Carbon Footprints at Notre Dame of Dadiangas University: A Step toward Sustainability

*Feln Lily F. Canonigo, MEP-ECE., Edgar B. Manubag, PhD

Notre Dame of Dadiangas University

ABSTRACT

This study evaluates the carbon footprint of Notre Dame of Dadiangas University (NDDU) by analyzing emissions from energy consumption, transportation, waste generation, and water usage. The results indicate that transportation contributes the highest carbon emissions, followed by energy, waste, and water. These findings highlight the university's environmental impact and the necessity for sustainability initiatives. This study proposes expanding the use of renewable energy sources such as solar power, implementing a smart energy management system, promoting sustainable transportation like carpooling and bicycle use and provision of on-campus dormitories, improving waste management through a Material Recovery Facility (MRF), and enhancing water conservation through rainwater harvesting and low-flow fixtures. Moreover, fostering environmental awareness and integrating sustainability in education and institutional policies, and campus operations are crucial for long-term environmental responsibility. Additionally, establishing a sustainability monitoring committee can help ensure the continuous assessment and improvement of these initiatives. NDDU can significantly lower its carbon footprint and reinforce its commitment to sustainability, positioning itself as a model for other institutions seeking to implement green practices and reduce environmental impact. The integration of sustainable practices at NDDU is not just a necessity but an opportunity to lead by example in the academic sector. Through a holistic approach that combines policy enforcement, infrastructure improvements, and active participation from the university community, NDDU can successfully create a greener, more sustainable learning environment. By taking decisive action today, the university will not only contribute to global environmental goals but also ensure a more resilient and sustainable future for generations to come. A strong commitment to sustainability will allow NDDU to serve as a model institution, inspiring other universities and organizations to follow suit in prioritizing environmental stewardship and social responsibility.

Keywords: Carbon footprint, sustainability, environmental awareness

INTRODUCTION

The Problem and its Setting

Universities worldwide are increasingly recognized as critical players in addressing the global climate crisis. Their dual role as educators and innovators positions them uniquely to lead the transition to a low-carbon economy. Through research, innovation, and sustainable practices, they have the potential to model climate solutions and inspire broader societal change. However, universities also contribute significantly to greenhouse gas (GHG) emissions through operational activities. These include energy consumption for lighting and HVAC systems, transportation for commuting and logistics, waste generation, and procurement of goods and services (Gómez et al., 2019; Filho et al., 2021).

In the Philippines, the impact of climate change is particularly pronounced, given the country's vulnerability to extreme weather events, rising sea levels, and natural disasters such as typhoons, floods, and droughts. These challenges are exacerbated by high population density, urbanization, deforestation, and inadequate infrastructure, which make communities more susceptible to climate-related risks. Educational institutions, such as universities, have a significant role in mitigating these risks by adopting sustainable practices and reducing their carbon footprint. Aligning with the United Nations Sustainable Development Goals (SDGs), particularly

Goal 13: Climate Action, is imperative for these institutions to contribute to national climate resilience and sustainability efforts (Garcia et al., 2020; Perez et al., 2021).

Notre Dame of Dadiangas University (NDDU)–Glamang Campus exemplifies the challenges and opportunities associated with sustainability in higher education within the Philippines. The campus supports various activities that contribute to its carbon footprint, including energy consumption, transportation, and waste management. Addressing these emissions is crucial for the university to fulfill its environmental responsibilities and align with global and national sustainability goals (Lorenzo et al., 2019).

NDDU–Glamang Campus has the potential to become a regional leader in sustainability by integrating climate action into its operations and culture. This integration not only addresses environmental concerns but also serves as a model for other institutions and communities. By fostering a culture of environmental stewardship, the university can influence broader societal attitudes and contribute to national sustainability efforts (Serrano et al., 2018; Villanueva et al., 2022).

Despite the critical role of universities in climate action, there is limited data on the specific carbon contributions of NDDU–Glamang Campus. A comprehensive assessment of the university's carbon footprint is needed to identify key areas for intervention, such as energy use, transportation, and waste management. This analysis will provide a blueprint for targeted strategies to reduce emissions and promote sustainability within and beyond the campus, positioning NDDU as a leader in climate action and sustainability education (Rivera et al., 2023).

