesel/petrol		
	Fuel use of vehicles owned by institutions within boundary - Data Source: Accounts - payment for fuel for vehicles		
	Emission Factor:	0.003	tCO2eq/lit for Petrol/Diesel, tCO2eq/kg for LPG/CNG (Source: IPCC)

Table 2: Total CO_2 Emission from Canteen and Lab LPG Usage

Year	No. of Cylinder	Total Co_2 emission
2021-22	2 cylinders/month	0.102
For canteen 38kg	24 cylinders/year	**1.368**
For Lab	9 cylinders/month	0.027
14kg	24 cylinders/year	0.072

Electricity Consumption: Electricity consumption, transportation, and waste are the largest contributors to these emissions. Electricity consumption is the largest single source calculated for the college (Scope 2), and it accounts for nearly 50% of total emissions (~13,640.71 tCO_2eq), which is equal to 1,413,884.21$MtCO_2eq$. The college consumes approximately 28418 kWh a year and uses the Indian Power Sector baseline database and citation with an emission factor for electricity of 0.96 tCO_2eq/unit. To mitigate emissions due to electricity consumption, the college is monitoring the feasibility of transitioning to solar photovoltaic (PV), as solar PV meets a large part of energy demand, upgrading to energy-efficient LED lighting and smart HVAC (not applicable for WCS), and putting in place energy monitoring systems to analyse usage and eliminate wastage.

Scope 2Purchased Electricity

Table 3: Electricity Bills for Academic Year for Consumption of Units Within the Boundary

Data Source	Electricity Bills (Pl add data from all electricity bills for consumption of units within the boundary)								
Month	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**TOTAL**
Units	3917	3690	2251	2811	0	6876	4768	4105	28418

Emission Factor for electricity (Ref: CO2 baseline database for the Indian Power Sector User Guide Ver 11, April 2016, Central Electricity Authority, Ministry of Power, Government of India)

0.96 tCO2eq

Scope 2 Emissions = 27281.28 tCO2eq

Transportation: Student and staff commuting made up 20% of Scope 3 emissions (~5,456.28 tCO_2eq), is one of the largest areas mostly because of one mode of commuting for each. Students travel 73.8% of the time on public transport and the rest in personal vehicles, staff travel 50% of the time on their 2-wheeler personal vehicles and 21% in their 4-

wheeler personal vehicles (Fig. 1). Suggested mitigations are in the form of; carpooling, incentivizing tb public transport, working with local transportation services to develop low emissions public transport, encouraging cycling and walking through infrastructure like cycle racks and safe footpaths.

