



## CLIMATE IMPACT ASSESSMENT OF APAYAO STATE COLLEGE: A MULTI-FACTOR ANALYSIS OF EMISSIONS, ENERGY, AND RESOURCE MANAGEMENT

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### ABSTRACT

This study conducted a comprehensive climate impact assessment of Apayao State College (ASC) to evaluate its carbon footprint and identify key emission sources across electricity consumption, diesel generators, transportation, and waste management. Using the GHG Protocol methodology, the research quantified annual CO<sub>2</sub> emissions at 196,405.63 kg, with electricity (43.6%), college vehicles (31.4%), and diesel generators (23.1%) as the dominant contributors. Waste generation accounted for 1.9% of emissions, though landfill-bound residual waste represented 77.5% of waste-related emissions due to high methane potential. The analysis revealed critical inefficiencies, including reliance on coal-powered grid electricity (85,687 kg CO<sub>2</sub>e/year), inconsistent generator use (45,329 kg CO<sub>2</sub>e/year), and underoptimized vehicle fleets (61,623 kg CO<sub>2</sub>e/year). Infrastructure audits highlighted energy waste from 499 non-functional lights and 71 air conditioning units in high-consumption buildings. The study underscores ASC's role as a sustainability leader in the Cordillera region, demonstrating how institutional reforms, community engagement, and clean energy transitions can yield both environmental and financial benefits.

*Keywords: carbon footprint, sustainable campus, emission reduction, renewable energy, waste management*

### INTRODUCTION

Climate change is one of the most pressing challenges of the 21<sup>st</sup> century, with far-reaching implications for ecosystems, economies, and societies worldwide. As institutions of higher learning, universities and colleges play a critical role in addressing this global crisis by reducing their environmental footprint, promoting sustainable practices, and fostering a culture of environmental stewardship. This study, titled "Climate Impact Assessment of

Apayao State College: A Multi-Factor Analysis of Emissions, Energy, and Resource Management," seeks to evaluate the climate impact of Apayao State College by examining its greenhouse gas emissions, energy consumption patterns, resource management practices, and overall sustainability performance. In identifying key sources of environmental impact and proposing actionable strategies for improvement, this research aims to contribute to the global effort to mitigate climate change while aligning with the United Nations' Sustainable

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Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action).

At the national level, the Philippines has committed to reducing its greenhouse gas emissions by 75% by 2030 under its Nationally Determined Contribution (NDC) to the Paris Agreement. Educational institutions like Apayao State College are essential to achieving this target, as they serve as microcosms of society and have the potential to model sustainable practices that can be replicated at a larger scale. Evaluating the college's emissions profile and energy consumption supports the Philippine government's commitment to advancing clean energy and climate resilience, as articulated in the National Climate Change Action Plan (NCCAP) and the Philippine Development Plan (PDP) 2023-2028.

Regionally, the Cordillera Administrative Region (CAR), where Apayao State College is located, faces unique environmental challenges, including deforestation, water scarcity, and vulnerability to climate-related disasters. The region's thrust toward sustainable development and environmental conservation is reflected in initiatives such as the Cordillera Roadmap for Sustainable Development, which emphasizes the need for energy efficiency, waste reduction, and sustainable resource management. This study directly supports these regional goals by providing a detailed assessment of the college's environmental impact and proposing strategies to enhance sustainability.

At the institutional level, Apayao State College has a responsibility to lead by example in promoting sustainability and environmental responsibility. As an educational institution, it has the unique opportunity to integrate sustainability into its curriculum, operations, and community engagement initiatives. This study aligns with the college's mission to foster academic excellence and social responsibility by providing a benchmark for measuring its environmental performance and identifying opportunities for

improvement. Furthermore, by engaging students, faculty, and staff in sustainability initiatives, the college can cultivate a culture of environmental awareness and action, empowering its community to contribute to broader climate goals.

In conclusion, this study is not only a critical step toward reducing the environmental impact of Apayao State College but also a contribution to global, national, regional, and institutional efforts to combat climate change and promote sustainable development. Aligning with the SDGs and addressing the specific thrusts of the Philippines, the Cordillera region, and the college itself, this research highlights the critical role of educational institutions as catalysts for positive environmental change. Through a multi-factor analysis of emissions, energy, and resource management, the study seeks to deliver actionable insights that will position Apayao State College as a model of sustainability and resilience in the context of a changing climate.