LITERATURE REVIEW

This literature review explores existing studies on carbon footprint estimation in universities, highlighting the major contributors to greenhouse gas emissions and the strategies for reducing them, which will inform the development of sustainability initiatives at NDDU–Glamang Campus.

Estimating Carbon Footprints in Educational Institutions

The measurement of carbon footprints in universities has gained significant attention due to their dual role as knowledge centers and contributors to greenhouse gas (GHG) emissions. Studies highlight that carbon footprints in academic institutions primarily arise from energy consumption, transportation, and waste management (Gómez et al., 2019). Frameworks like the Greenhouse Gas Protocol provide standardized approaches for calculating carbon emissions across three scopes: Scope 1 (direct emissions from fuel combustion), Scope 2 (indirect emissions from purchased electricity), and Scope 3 (other indirect emissions such as commuting and waste disposal) (World Resources Institute [WRI], 2023). These frameworks are widely applied to assess institutional emissions and guide sustainability strategies.

Research on universities in Southeast Asia reveals common trends in carbon emissions. For instance, a study of energy consumption in Philippine universities found that electricity usage accounts for the largest share of emissions, driven by reliance on air-conditioning and lighting in tropical climates (Department of Energy [DOE], 2022). Transportation emissions are also significant due to high commuting rates among students, faculty, and staff, with private vehicles often being the preferred mode of transport (Tuazon et al., 2018). Waste generation, another major contributor, aligns with urban waste profiles, highlighting the need for improved waste segregation and recycling programs (GIZ, 2020).

Identifying Major Contributors to Greenhouse Gas Emissions

Identifying and prioritizing emission sources is crucial for effective carbon management in universities. Gómez et al. (2019) emphasize that energy usage, particularly electricity, typically contributes the most to a university's carbon footprint. Transportation is another significant source, with emissions varying based on the availability of public transport and campus proximity. Studies from urban universities, such as Ateneo de Manila University, have shown that lack of accessible and sustainable transport options exacerbates transportation-related emissions (Tuazon et al., 2018). Waste management practices also play a critical role, with poorly managed waste disposal systems contributing disproportionately to GHG emissions.

Actionable Strategies for Reducing Carbon Emissions

Numerous studies advocate for integrated sustainability strategies to reduce carbon footprints in educational institutions. Embedding sustainability principles into university operations and policies can influence long-term cultural shifts (Lozano et al., 2015). Energy efficiency measures, such as transitioning to LED lighting and improving building insulation, have been shown to significantly reduce energy-related emissions (DOE, 2022). For transportation, initiatives like carpooling programs, bicycle-friendly infrastructure, and campus shuttle services can reduce reliance on private vehicles and lower emissions (Tuazon et al., 2018). In waste management, implementing campus-wide recycling programs and reducing single-use materials are effective measures aligned with global sustainability practices (GIZ, 2020).

Legal Basis of Sustainable Development Goals

The Sustainable Development Goals (SDGs), adopted by all United Nations Member States in 2015, provide a comprehensive framework for addressing global challenges, including climate change. SDG 13: Climate Action calls for urgent action to combat climate change and its impacts, emphasizing the need for integration into national policies, strategies, and planning (United Nations, 2015). The legal basis for implementing SDGs in the Philippines is reinforced through national legislation, such as the Climate Change Act of 2009 and the National Framework Strategy on Climate Change 2010-2022, which align with global commitments to sustainability and climate resilience (Climate Change Commission, 2020).

By combining these approaches, universities can create a roadmap for carbon reduction while fostering environmental awareness among students and faculty. NDDU–Glamang Campus stands to benefit from these insights, aligning its sustainability initiatives with global best practices and positioning itself as a leader in climate action within the academic community.

