
CALCULATING CARBON EMISSION AND CULTIVATING CARBON SINKS IN GOVT POLYTECHNIC HAMIRPUR

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ABSTRACT

This study evaluates the carbon footprint of an educational institution by quantifying greenhouse gas (GHG) emissions generated from various campus activities in accordance with the GHG Protocol Corporate Standard. A bottom-up life cycle assessment (LCA) approach is used to identify emission sources and estimate carbon emissions in terms of carbon dioxide equivalent (CO₂e). The research also assesses the carbon sequestration potential of existing vegetation using allometric equations and examines suitable carbon offset measures, including renewable energy integration and green infrastructure development. The findings provide practical strategies for reducing institutional carbon emissions, improving environmental sustainability, and supporting climate action through effective carbon management.

Keywords: Carbon Footprint, Greenhouse Gas Emissions, Life Cycle Assessment (LCA), GHG Protocol, Carbon Sequestration, Carbon Offset, Educational Institution, Sustainable Development, Govt Polytechnic Hamirpur.

INTRODUCTION

Greenhouse gas (GHG) emissions have become one of the primary drivers of global climate change, with the building sector contributing significantly through energy consumption transportation, material use, and operational activities. Measuring the carbon footprint of educational institutions is essential for identifying major emission sources and developing effective mitigation strategies. Carbon footprint assessment, based on the GHG Protocol Corporate Standard, provides a systematic framework for quantifying direct (Scope 1), indirect electricity-related (Scope 2), and other indirect (Scope 3) emissions generated during institutional operations.

This study emphasizes the importance of sustainability, renewable energy adoption, energy efficiency, and carbon sequestration in reducing institutional greenhouse gas emissions. It highlights the role of carbon sinks, sustainable campus management, and climate-resilient infrastructure in achieving long-term environmental goals. The integration of emission assessment with international frameworks such as the Paris Agreement, Sustainable Development Goals (SDGs), and Environmental, Social, and Governance (ESG) principles strengthens institutional climate action and environmental accountability .Overall, the study provides a comprehensive approach for evaluating carbon emissions and cultivating carbon sinks within educational campuses, supporting the transition toward low-carbon, resource-efficient, and sustainable institutions while contributing to global climate change mitigation efforts.

STUDY AREA

The study was conducted at Government Polytechnic Hamirpur, Himachal Pradesh, an educational institution with academic, administrative, residential, and recreational facilities. The campus includes classrooms, laboratories, workshops, hostels, offices, internal roads, parking areas, and green spaces, all of which contribute to greenhouse gas emissions through electricity consumption, fuel use, transportation, and

waste generation. The presence of trees and landscaped areas also provides natural carbon sinks that help absorb atmospheric carbon dioxide. Owing to the coexistence of emission sources and vegetation, the campus serves as an appropriate case study for assessing carbon emissions and estimating carbon sequestration potential. The study supports the development of sustainable campus management practices and provides recommendations for reducing the institutional carbon footprint and promoting climate-resilient infrastructure.

METHODOLOGY

This study adopted a bottom-up approach to quantify the carbon footprint of **Government Polytechnic Hamirpur** by following the guidelines of **ISO 14064-1** and the **GHG Protocol Corporate Standard**. The assessment involved defining the institutional boundary and study period, identifying greenhouse gas emission sources, collecting activity-based data, and estimating carbon emissions using appropriate carbon conversion factors. Emissions were categorized into **Scope 1** (direct emissions from fuel consumption), **Scope 2** (indirect emissions from purchased electricity), and **Scope 3** (other indirect emissions such as employee commuting, water consumption, waste generation, and paper usage). Carbon emissions were expressed as carbon dioxide equivalent (CO₂) To evaluate the carbon sequestration potential of the campus existing trees were assessed using standard allometric equations to estimate above-ground and below-ground biomass and the corresponding carbon storage.

The study also explored potential carbon offset measures, including rooftop solar energy, energy-efficient technologies, natural ventilation, and other sustainable campus practices. The adopted methodology provides a comprehensive framework for assessing institutional carbon footprints and developing practical strategies for achieving carbon neutrality and sustainable campus management.