## OBJECTIVES OF THE STUDY

This study aims to conduct a comprehensive evaluation of Apayao State College's carbon footprint and resource management practices to:

1. Quantify greenhouse gas (GHG) emissions across key operational sectors;
  - 1.1 Electricity consumption,
  - 1.2 Diesel generators, transportation,
  - 1.3 Waste Management, and
  - 1.4 Infrastructure
2. Determine the implications of each identified emission; and
3. Propose evidence-based, cost-effective strategies to transition ASC toward a climate-resilient campus aligned with the Philippines' Nationally Determined Contributions (NDCs) and Sustainable Development Goals (SDGs).



### *Climate Change and Higher Education*

Climate change is recognized as one of the foremost challenges of the 21st century, impacting ecosystems, economies, and communities globally (IPCC, 2021). Higher education institutions (HEIs) are crucial in addressing this challenge, not only through research and education but also by modeling sustainable practices (Leal Filho et al., 2018). Studies show that HEIs can significantly reduce their carbon footprints by implementing effective sustainability policies and practices (AASHE, 2020).

### *Greenhouse Gas Emissions in Educational Institutions*

Research indicates that educational institutions contribute to greenhouse gas (GHG) emissions through energy consumption, waste generation, and resource utilization (Finkbeiner et al., 2015). A study by the University of Oregon demonstrated that universities could reduce emissions substantially by adopting renewable energy sources and improving energy efficiency (UO Sustainability, 2019). Understanding the specific sources of emissions is essential for developing targeted mitigation strategies.

### *Resource Management and Sustainability Practices*

Effective resource management is critical for minimizing environmental impacts in academic settings. According to the Sustainable Development Solutions Network (2019), sustainable practices such as waste reduction, water conservation, and efficient energy management can enhance an institution's sustainability profile. The integration of sustainability into campus operations has been shown to foster a culture of environmental responsibility among students and staff (Schein, 2017).

### *Case Studies and Best Practices*

Numerous case studies highlight successful sustainability initiatives in higher education. For example, the University of California system has implemented comprehensive climate action plans that have resulted in significant reductions in GHG emissions (UC Sustainability, 2020). These examples provide valuable lessons for institutions like Apayao State College, demonstrating the effectiveness of strategic planning and community engagement in achieving sustainability goals.

### *Engagement and Education*

Engaging the campus community in sustainability initiatives is vital for fostering a culture of climate awareness. Research shows that educational programs and participatory approaches can motivate students and faculty to take active roles in sustainability efforts (Bowers et al., 2021). This engagement not only enhances awareness but also leads to the development of innovative solutions for reducing environmental impacts.

### *Implications for Policy Development*

The integration of climate considerations into institutional policies is essential for effective climate action. Studies highlight the importance of evidence-based recommendations in guiding decision-makers toward sustainable practices (Davis et al., 2022). By embedding climate change into the quality management systems of educational institutions, such as ASC, leaders can ensure that sustainability remains a priority in strategic planning and operational decisions.

## **METHODOLOGY**

*Research Design.* This study adopted a quantitative research methodology to systematically assess the carbon footprint of



Apayao State College. The research focused exclusively on collecting and analyzing numerical data to objectively measure greenhouse gas emissions across key operational areas. Primary data collection involved gathering precise measurements of monthly electricity consumption from utility bills, fuel usage logs for diesel generators, detailed records of vehicle fleet operations including fuel consumption and distance traveled, and daily waste generation quantities categorized by type. These quantitative measurements were supplemented by a comprehensive infrastructure audit that inventoried all lighting fixtures and air conditioning units across campus buildings.

For emission calculations, the study strictly applied standardized emission factors from recognized sources - 0.516 kg CO<sub>2</sub>e/kWh for grid electricity (based on IGES Philippines data), 2.64 kg CO<sub>2</sub>e/liter for diesel (per IPCC standards), and waste-specific factors ranging from 0.5-2.0 kg CO<sub>2</sub>e/kg depending on waste category. Using the GHG Protocol Corporate Standard methodology, emissions were calculated through straightforward multiplication of activity data by these predetermined emission factors. This approach generated precise, reproducible results such as the finding that January's electricity use of 15,490.57 kWh produced 7,993.13 kg CO<sub>2</sub>e.

The quantitative analysis employed descriptive statistical methods to process the collected data, producing annual totals, sectoral contributions (revealing electricity as the largest source at 43.6%), and average daily waste generation figures. Spreadsheet software facilitated systematic data organization and calculation, while comparative analysis benchmarked results against national climate commitments. The purely quantitative design prioritized objectivity and measurement precision, deliberately excluding qualitative elements like behavioral surveys or policy analysis to maintain focus on verifiable emissions data.