Conceptual Framework

The conceptual framework for this study centers around analyzing and reducing the carbon footprint of Notre Dame of Dadiangas University (NDDU)–Glamang Campus. At the heart of this framework is the assessment of greenhouse gas (GHG) emissions resulting from the university's energy consumption, transportation, and waste management practices. The framework focuses on several key components that contribute to the overall carbon footprint: First, the energy consumption profile examines the campus' electricity use, including the energy sources (e.g., grid electricity vs. renewable sources), the efficiency of energy systems, and the overall demand across various buildings. Second, the transportation emissions component evaluates the carbon impact of commuting and campus transportation. It takes into account the travel behaviors of students, faculty, and staff, such as the modes of transportation, frequency of use, and the potential impact of sustainable transportation policies. Third, the waste management profile looks at the waste generation practices at NDDU–Glamang Campus, considering waste segregation, recycling, disposal methods, and the associated emissions. The overall carbon footprint will be calculated by applying emission factors to the data collected in these three areas, using the Greenhouse Gas Protocol methodology as a guide. Based on the calculated carbon footprint, the framework will also propose actionable sustainability strategies, including energy efficiency measures, alternative transportation options, and improved waste management practices. These recommendations will align with the United Nations Sustainable Development Goal 13 (Climate Action) and help guide the campus toward more sustainable operations. This framework provides a structured approach to identifying and reducing the environmental impact of NDDU–Glamang Campus.
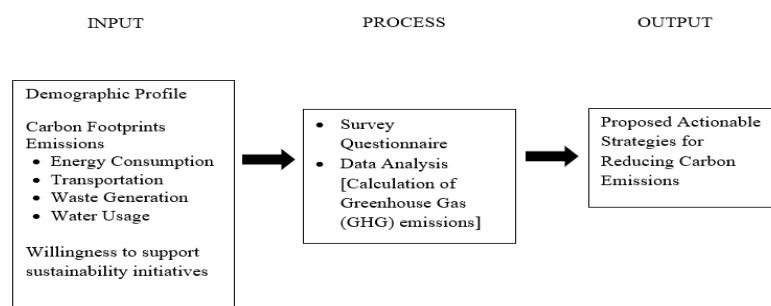

Figure 1. Conceptual Framework

Statement of the Problem

Educational institutions are expected to minimize their carbon footprint through sustainable practices, efficient energy management, and eco-friendly operations. However, the current state of Notre Dame of Dadiangas University (NDDU) – Glamang Campus's carbon footprint remains unclear, with limited data on energy consumption patterns, waste management strategies, and overall environmental impact. This gap in information hinders the university's ability to implement targeted strategies for reducing its carbon footprint effectively, thus justifying the need for this study to analyze NDDU – Glamang Campus's carbon footprint and provide recommendations for sustainable practices.

Specifically, this study will answer the following questions:

1. What is the profile of the population of NDDU-Glamang Campus in terms of:

   1.1 Role/position;

   1.2 Age;

   1.3 Sex; and

   1.4 Residence distance from campus?

2. What is the carbon footprint of NDDU–Glamang Campus based on:

   2.1 Energy usage;

   2.2 Transportation;

   2.3 Waste management; and

   2.4 Water usage?

3. To what extent are the respondents aware of the environmental sustainability programs;

4. To what extent are the respondents support specific sustainability initiatives such as:

   4.1 Carpooling;

   4.2 Renewable energy usage;

   4.3 Waste reduction; and

   4.4 Water conservation programs?

5. To what extent are the respondents willing to change their daily habits to reduce carbon footprint;

6. What strategies can be proposed to integrate sustainable practices into the university's operations?

Scope and Delimitation of the Study

This study focuses on analyzing the carbon footprint of Notre Dame of Dadiangas University (NDDU)–Glamang Campus. It examines key areas such as energy consumption in campus facilities, including academic buildings and offices, transportation patterns of students, faculty, and staff, and the management of waste generated within the campus. The study employs hypothetical but realistic data to simulate carbon emissions where direct measurements are unavailable, ensuring feasibility and relevance to the university context. It aims to propose strategies for reducing greenhouse gas emissions and promoting sustainable practices across campus operations.

NDDU–Glamang Campus is a prominent educational institution in the Philippines, known for its commitment to academic excellence and community engagement. The campus hosts a diverse population of faculty, staff, and students, all of whom play integral roles in its day-to-day operations. Faculty members deliver educational programs and conduct research, often influencing the campus's energy and resource usage. The staff supports the administrative and operational functions, contributing to overall energy consumption and waste management processes. Students, who make up the majority of the campus population, engage in various academic and extracurricular activities that impact transportation patterns and energy use. This detailed analysis of the campus and its constituents is essential for understanding their collective and individual contributions to the carbon footprint, which will inform tailored sustainability initiatives.