RESULTS AND DISCUSSIONS

This study presents a systematic assessment of greenhouse gas (GHG) emissions at Government Polytechnic Hamirpur using the GHG Protocol Corporate Standard. Activity-based data were collected from various campus operations, including LPG consumption, institute-owned vehicles, electricity use, paper consumption, water use, waste generation, and employee commuting. Emissions were classified into Scope 1, Scope 2, and Scope 3 categories and estimated using standard emission factors. Information was obtained from departmental records, inventory registers, utility bills, and field surveys, followed by cross-verification to ensure data accuracy and reliability. The assessment identifies the major sources of carbon emissions within the campus and establishes a comprehensive emission inventory. The results provide a strong basis for estimating the institutional carbon footprint and support the development of practical strategies such as energy efficiency, renewable energy adoption, waste minimization, and sustainable resource management to reduce emissions and promote a low-carbon educational campus.

Table4.1 LPG Consumption Data for the Institute

Fossil fuel (LPG) consumption in number of LPG cylinders													
Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
Girl's Hostel	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	9	5	9	9	10	10
	2026	8.5	10	10	9.5	9	-	-	-	-	-	-	-
Boy's Hostel	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	12	16	16	15	15	15	15	10	15	15	16	16
	2026	14	16	15.5	15	16	15	-	-	-	-	-	-
College Canteen	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	0	0	0	2	2	3
	2026	2	2	2	1	1.5	-	-	-	-	-	-	-

Table 4.1 presents the monthly LPG consumption recorded for the girls' hostel, boys' hostel, and college canteen at Government Polytechnic Hamirpur during the study period. The boys' hostel showed the highest LPG consumption throughout the year, ranging from 10 to 16 cylinders per month, with maximum consumption observed during February, November, and December. The girls' hostel began LPG consumption from July 2025, with usage varying between 5 and 10 cylinders per month, reaching its highest level during November 2025 to March 2026. The college canteen started operations in October 2025, and its LPG consumption remained comparatively low, ranging from 1 to 3 cylinders per month, with the highest consumption recorded in December 2025. No LPG consumption was recorded during periods when hostel or canteen operations were suspended. The observed monthly variations mainly reflect changes in student occupancy, academic schedules, and institutional activities. These data were used to estimate Scope 1 greenhouse gas emissions resulting from LPG combustion and form an important component of the institutional carbon footprint assessment.

Table 4.2 Electricity Consumption for the Institute

Electricity consumption in kWh													
Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
Girl's Hostel meter-1	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	1729	1020	0	449	836	3262
	2026	4213	2284	2039	2782	1800	-	-	-	-	-	-	-
Girl's Hostel meter-2	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	1445	324	1232	1385	1273	3334
	2026	4047	864	4459	3234	2292	-	-	-	-	-	-	-
Boy's Hostel	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	3050	765	1402	1483	2076	1504
	2026	5303	1778	2348	1961	1810	-	-	-	-	-	-	-
Institute meter-1	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	796	391	805	757	868	2371
	2026	3487	1436	1489	2033	1259	-	-	-	-	-	-	-
Institute meter-2	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	478	229	152	352	367	890
	2026	1422	801	716	1091	533	-	-	-	-	-	-	-
Institute meter-3	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	220	87	196	192	120	645
	2026	953	402	429	767	356	-	-	-	-	-	-	-

Table 4.2 presents the monthly electricity consumption of Government Polytechnic Hamirpur, including the girls' hostels, boys' hostel, and institute buildings, during the study period (July 2025–May 2026). Electricity consumption varied considerably across different campus facilities and seasons. During July to September 2025, consumption remained relatively low because of reduced occupancy and academic activities. A noticeable increase was observed from October to December 2025, with the highest consumption recorded in December, particularly in the girls' hostels and institutional buildings, reflecting increased electricity demand during the winter season. In 2026, electricity consumption reached its maximum in January, where the boys' hostel recorded 5,303 kWh, Girls' Hostel Meter-1 recorded 4,213 kWh, and Girls' Hostel Meter-2 recorded 4,047 kWh. Consumption gradually declined from February to May 2026, corresponding to reduced heating requirements and seasonal variations in campus operations. The monthly electricity consumption data were used to estimate Scope 2 greenhouse gas emissions using the standard grid emission factor and served as a major component of the institutional carbon footprint assessment.