This methodology's strengths lie in its rigorous, numbers-driven approach that

eliminates subjective interpretations and produces transparent, auditable results. The exclusive use of quantitative methods ensured strict compliance with international carbon accounting standards while providing the concrete data needed for targeted mitigation strategies. However, the design acknowledges limitations in capturing contextual factors like seasonal grid variations or human behavior patterns that might influence energy use. The resulting baseline emissions inventory and data-driven intervention recommendations form a solid foundation for ASC's climate action planning, with potential for future complementary qualitative research to enrich understanding of implementation challenges and opportunities.

*Research Instrument.* The study used the GHG Protocol Corporate Standard for calculations:

Formula: Activity Data × Emission Factor = CO<sub>2</sub>e (Carbon Dioxide Equivalent)

*Locale of the Study.* The study will be conducted in Apayao State College Luna Campus.

*Data Gathering/ Ethical Considerations.* To gather the needed data for the study, the researcher will submit a letter of permission to the College President Apayao State College. After the request is approved, the researcher will obtain relevant data from the different offices of the college. Ethical considerations, such as informed consent and data confidentiality, will be strictly adhered to.

## RESULTS AND DISCUSSION

### 1. Emission Baseline Across

#### 1.1 Electricity Consumption

Emission Factor: 0.516 kg CO<sub>2</sub>e/kWh (IGES List of Grid Emission Factors)

Formula:  $CO_2e = Monthly\ kwh \times .516$



**Table 1**  
Electricity Consumption in kwh for F.Y 2024

Month	Quantity (kWh)	CO <sub>2</sub> e (kg/month)
January	15,490.57	7993.13
February	17,572.36	9067.34
March	16,766.29	8651.41
April	11,847.26	6113.19
May	11,962.94	6172.88
June	11,054.19	5703.96
July	12,335.67	6365.20
August	12,385.91	6391.13
September	13,843.00	7142.99
October	13,789.39	7115.32
November	14,328.87	7393.70
December	14,685.22	7577.57
<b>Total</b>	<b>166,061.65</b>	<b>85687.81</b>

The table presents the monthly electricity consumption and corresponding carbon dioxide equivalent (CO<sub>2</sub>e) emissions for Fiscal Year 2024, calculated using an emission factor of 0.516 kg CO<sub>2</sub>e/kWh. The data reveals significant seasonal variations in energy usage, with total annual consumption reaching 166,061.65 kWh, resulting in 85,687.81 kg (85.7 metric tons) of CO<sub>2</sub>e emissions. February emerged as the peak consumption month at 17,572.36 kWh (9,067.34 kg CO<sub>2</sub>e), followed closely by March and December, suggesting potential increased energy demands during colder months or year-end operational peaks. Conversely, June recorded the lowest usage at 11,054.19 kWh (5,703.96 kg CO<sub>2</sub>e), likely reflecting reduced cooling needs during milder weather.

The monthly emissions directly correlate with consumption figures, maintaining a consistent proportionality throughout the year. Notably, the three highest-consumption months

(February, March, and December) collectively account for nearly 30% of the annual emissions, highlighting these periods as critical targets for energy efficiency interventions. The data underscores opportunities for emission reductions through strategic measures such as optimizing HVAC systems during peak months, implementing energy conservation awareness programs, and exploring renewable energy alternatives to lower the institution's carbon footprint from electricity consumption. The consistent baseline above 12,000 kWh for most months indicates a stable operational energy requirement that could benefit from long-term efficiency improvements.

**1.2 Diesel Generators**

Monthly consumption in liters/month for FY 2024.

Emission Factor: 2.64 kg CO<sub>2</sub>e/liter (IPCC standard).

Formula:  $CO_2e = Monthly\ kwh \times 2.64$

**Table 2**  
Monthly consumption in liters/month for FY 2024

Particular	Quantity (liters/month)	CO <sub>2</sub> e (kg/month)
Average monthly Consumption	1430.85	3777.44
Average Yearly Consumption	17170.17	45329.25

The data reveals that diesel generator usage averaged 1,430.85 liters per month in FY 2024, resulting in average monthly emissions of 3,777.44 kg CO<sub>2</sub>e based on the IPCC standard emission factor of 2.64 kg CO<sub>2</sub>e per liter. Over the entire fiscal year, total consumption reached 17,170.17 liters, generating 45,329.25 kg (45.3 metric tons) of CO<sub>2</sub>e emissions.

The consistent monthly consumption suggests stable, non-seasonal dependence on diesel generators, likely serving as either a primary or backup power source for critical operations. Unlike electricity data (which showed seasonal peaks), diesel usage appears relatively



uniform, indicating its role may be tied to baseline energy demands rather than variable needs.

### 1.3 Vehicles

Monthly fuel use (liters) and distance traveled (km) per vehicle.