The study is limited to the operations and activities of NDDU–Glamang Campus and does not extend to other campuses or affiliated institutions. It relies on hypothetical data, which may introduce assumptions that could slightly differ from actual emissions. Indirect emissions, such as those arising from the production and transportation of purchased goods outside the university's control, are excluded from the analysis. Additionally, the study does not address emissions from external stakeholders or alumni activities unrelated to campus operations. Seasonal variations in activities or energy use are also not specifically considered due to time constraints and the use of generalized data. Despite these limitations, the study seeks to provide a foundational understanding of the campus's carbon footprint and actionable insights for sustainability initiatives.

Significance of the Study

This study will be significant to the following groups and individuals:

Environmental Advocates and Policymakers. The results of this study can serve as a reference for environmental advocates and policymakers in designing sustainability strategies applicable to other educational institutions. It can also inspire partnerships and collaborative efforts aimed at promoting sustainable development in the region.

Local and Regional Communities. The outcomes of this study will extend beyond the campus, as the implementation of sustainable practices can inspire neighboring communities to adopt similar approaches. The university's leadership in environmental sustainability can serve as a model for broader societal change, contributing to regional efforts to combat climate change.

Notre Dame of Dadiangas University (NDDU) Administration. The findings will provide the administration with a clear understanding of the campus's carbon footprint and its primary sources of greenhouse gas (GHG) emissions. This information will enable informed decision-making to implement targeted sustainability initiatives, optimize resource use, and align institutional practices with global sustainability goals such as the United Nations Sustainable Development Goals (SDGs).

Faculty. The study will enhance engagement by showcasing their influence in driving sustainability initiatives on campus. It will provide opportunities to incorporate sustainability concepts into teaching, research, and community service. By doing so, faculty can lead by example, fostering a deeper understanding of environmental responsibility among students and contributing to the university's overall sustainability goals.

Students. The study will foster awareness among students by emphasizing their role in contributing to and reducing the campus's environmental impact. It will serve as an educational tool, integrating sustainability concepts into the curriculum and extracurricular activities. This approach aims to cultivate a culture of environmental stewardship, encouraging students to adopt sustainable practices in their daily lives and future careers.

Future Researchers. This research will provide valuable data and methodologies that future researchers can build upon to explore deeper aspects of sustainability in educational institutions. It will also serve as a baseline for longitudinal studies on the effectiveness of sustainability initiatives over time.

METHODOLOGY

This chapter encompasses the research design, selection of respondents, data collection and analysis, and ethical considerations that guided the research designs and practices. The methodology outlines the steps and techniques used to address the research questions or objectives and serves as a roadmap for conducting the study systematically and rigorously.

Research Design

A descriptive research strategy is utilized in this study to systematically assess the carbon footprint of Notre Dame of Dadiangas University (NDDU)–Glamang Campus and identify actionable strategies for reducing greenhouse gas (GHG) emissions. According to O'Leary (2017), a descriptive research design is appropriate for studies that aim to describe the characteristics of a phenomenon or population systematically. This method is employed to analyze and understand the current state of NDDU's environmental sustainability practices, while computational methods are integrated to quantify the institution's carbon footprint.

The descriptive aspect of this study involves gathering and analyzing data to profile the campus population and assess respondents' awareness, willingness, and support for sustainability initiatives. This includes understanding their roles, age, sex, and residence distance, as well as evaluating their willingness to adopt specific programs such as carpooling, renewable energy use, waste reduction, and water conservation.

The computational research approach focuses on quantifying the carbon footprint using measurable data related to energy usage, transportation, waste management, and water usage. To facilitate accurate computations, relevant data will be collected through surveys, institutional records, energy consumption reports, and other existing documents. Tools for carbon footprint calculations, such as standard GHG emission conversion factors and carbon calculators, will be utilized to ensure reliable estimates.

This research design ensures a comprehensive, evidence-based analysis of NDDU's carbon footprint while fostering informed recommendations for promoting environmental sustainability.