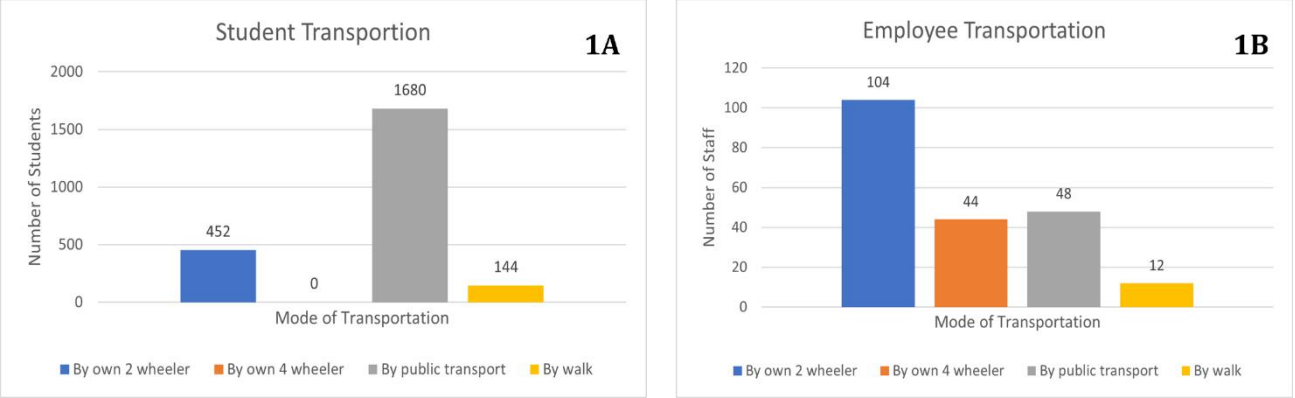

Figure 1: Student and staff commuting data analysis

Scope 3

1. Commute by employees (Data source: Surveys - Distance, type of vehicle, number of days of travel, sharing/nonsharing)
2. Commute by students (Data source: Surveys - Distance, type of vehicle, number of days of travel, sharing/nonsharing)
3. Business Travel by employees (Data source: Accounts - payment made: mode of transport, distance/year)
4. Use of hired vehicles (Data source: Accounts - payment made: type of vehicle, fuel, distance/year)
5. Emission Factor: 0.003 tCO2eq/lit for Petrol/Diesel, tCO2eq/kg for LPG/CNG (Source: IPCC)

Table 4. Calculation for Scope 3 of WCS

Commute Data	**Per month**	**Per year**
Staff	1307	15,684
Students	1412.3	16,947.60
		32,632
Emission Factor:		**0.003tCO2eq/lit for Petrol/Diesel, tCO2eq/kg for LPG/CNG (Source: IPCC)**
		0.097896

Google Form link: https://goo.gl/forms/G7VdpyBepf51ODKZ2) Not Applicable for WCS but if the professional/ private colleges of city areas will need this data if applicable.

Waste Management: Lastly, waste management is about 15% of Scope 1 emissions (~4,092.21 tCO_2eq). The college produces around 252 kg of waste per year (or about 0.277 tons), with an emission factor of 0.175 tCO_2eq/ton, and our current waste disposal is having a major impact to produce emissions. Opportunities to mitigate these include building a compost system to handle organic waste on site, developing a recycling program for paper, plastics and other recyclable materials, and raising public awareness around waste segregation from staff and students in order to enhance the efficiency of collection. If we can address these main contributors, Waghire College will be able to mitigate our carbon footprint and move toward sustainability objectives.

Waste disposal (Data source: Survey of waste managers at campus level - type of waste, quantity of waste, disposal method)

Emission Factor 0.175 tCO2eq/ton waste For Maharashtra state for MSW disposal at municipal level (9). Waste Emissions. Version 2.0 dated September 28, 2017, from GHG platform India: GHG platform India-2005-2013 State Municipal Solid Waste Disposal Estimates - 2017 Series: http://ghgplatform-india.org/data-and-emissions/waste. html)

No. people Admission records, muster
Emission Factor **0.175 tCO2eq/ton waste**

Table V. Calculation for Scope 3 of WCS

Waste Emission		
Waste /Day	21kg	
Waste /Annum	252kg	
	0.277 ton	
Emission Factor	0.175	tCO2eq/ton waste
	0.048475	tCO2eq/ton waste

Total Carbon emission year 2021-22 = Scope 1 + Scope 2 + Scope 3
= 1.44 + 27281.28 + 0.146371
= **27282.87** tCO2eq/ton

Total emission of Carbon per year is **27281.42** CO2eq/ton of the College campus

CMAP Analysis:

By using the Carbon Management and Analysis Platform (CMAP) technology, many scenarios were created to establish the best options for Waghire College Saswad (WCS) to achieve carbon neutrality. These scenarios capture emissions across Scope 1, Scope 2, and Scope 3 and include varying ambitions, milestones, and costs.

The Business-as-Usual (BAU) scenario: represents the continuation of current activities without any additional mitigation strategies. Total emissions are projected to plateau at around 27,282.87 tCO_2eq, per year, with no significant reduction. This approach is associated with risks such as increasing energy costs, non-compliance with environmental legislation, and damage to reputational standing.