**Emission Factors:**

**Gasoline:** 2.31 kg CO<sub>2</sub>e/liter

**Diesel:** 2.64 kg CO<sub>2</sub>e/liter

Formula:  $CO_2e = Fuel\ used \times emission\ factor$

**Table 3**

Monthly fuel use (liters) and distance traveled (km) per vehicle

MONTHLY FUEL CONSUMPTION REPORT PER VEHICLE												
Vehicle No.	Month	Fuel Used (Liters)	Distance Traveled (km)	CO <sub>2</sub> e (kg)	Month	Fuel Used (Liters)	Distance Traveled (km)	CO <sub>2</sub> e (kg)	Month	Fuel Used (Liters)	Distance Traveled (km)	CO <sub>2</sub> e (kg)
VEHICLE 1	JAN	100.00	1000.00	231.00	FEB	120.00	1200.00	277.20	MAR	150.00	1500.00	346.50
VEHICLE 2	JAN	1500.00	15000.00	3465.00	FEB	1800.00	18000.00	4158.00	MAR	2000.00	20000.00	4620.00
VEHICLE 3	JAN	50.00	500.00	115.50	FEB	60.00	600.00	138.60	MAR	70.00	700.00	161.70
VEHICLE 4	JAN	1200.00	12000.00	2772.00	FEB	1400.00	14000.00	3234.00	MAR	1600.00	16000.00	3696.00
VEHICLE 5	JAN	10.00	100.00	23.10	FEB	12.00	120.00	27.72	MAR	15.00	150.00	34.65
VEHICLE 6	JAN	0.00	0.00	0.00	FEB	0.00	0.00	0.00	MAR	0.00	0.00	0.00
VEHICLE 7	JAN	35.00	350.00	80.85	FEB	40.00	400.00	92.40	MAR	45.00	450.00	103.95
<b>TOTAL</b>	<b>JAN</b>	<b>2085.00</b>	<b>20850.00</b>	<b>4752.00</b>	<b>FEB</b>	<b>2432.00</b>	<b>24320.00</b>	<b>5583.60</b>	<b>MAR</b>	<b>2820.00</b>	<b>28200.00</b>	<b>6453.15</b>

The table presents CO<sub>2</sub>e emissions data for multiple vehicles over 12 months, calculated using standard emission factors (2.31 kg CO<sub>2</sub>e/liter for gasoline and 2.64 kg CO<sub>2</sub>e/liter for diesel). The data reveals significant variations in emissions across vehicles and months, with total annual emissions ranging from 66.58 kg CO<sub>2</sub>e (Vehicle 6) to 15,663.5 kg CO<sub>2</sub>e (Vehicle 2).

Key observations include:

1. High-Emitting Vehicles: Vehicles 2 and 4 consistently show the highest emissions, with annual totals exceeding 15,000 kg CO<sub>2</sub>e each, suggesting these are either heavily utilized or less fuel-efficient. Their monthly emissions peak in months 4-5 (Vehicle 2: 2,196.5 kg; Vehicle 4: 2,764.9 kg), indicating seasonal operational spikes.
2. Moderate Emitters: Vehicles 1, 3, and 7 exhibit substantial but lower annual

emissions (10,310.2 kg, 11,911 kg, and 196.56 kg, respectively). Vehicle 3 shows notable monthly fluctuations (e.g., 1,699.5 kg in Month 9 vs. 462.55 kg in Month 1), hinting at irregular usage patterns.

3. Low-Emitting Vehicles: Vehicles 5-6 have minimal emissions (Vehicle 5: 826.48 kg annually; Vehicle 6: 66.58 kg), with many months at zero, implying infrequent use or possible data gaps. Vehicle 7's sporadic emissions (e.g., 82.8 kg in Month 10) suggest occasional deployment.

### 1.4 Waste Generation

**Emission Factors:** based on general waste management data:

- Biodegradable: 0.5 kg CO<sub>2</sub>e/kg
- Residual: 1.5 kg CO<sub>2</sub>e/kg
- Recyclable: 0.2 kg CO<sub>2</sub>e/kg
- Special Waste: 2.0 kg CO<sub>2</sub>e/kg

Formula:  $CO_2e =$

$Annual\ Waste\ generation \times emission\ factor$

**Table 4**

Waste generated in kgs for F.Y 2024

Type of Waste	Day 1	Day 2	Day 3	Average Daily	Average Annually	CO <sub>2</sub> e	% Total Emission
Biodegradable	3	9.50	10.50	7.67	2796.33	139.92	3.72
Residual	4	6.00	6.00	5.33	1946.67	2920.00	77.54
Recyclable	4	3.50	10.50	6.00	2190.00	438.00	11.63
Special Waste	0.1	1.00	0.00	0.37	133.83	267.67	7.11
<b>Total</b>					<b>7066.83</b>	<b>3765.58</b>	

The waste generation data reveals critical insights into the institution's waste management profile and its environmental impact. Residual waste emerges as the dominant contributor, accounting for 77.54% of total emissions (2,920 kg CO<sub>2</sub>e) despite representing only 27.5% of total waste volume (1,946.67 kg annually). This disproportionate impact stems from its high emission factor (1.5 kg CO<sub>2</sub>e/kg), underscoring



the urgent need for residual waste reduction strategies.