Selection of Respondents

The respondents for this study include students, faculty, staff, and administrative personnel of Notre Dame of Dadiangas University (NDDU)–Glamang Campus. These individuals were chosen based on their role in campus activities and their potential contributions to the assessment of carbon footprint and sustainability practices. Their diverse perspectives are essential for understanding the university's energy usage, transportation habits, waste management, and water consumption. The study will employ a complete enumeration approach, where every student, faculty member, staff, and administrative personnel will be invited to participate in the survey. This approach, as discussed by Teddlie and Yu (2016), ensures that all segments of the campus community are represented, allowing for a more inclusive and comprehensive analysis.

By including all members of the campus community, the study seeks to gather detailed data on their awareness, willingness, and support for sustainability initiatives. This will help capture actionable suggestions for reducing greenhouse gas emissions, as well as provide insights into the community's habits and attitudes toward sustainability. The use of complete enumeration enhances the reliability and generalizability of the findings, offering a holistic view of the current state of sustainability practices at NDDU–Glamang Campus. This approach ensures that no key group is left out, contributing to a thorough understanding of the campus's environmental impact and opportunities for improvement.

Research Instruments

The primary research instrument used in this study is a structured questionnaire, designed to gather comprehensive data on commuting habits, energy usage, waste management practices, water consumption, and sustainability awareness of the students, faculty, and staff at Notre Dame of Dadiangas University (NDDU)–Glamang Campus. The questionnaire is divided into seven sections: demographics, transportation, energy usage,

waste management, water usage, awareness, and willingness. Each section is carefully crafted to address the specific objectives of the study and ensure that all relevant factors contributing to the campus's carbon footprint are captured. The questionnaire consists primarily of closed-ended questions, providing structured responses for quantitative analysis.

The questionnaire underwent a validation process to ensure its content and construct validity. Three experts validated the questionnaire. These validators assessed the clarity, relevance, and comprehensiveness of the items in relation to the study's objectives. Based on their feedback, necessary revisions were made to improve the instrument's validity and ensure that it effectively measured the intended variables. The validators suggested removing some questions that were not relevant to the statement of the problem.

By using this comprehensive and well-structured instrument, the study ensures the collection of reliable and relevant data, enabling an accurate assessment of NDDU–Glamang Campus's carbon footprint and the identification of actionable strategies for reducing greenhouse gas emissions.

Furthermore, the study incorporates documentary analysis, which involves reviewing existing reports, records, and data logs on energy usage, transportation patterns, waste management practices, and water consumption within the campus. This approach enhances the credibility of the findings by relying on both firsthand survey data and documented evidence. By combining computational and descriptive research, this study aims to provide a clear profile of the NDDU–Glamang Campus population and their role in sustainability efforts, systematically compute the campus's carbon footprint across identified categories, evaluate the extent of support for various sustainability initiatives, and recommend actionable strategies for reducing emissions and integrating sustainable practices into the institution's operations.

Data Gathering Procedure

The data gathering process for this study begins with the preparation and dissemination of formal notification letters to the targeted respondents. These letters serve as an official request for participation and provide an overview of the study's objectives, scope, and significance. The letters are addressed to students, faculty, and staff of Notre Dame of Dadiangas University (NDDU)–Glamang Campus, highlighting the importance of their responses in assessing the campus's carbon footprint and fostering sustainability initiatives.

The questionnaire, the primary tool for data collection, is administered digitally using Google Forms. This platform was chosen for its accessibility, efficiency, and ability to streamline the data collection process. A link to the Google Form is included in the notification letters and is also shared through official communication channels, such as email or group messaging platforms. The digital format ensures ease of participation, allowing respondents to complete the survey at their convenience using smartphones, computers, or other internet-enabled devices.

To encourage a high response rate, follow-up reminders are sent periodically to participants who have not yet completed the questionnaire. The Google Forms responses are automatically compiled, reducing the risk of data entry errors and enabling efficient organization and analysis. Strict confidentiality is maintained throughout the process, with access to the responses restricted to the research team.

This systematic and technology-driven approach ensures the smooth dissemination of the questionnaire, timely data collection, and accurate recording of responses, ultimately contributing to the reliability and validity of the research findings.