Table 4.3 Paper Consumption for various institute activities

Consumption of Papers in the Institution in numbers				
	July-Sep2025	Oct-Dec 2025	Jan-Mar 2026	Apr-may 2026
A4-Sheets (no. of Sheets)	18000	19000	15500	25500
Ruled Sheets (Numbers)	7500	9500	8500	15000
Drawing Sheets (Numbers)	150	100	150	200

Table 4.4 Waste Disposal for Various Institute Activities

Waste Disposal in Kg													
Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
Girl's Hostel	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	280	150	310	320	340	320
	2026	320	320	310	300	340	-	-	-	-	-	-	-
Boy's Hostel	2024	-	-	-	-	-	-	-	-	-	-	-	-
	2025	-	-	-	-	-	-	260	120	270	260	280	290
	2026	280	270	270	260	280	-	-	-	-	-	-	-

Tables 4.3 and 4.4 present the paper consumption and solid waste generation at Government Polytechnic Hamirpur during the study period. A total of 78,000 A4 sheets, 40,500 ruled sheets, and 600 drawing sheets were consumed. Paper usage increased from July–September 2025 to April–May 2026, with the highest consumption recorded during April–May 2026 (25,500 A4 sheets, 15,000 ruled sheets, and 200 drawing sheets), mainly due to examination and academic activities. Waste generation was recorded from July 2025 to May 2026. The girls' hostel generated a total of 3,310 kg of waste, while the boys' hostel generated 2,840 kg. The highest waste generation was observed during November 2025 and May 2026 in the girls' hostel (340 kg/month) and December 2025 in the boys' hostel (290 kg/month), whereas the lowest waste generation occurred in August 2025 (150 kg in the girls' hostel and 120 kg in the boys' hostel). These data were used to estimate Scope 3 greenhouse gas emissions and assess resource consumption and waste management practices within the institute.

Table 4.5 Water Consumption for Various Institute Activities

Water Consumption in Kiloliter				
	July-Sep2025	Oct-Dec 2025	Jan-Mar 2026	Apr-May 2026
Girl's Hostel	320	590	1350	1040
Boy's Hostel	365	545	400	320
Institution	700	286	500	600

Table 4.6 Employee Commuting to the Institute

Employee Commuting fuel consumption in litres												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
2024	-	-	-	-	-	-	-	-	-	-	-	-
2025	-	-	-	-	-	-	410	48	410	410	410	410
2026	48	410	410	410	410	-	-	-	-	-	-	-

Tables 4.5 and 4.6 present the water consumption and employee commuting fuel consumption at Government Polytechnic Hamirpur during the study period. The girls' hostel consumed a total of 3,300 kL of water, with the highest

consumption during January–March 2026 (1,350 kL), followed by April–May 2026 (1,040 kL). The boys' hostel consumed 1,630 kL, while the institution consumed 2,086 kL, with the highest usage recorded during July–September 2025 (700 kL). Employee commuting records indicate a total fuel consumption of 3,786 litres between July 2025 and May 2026. Fuel consumption was 410 litres per month during July, September, October, November, December 2025 and February, March, April, and May 2026, whereas August 2025 and January 2026 recorded the lowest consumption of 48 litres each.

CONCLUSION AND RECOMMENDATIONS

This study evaluated the carbon footprint of Government Polytechnic Hamirpur using the GHG Protocol Corporate Standard and ISO 14064-1 framework. The assessment identified electricity consumption as the largest source of greenhouse gas emissions, followed by fuel consumption, transportation, paper use, water consumption, and waste generation. The existing tree cover on the campus provides substantial carbon sequestration, helping offset a significant portion of the institutional emissions. The findings indicate that adopting renewable energy systems, improving energy efficiency, strengthening waste management, and expanding green cover can further reduce the campus carbon footprint. The developed carbon accounting framework offers a practical approach for monitoring emissions and planning sustainability initiatives. It can also serve as a model for other educational institutions seeking to achieve low-carbon and environmentally sustainable campus operations.

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