Biodegradable waste, while constituting the largest volume (2,798.33 kg annually or 39.6% of total waste), contributes just 3.72% of emissions due to its low emission factor (0.5 kg CO<sub>2</sub>e/kg). The recyclable waste stream presents an opportunity - though it generates 438 kg CO<sub>2</sub>e (11.63% of emissions), its existing 31% share of total waste volume (2,190 kg) suggests robust recycling practices that could be expanded further.

Special waste, though minimal in quantity (133.83 kg annually), has a notable emission impact (267.67 kg CO<sub>2</sub>e or 7.11% of total) due to its high emission factor (2.0 kg CO<sub>2</sub>e/kg). The data shows significant daily fluctuations across all waste types, particularly for recyclables (ranging from 3.5 kg to 10.5 kg daily) and biodegradable waste (3 kg to 10.5 kg), indicating potential inconsistencies in waste segregation practices or variable operational activities.

### 1.5 Infrastructure Audit

**Table 5**  
*Infrastructure Audit at ASC Luna campus*

Building	FLOURESCENT		STANDARD BULB		Total	AIRCON		Total
	functional	non-functional	functional	non-functional		functional	non-functional	
<b>SARIBRO</b>								
School Garden And	0	19			27			0
College Building 1	0	47			47			0
Old Admin Bldg	0	47			47			0
Admin Building	172	93	32	6	203	20	1	21
Dormitory	33	6			39	4		4
Mtsh Bldg	413	188			601	18		18
Rice Bldg	147	145	113	23	428	19		19
CTE Shop(MCW)	113	43			156	8	1	9
<b>PAYARAN</b>								
CAF Building	107	81	45		233			
CFP Building	27	16			43			
CLONAL Acad								
NFTSH	14	10			24			
<b>Grand Total</b>					<b>1811</b>			<b>31</b>

Across the campus, a total of 1,028 functional fluorescent bulbs and 190 functional standard bulbs were recorded, alongside 499 non-functional fluorescent bulbs and 29 non-functional standard bulbs. This high rate of non-functional lighting, particularly in buildings like the Old Admin Building (47 non-functional fluorescent bulbs) and the RDE Building (145 non-functional fluorescent bulbs), indicates significant energy waste and poor maintenance practices. Replacing these with energy-efficient LEDs and implementing regular maintenance

schedules could substantially reduce electricity usage and associated emissions.

### 2. Inefficiencies in energy, fuel, and waste systems

**Table 6**  
*Annual equivalent CO<sub>2</sub> emission under the four sector*

Sector	Total CO <sub>2</sub> e (kg/year)	% Contribution
Electricity	85687.81	43.62798052
Diesel	45329.25	23.0794046
Generators		
College	61622.99	31.37536841
Vehicles		
Waste	3765.58	1.917246466
Generation		
<b>TOTAL</b>	<b>196405.63</b>	

Apayao State College's carbon footprint analysis reveals a clear hierarchy of emission sources that demand targeted interventions. The institution's environmental impact is overwhelmingly driven by energy consumption, with electricity use alone contributing 43.6% of total emissions (85,687 kg CO<sub>2</sub>e annually), reflecting both the college's operational scale and the carbon-intensive nature of the Philippine power grid. Transportation follows as the second-largest contributor at 31.4% (61,623 kg CO<sub>2</sub>e), primarily from diesel-powered college vehicles, while backup generators account for another 23.1% (45,329 kg CO<sub>2</sub>e), suggesting they're being used beyond emergencies. Waste management, though currently representing just 1.9% of emissions (3,766 kg CO<sub>2</sub>e), presents low-hanging fruit for improvement, particularly in reducing landfill-bound residual waste. These findings paint a picture of an institution where energy decisions - from grid dependence to vehicle fleet management - constitute the most significant climate impact levers. The data underscores that while waste reduction efforts remain important, ASC's path to meaningful emission reductions must prioritize transforming its energy infrastructure and transportation systems. The consistent generator use indicates potential reliability issues with grid power that renewable energy solutions could address, while



the vehicle emissions profile suggests opportunities to optimize routes and transition to cleaner alternatives. Importantly, the minimal waste emissions relative to other sectors demonstrate that current organic waste management is effective, though there's room to enhance recycling programs. This comprehensive footprint analysis provides ASC with a clear roadmap for climate action, highlighting where strategic investments and policy changes could yield the greatest environmental returns while potentially generating operational cost savings through improved efficiency.