Data Analysis

The data analysis for this study uses descriptive statistics with a focus on statistical mean, frequency count, and percentage. This will provide insight into the distribution of answers across various questions, helping to identify the most common practices and trends among participants regarding commuting habits, energy usage, waste management, water conservation, and support for sustainability initiatives. Additionally, the percentage of respondents choosing each option will be calculated. This will enable the study to show the proportion of

participants who selected particular answers, providing a clearer understanding of the significance of each response relative to the whole sample. The statistical mean will be applied to responses involving numerical or ordinal data, such as the average number of hours spent on campus, frequency of water usage, or the number of days per week respondents engage in carpooling. The mean will offer a summary of central tendencies, helping to summarize typical behaviors and practices of the respondents.

To interpret the data related to respondents' awareness, support, and willingness to adopt sustainability initiatives, the following scale in Table 1 will be used.

Table 1. Interpretation of Awareness, Support, and Willingness

Scale	Percentage	Description	Interpretation
5	81-100	Very High Extent	Awareness, Support, and Willingness are manifested between 81-100% of the respondents.
4	61-80	High Extent	Awareness, Support, and Willingness are manifested between 61-80% of the respondents.
3	41-60	Moderate Extent	Awareness, Support, and Willingness are manifested between 41-60% of the respondents.
2	21-40	Less Extent	Awareness, Support, and Willingness are manifested between 21-40% of the respondents.
1	0-20	Least Extent	Awareness, Support, and Willingness are manifested between 0-20% of the respondents.

By combining frequency counts, percentages, and statistical means, the study will provide a comprehensive overview of the data, allowing for a detailed understanding of the carbon footprint at NDDU–Glamang Campus and identifying opportunities for improving sustainability practices.

Ethical Considerations

To protect the rights and well-being of participants at Notre Dame of Dadiangas University (NDDU)–Glamang Campus, strict adherence to ethical principles is critical in this study on the campus's carbon footprint. Informed consent will be obtained from all participants, which involves providing a clear explanation of the study's objectives, methods, and potential risks before their participation. This ensures that participants are fully aware of their involvement in the research. Voluntary participation is emphasized, with an emphasis on allowing participants to make their own informed decisions about participation, understanding the possible benefits and drawbacks.

To ensure privacy and confidentiality, the study will maintain anonymity by replacing participants' personal names with unique identifiers. This protects their privacy and encourages honest participation, as participants will be assured that their personal information is secure and accessible only to authorized personnel. In reporting results, accuracy and transparency will be maintained, ensuring that findings are clearly presented without compromising participants' identities. The study's commitment to respecting participants' rights and upholding ethical standards throughout its lifecycle strengthens the integrity and credibility of the research process, ensuring that the rights of all involved are safeguarded at every stage of the study.

RESULTS AND DISCUSSION

This chapter presents the data through various visual formats, including tables, graphs, and charts, to highlight key findings and trends. A detailed textual analysis accompanies these visuals, providing a comprehensive interpretation and justification of the results. The chapter delves into the implications of the findings, discussing relevance to the statement of the problem and the broader context of the study. It concludes with a synthesis of

key outcomes and offers practical recommendations for future research, policy formulation, or implementation strategies based on the study's insights.

Population Profile of NDDU-Glamang Campus

The population of NDDU-Glamang Campus consists of three main groups: faculty members, staff, and students. The majority of the population is composed of students, totaling 952, while faculty members and staff account for 27 and 3, respectively as shown in Figure 2. This indicates that the campus primarily serves a large student community, with faculty and staff numbers reflecting a lean administrative and academic workforce.
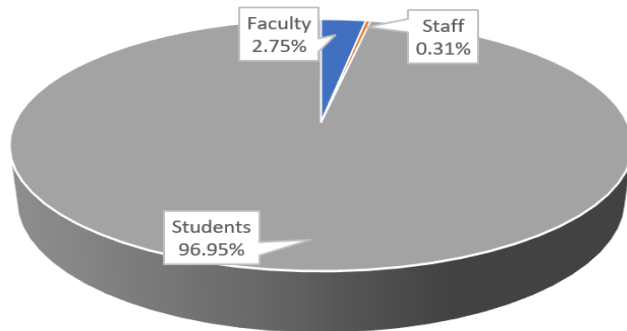

Figure 2. Role/position

Out of the total 1,049 individuals on campus, 982 responded to the survey, representing a 93.6% response rate. This high response rate ensures that the collected data provides a reliable representation of the campus population and minimizes nonresponse bias, which can affect survey accuracy (HiPeople, 2023).