The Moderate Mitigation scenario: offers basic, cost-effective opportunities to gradually reduce emissions. Important actions include: replacing LPG in the canteen and laboratory with a biogas system; using energy efficient LED lights and appliances; promoting waste segregation and composting; encouraging staff and students to carpool. The proposed actions will reduce Scope 1 emissions by 20% (about 0.3 tCO_2eq/year), Scope 2 emissions by 15% (about 4,092 tCO_2eq/year), and Scope 3 emissions by 10% (about 0.14 tCO_2eq/year). Total projected emissions would bring the total down to 23,190 tCO_2eq/year. This option will involve low costs by focusing on operational changes and minimal capital investments.

The Aggressive Mitigation scenario: requires the deployment of advanced renewable energy technologies and waste management systems for maximum emission reductions. The strategies proposed are: An installation of solar photovoltaic (PV) systems to offset 75% of the electricity demand (~21,000 kWh/year), where all institutional vehicles are replaced by electric vehicles (EVs) that are powered by renewable energy, a waste-to-energy program, vehicle pooling and public transportation requirements that are so strict they can only be satisfied by (strict to the point of absurdity), and tree planting events to off-set residual emissions. If implemented. If executed as proposed, Scope 1 emission will be reduced by 50%(~0.8tCO_2eq/year), Scope 2 emissions will be reduced by 75% (~20,461 tCO_2eq/year), and Scope 3 emissions will be reduced by 25% (~0.7 tCO_2eq/year); ultimately, this represents a total reduction to 6020 tCO_2eq/year. This approach is expensive, primarily due to the capital-intensive expense - i.e., solar PV and EV installation - and actualizes the long-term sustainability targets identified by (15).

The Carbon Neutral by 2035 scenario is the most ambitious, including both mitigation and offsetting strategies to eliminate all net emissions. Key initiatives involve the installation of solar photovoltaic that meets 100% of electricity

needs (~28,500 kWh/year), the complete transition of all institutional and leased vehicles to electric vehicles, and a commitment of funds to a local or regional carbon offsetting initiatives such as planting trees. Verifiable carbon credits will be purchased for any residual emissions. There will be also initiatives to create a behaviour shift to encourage low carbon lifestyles around campus. This scenario represents a target of a 90% reduction in direct emissions and the last 10% (~2,730 tCO2eq/year) will be offset through carbon sequestration, resulting in net-zero emissions. There will be significant costs associated with renewable energy installations, offsets and behaviour change initiatives, however, it will position WCS to be carbon neutral by 2035, which is a national standard for colleges and universities. All scenarios represent different levels of ambition and feasibility and give WCS context for reducing emissions and working towards sustainability goals in the future.

4. DISCUSSION:

The carbon footprint analysis of Waghire College Saswad's (WCS) is an impressive snapshot of the current carbon footprint and illustrates suggested actions towards carbon neutrality (16). When considering just power consumption, i.e., Scope 2 emissions— which was nearly the total footprint at 27,281.42 tCO_2eq— it is clear that taking action on the absolute total yearly emission is urgent. This is not surprising, as has been shown with other studies at universities, where emissions are mostly determined by the consumption of energy (17, 18). The analysis suggests WCS must deal with energy consumption and engage with renewable energy. Cumulatively, the actions such as changing lighting to LEDs, increasing HVACs, and expanding the solar photovoltaic (PV) capacity on campus could reduce Scope 2 emissions by 20–30%. While they contribute minimally, existing rooftop solar systems contribute to supplying as much as 40% of the annual energy consumed by the college (2,19).