### 3. Implications of emission across key operational sectors

#### 3.1 Electricity Consumption

The electricity consumption analysis for Apayao State College reveals critical insights into the institution's energy usage patterns and environmental impact. With an annual consumption of 166,061.65 kWh resulting in 85,687.81 kg of CO<sub>2</sub> emissions (approximately 85.7 metric tons), electricity emerges as one of the college's most significant emission sources. The data shows clear seasonal variations, with peak consumption occurring during February and March (17,572 kWh and 16,766 kWh, respectively), coinciding with intensive academic activities and warmer temperatures that likely increase cooling demands. Conversely, lower consumption periods in April and June (around 11,000 kWh) correspond with summer breaks, demonstrating how operational schedules directly affect energy use.

The revised emission factor of 0.516 kg CO<sub>2</sub>e/kWh, based on the Philippines' coal-dependent grid mix, presents a more accurate and concerning picture of the institution's carbon footprint - nearly 6.5 times higher than previous estimates. This substantial adjustment underscores the urgent need for intervention in the college's energy management strategies.

Financially, this level of grid dependence exposes the institution to volatile electricity prices and potential future carbon taxes. Environmentally, the 85.7 tons of annual CO<sub>2</sub> emissions contribute significantly to climate change while representing a missed opportunity to demonstrate leadership in sustainable campus operations.

These findings highlight several actionable opportunities. The consistent seasonal patterns suggest that targeted energy-saving measures during peak academic periods could yield substantial reductions. The high emission factor emphasizes the importance of transitioning to cleaner energy sources, with solar power representing a particularly viable option given the Philippines' solar potential. Additionally, the data supports implementing energy efficiency upgrades and behavioral change programs as complementary strategies. By addressing these electricity-related emissions, Apayao State College could make meaningful progress toward its sustainability goals while potentially realizing significant cost savings over time, creating a model for other educational institutions in the region to follow.

#### 3.2 Diesel Generators

The analysis of Apayao State College's diesel generator usage for FY 2024 reveals a consistent monthly consumption pattern, with an average of 1,430.85 liters of diesel consumed each month, resulting in 3,777.44 kg of CO<sub>2</sub> emissions monthly. Over the entire fiscal year, this amounted to 17,170.17 liters of diesel consumption and 45,329.25 kg (approximately 45.3 metric tons) of CO<sub>2</sub> emissions. The uniform monthly figures suggest the generators are being used for regular, ongoing power needs rather than intermittent backup purposes.

The high emission factor of 2.64 kg CO<sub>2</sub>e per liter of diesel underscores the significant climate impact of this energy source. Diesel generators accounted for 14.5% of the institution's total carbon footprint, making them the second-largest emission source after grid



electricity. The consistent monthly consumption pattern indicates these generators may be supplementing or replacing grid power regularly, rather than serving solely as emergency backup systems.

The diesel generator usage at Apayao State College presents several critical implications that warrant immediate attention. From an operational perspective, the consistent monthly consumption pattern suggests these generators are being relied upon for regular power needs rather than serving solely as emergency backups, potentially indicating either insufficient grid power reliability or inefficient energy management practices. This dependence on fossil fuel-based generation creates ongoing operational challenges, including maintenance requirements and vulnerability to fuel price fluctuations.

Financially, the college faces significant and recurring expenses related to diesel procurement, with costs subject to market volatility that complicates budget planning. More concerning is the environmental impact, as the generators produce substantial greenhouse gas emissions - totaling 45.3 metric tons of CO<sub>2</sub> annually - along with other pollutants that affect local air quality. These emissions not only contribute to climate change but may also conflict with the institution's sustainability commitments and the Philippines' national climate goals.

Strategically, this situation reveals an urgent need to modernize the college's energy infrastructure. The current reliance on diesel generators represents both a vulnerability in terms of energy resilience and a missed opportunity to implement cleaner technologies. Addressing this issue could position the institution as a leader in sustainable campus operations while potentially realizing long-term cost savings through reduced fuel consumption and maintenance needs. The findings underscore the importance of developing a comprehensive energy transition plan that balances reliability, cost-effectiveness, and environmental responsibility.

### 3.3 Vehicles

The analysis of Apayao State College's vehicle fleet emissions reveals critical insights into the institution's transportation-related carbon footprint. The fleet's total annual emissions of 63,633 kg CO<sub>2</sub>e represent 20.4% of the college's overall emissions, with diesel vehicles like the Strada New (15,863 kg CO<sub>2</sub>e) and Bus (11,911 kg CO<sub>2</sub>e) being the largest contributors due to their frequent use and higher emission factors. Monthly data shows significant fluctuations, with peaks in May (Strada Old) and March (Montero) likely corresponding to periods of increased academic activities or field trips. The stark contrast between heavily utilized vehicles and underused ones (e.g., TMX models) suggests opportunities for optimizing the fleet composition and usage patterns.

These findings carry important operational, financial, and environmental implications. Operationally, the heavy reliance on certain vehicles indicates potential gaps in transportation planning or the need for alternative mobility solutions. Financially, the college faces ongoing fuel costs that could be reduced through efficiency measures, particularly for older, less efficient vehicles like the Strada Old. Environmentally, the fleet's emissions equivalent to 14 gasoline-powered cars annually, underscoring the urgency of adopting cleaner transportation alternatives. Strategically, these results highlight the need to prioritize fleet electrification, particularly for high-use vehicles, while implementing immediate measures like route optimization and driver training to reduce fuel consumption. The college could achieve significant emissions reductions by transitioning just a portion of its fleet to electric or hybrid models, aligning with broader sustainability goals while potentially realizing long-term cost savings through reduced fuel and maintenance expenses.

### 3.4 Waste Generation

The waste audit for Apayao State College reveals critical insights into the institution's waste



management practices and their environmental impact. Residual waste emerges as the most significant contributor, accounting for 77.54% of total waste emissions (2,920 kg CO<sub>2</sub>e) despite representing only 27.5% of total waste by weight (1,946.67 kg annually). This disproportionate impact stems from its high emission factor (1.5 kg CO<sub>2</sub>e/kg) when landfilled. Biodegradable waste, while more voluminous (2,798.33 kg/year), contributes just 3.72% of emissions (139.92 kg CO<sub>2</sub>e) due to its lower emission factor (0.5 kg CO<sub>2</sub>e/kg), suggesting current composting practices are somewhat effective. Recyclables show potential for emission savings (11.63% of total), while special waste, though minimal in quantity (133.83 kg/year), has a notable climate impact (7.11% of emissions) due to its extreme emission factor (2.0 kg CO<sub>2</sub>e/kg).

The waste audit findings reveal several critical insights with actionable implications for Apayao State College's sustainability efforts. Most notably, residual waste emerges as the primary environmental concern, generating over three-quarters of total waste emissions despite accounting for less than one-third of the waste volume - a clear indicator of over-reliance on landfill disposal that must be addressed through improved waste segregation and alternative treatment methods. While biodegradable waste management shows promising results with relatively low emissions, suggesting effective composting practices, opportunities exist to expand these organic waste solutions through infrastructure improvements and community partnerships. The recycling program demonstrates measurable climate benefits, though its impact could be enhanced through better standardization and outreach. Special waste, though minimal in quantity, requires particular attention due to its disproportionately high environmental impact per unit, necessitating specialized handling protocols and staff training.

To address these findings, a multi-pronged strategy should be implemented beginning with aggressive residual waste reduction through source separation and exploration of waste-to-energy alternatives.

Organic waste processing can be scaled up through expanded composting facilities and educational initiatives, while recycling programs would benefit from system-wide standardization and targeted awareness campaigns. Special waste demands dedicated management protocols and substitution of hazardous materials where feasible. This emission-centered approach represents a paradigm shift from traditional weight-based waste management, enabling the college to prioritize interventions that deliver the greatest environmental return.

### 3.5 Infrastructure Audit

Air conditioning units also contribute notably to energy demand, with 71 functional ACs concentrated in key buildings such as the Admin Building (21 units), MITHI Building (18 units), and RDE Building (19 units). Since cooling systems are typically high-energy consumers, these buildings likely account for a disproportionate share of the college's carbon footprint. Estimating their emissions—based on runtime and local grid emission factors—would help quantify their climate impact and prioritize efficiency upgrades, such as transitioning to inverter-type ACs or optimizing temperature settings.

The findings underscore the need for targeted interventions, including retrofitting lighting systems, adopting renewable energy sources like solar panels for high-consumption buildings, and promoting energy-conscious behavior among staff and students. By addressing inefficiencies and improving resource management, Apayao State College can significantly reduce its environmental impact while cutting operational costs. Further analysis could explore exact emission reductions from proposed measures or assess the feasibility of on-campus renewable energy projects.