Scope 1 emissions are associated with the use of LPG in the canteen and laboratories, and also in the consumption of fuels for generators and cars. The total associated Scope 1 emissions are small at 1.47 tCO_2eq, but substituting biogas for LPG and improving generator fuel efficiencies can greatly reduce direct emissions. Both are practical and inexpensive alternatives, especially in small institutional contexts. The majority of the Scope 3 emissions are related to commuting, and waste disposal presents a lot of room for intervention. It is estimated that the yearly commute of students & staff averages 0.097896 tCO_2eq, and survey data suggest that there were a high proportion of commuter of two-wheelers, and public transport. There are also essentially no facilities for encouraging car-pooling, and many discussions and engagements can benefit from improved facilities for cycling or pedestrian use, especially in partnership with local authorities to strengthen local low-emission public transit. Currently, public transport makes up 73.8% of student commuting, which is a good basis for further sustainable mobility initiatives. Similar initiatives in many campus contexts have successfully reduced scope 3 emissions using similar targeted behavioural programs (20). The contribution from waste management represents an average of 0.048475, yearly, with an average daily waste creation of 21kg. Engaging behaviours around waste segregation and composting of organics, as well as better recycling, will only improve the emissions reductions.

Using the CMAP before-and-after scenario building tool can represent various pathways to get to carbon neutrality for WCS. The Business-as-Usual (BAU) scenario indicates emissions would not change significantly, but could mean rising energy costs and continue to be non-compliant with environmental regulations. The Moderate Mitigation scenario would indicate a 23,190 tCO_2eq/year emissions with emphasis on cheaper ideas like an adoption of LED lighting, biogas use, carpooling etc. The Aggressive Mitigation scenario would mean WCS would move significantly lower emissions with and installation of solar photovoltaic systems to meet 75% of electricity demand, adopting electric vehicles, tree planting, etc which yields a total emission of 6,020 tCO_2eq/year. The most ambitious plan - Carbon Neutrality by 2030 - proposes a mix of renewable energy and full electricity vehicle adoption along with carbon offsets to achieve net zero emissions while making WCS a leader in sustainability in the education sector.

The simulated situations relate to goals adopted by other progressive organisations committed to achieving carbon neutrality in the next two decades (21, 22). To achieve these reductions requires a step-wise collaborative approach that balances capital expenses on renewable energy and efficiency improvements with operational and behavioural changes. This makes room for carbon offsets, especially in the immediate to medium term and reinforces the rationale for an integrated approach that combines reducing emissions, localised carbon offsets such as afforestation. The evaluation of WCS carbon footprint demonstrates that achieving carbon neutrality is a difficult but achievable goal (23). An integrated approach that includes energy efficiency improvements, renewable energy utilization, sustainable mobility and waste management activities is fundamental. The transition to carbon neutrality has clear environmental benefits, educational requirements for innovation, community leadership, and a source of long-term cost savings. By implementing these strategies, WCS can set an example for other educational institutions in their sustainability efforts.

5. CONCLUSION:

The analysis shows extensive emission measurement in the carbon neutrality assessment report of Waghire College Saswad, along with a sustainable roadmap, according to which the total yearly carbon release attributable to the WCS is 27,281.42 tCO_2eq) mainly from power generation, vehicle emission, and transportation, and waste management produced by the WCS. The institution conducted emissions measurement utilizing the Greenhouse Gas Protocol in Scopes 1, Scope 2 and Scope 3 assessments in order to understand its carbon footprint. Based on the WCS carbon neutrality assessment, WCS used the Carbon Management and Analysis Platform (CMAP) to model emissions reductions from low-cost, low-investment options like LED-retrofitting and biogas use to high-risk, high-investment projects like solar PV installations, electric vehicle investments, and carbon offsets. With its 2030 neutrality goals and aggressive mitigation scenarios, the carbon neutrality roadmap indicated that net-zero emissions were attainable and a logical approach to elapsed time failure. WCS's ability to reduce carbon emissions and set a standard for other academics may lead to net emissions reductions through renewable energy, energy-efficient equipment, and less personal automobile commuting and waste. The programs' goals will help WCS students, staff, and stakeholders comprehend environmental risk and awareness as engaged institutional participants and educational leaders. Carbon neutrality plans for WCS demonstrate institutional commitment to climatic, social, and socioeconomic sustainability.

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