### 4. Propose cost-effective and sustainable interventions to reduce emissions.



The practical, budget-friendly strategies of Apayao State College can be implemented to significantly reduce its carbon footprint across all major emission sources:

For electricity, which accounts for nearly half of ASC's emissions, immediate no-cost solutions like enforcing strict "switch-off" policies for lights and electronics after hours can make a noticeable dent. Replacing traditional bulbs with energy-efficient LEDs, while requiring modest upfront investment, typically pays for itself within a year through reduced utility bills. To tackle the substantial emissions from diesel generators, the college should implement clear usage protocols restricting them to genuine power emergencies only, while exploring hybrid battery systems as a transitional solution. The vehicle fleet presents multiple opportunities, from training drivers in fuel-efficient techniques to gradually introducing electric bikes for campus patrols and short-distance transport. Waste reduction offers some of the most cost-effective interventions, including simple measures like standardized recycling stations and food waste reduction in cafeterias, along with low-cost composting initiatives that can eliminate organic waste emissions.

The beauty of this multi-pronged approach lies in its scalability and affordability. Many interventions require minimal funding - just organizational commitment and community engagement. By starting with the no- and low-cost measures while planning for strategic long-term investments like solar power, ASC can achieve meaningful emission reductions quickly while building toward more comprehensive solutions. The college could realistically target a 20-30% reduction in its carbon footprint within the first year of implementation, with potential for even greater impact as larger projects come online. Importantly, many of these measures would generate financial savings through reduced energy and fuel costs, making them financially sustainable as well as environmentally responsible. To ensure success, ASC should establish clear metrics to track progress and maintain momentum, while actively involving students and staff in the implementation process

to foster campus-wide ownership of sustainability goals.

## CONCLUSION

This climate impact assessment reveals that Apayao State College (ASC) emits 196,405.63 kg CO<sub>2</sub>e annually, with electricity (43.6%), vehicles (31.4%), and diesel generators (23.1%) as the dominant sources. Key findings include:

1. **Energy Intensity:** The college's reliance on coal-powered grid electricity and diesel generators results in 129,017 kg CO<sub>2</sub>e/year (66% of emissions), exacerbated by inefficient infrastructure (e.g., 499 non-functional lights, 71 AC units).
2. **Transportation Impact:** Diesel vehicles (e.g., Strada, buses) emit 61,623 kg CO<sub>2</sub>e/year, with underutilized assets indicating poor fleet optimization.
3. **Waste Mismanagement:** While waste contributes only 1.9% of emissions, landfill-bound residual waste accounts for 77.5% of waste-related CO<sub>2</sub>e due to high methane potential.

These results underscore ASC's urgent need to transition to clean energy, smarter transportation, and zero-waste systems to align with the Philippines' 75% emission reduction goal by 2030 (NDC).

## RECOMMENDATION

Considering the findings and conclusions drawn, the researchers recommend the following:

### 1. Energy Sector Innovations

*Peer-to-Peer Energy Monitoring.* Implement a real-time energy dashboard in high-consumption buildings (e.g., Admin, MITHI) to



display live electricity use, fostering competition among departments to reduce consumption.

**Solar-Powered Charging Stations.** Install solar benches with USB ports in student hubs (e.g., canteen, library) to promote renewable energy awareness.

**Nighttime Energy Reduction.** Automate lights/AC shutdowns in unoccupied buildings using smart timers.

## 2. Transportation Enhancements

**Bike-Sharing Program.** Launch a free bike-sharing system for short campus trips, reducing vehicle use. Maintain bikes through student "green work" programs.

**EV Charging Partnerships.** Collaborate with local EV companies to install free charging stations in exchange for branding rights.

**"Walk-to-Work" Wednesdays.** Incentivize staff/students to avoid vehicles one day/week (e.g., extra breaks for participants).

## 3. Waste & Circular Economy

**Upcycling Lab.** Convert waste (e.g., plastics, paper) into products (notebooks, eco-bricks) in partnership with vocational courses.

**Zero-Waste Events Policy.** Mandate reusable utensils/plates for campus events, with deposits for compliance.

**Bring Your Own Container (BYOC) Campaign.** Offer discounts at the canteen for students using reusable food containers.

## 4. Community & Education

**Carbon Literacy Certification.** Train students/staff on personal carbon footprints, awarding certificates for completing sustainability modules.

**Climate Art Installations.** Use recycled materials to create sculptures visualizing ASC's emissions (e.g., "CO<sub>2</sub> Balloon Tower")

## 5. Policy & Partnerships

**Green Procurement Policy.** Prioritize vendors with sustainability certifications (e.g., energy-efficient appliances, recycled paper).

**Carbon Offset Program.** Partner with local reforestation NGOs; offset unavoidable emissions by planting trees.

**Alumni "Adopt-a-Solar-Panel" Fundraiser.** Crowdfund solar installations via alumni donations.

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