In terms of age distribution, shown in Figure 3, the largest group falls within the 18-24 age range, with 913 individuals, representing the traditional college-age demographic. Other age groups are significantly smaller, with 45 individuals aged 25-34, followed by 8 in the 35-44 bracket, 4 in the 45-54 category, and only 1 individual aged 55 and above. The under-18 category comprises 11 individuals, possibly early-entry students.
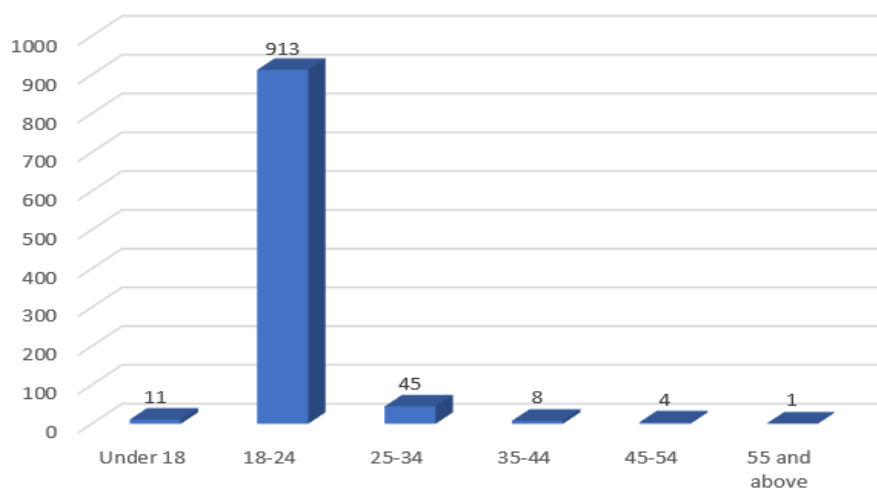

Figure 3. Age Distribution

Regarding gender shown in Figure 4, 630 respondents (64.2%) are male, while 352 (35.8%) are female. This higher male-to-female ratio can be attributed to the academic programs offered at the NDDU-Glamang Campus, which houses the College of Engineering, Architecture, and Technology (CEAT). The campus caters to students enrolled in BS in Architecture, BS in Computer Engineering, BS in Multimedia Arts, BS in Electrical Engineering, BS in Industrial Engineering, BS in Electronics Engineering, BS in Civil Engineering, BS in Information Technology, BS in Computer Science, and BS in Environmental Planning—fields traditionally dominated by male students (UNESCO, 2021).
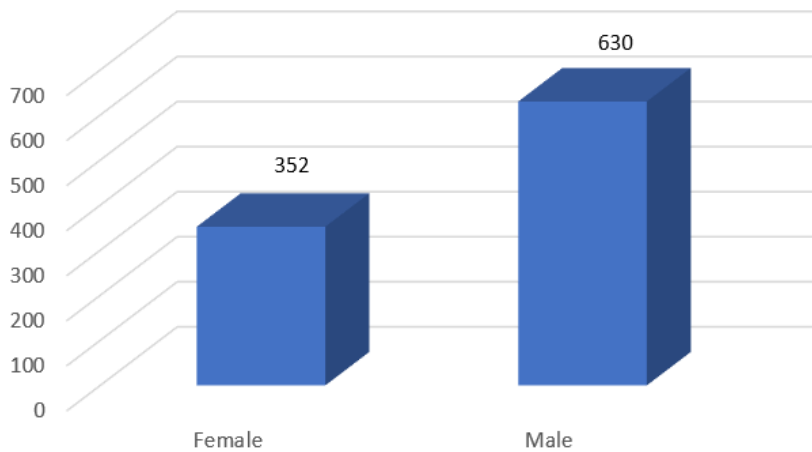
Figure 4. Gender Distribution

The residence distance from the campus of the respondents shows that the majority of individuals, 619, reside more than 10 km away, while 225 live within a 6-10 km radius. A smaller proportion, 121 individuals, reside 1-5 km from the campus, and only 17 individuals live less than 1 km away. Figure 5 suggests that most students, faculty, and staff commute from relatively distant locations, highlighting potential transportation needs and accessibility considerations for campus planning.
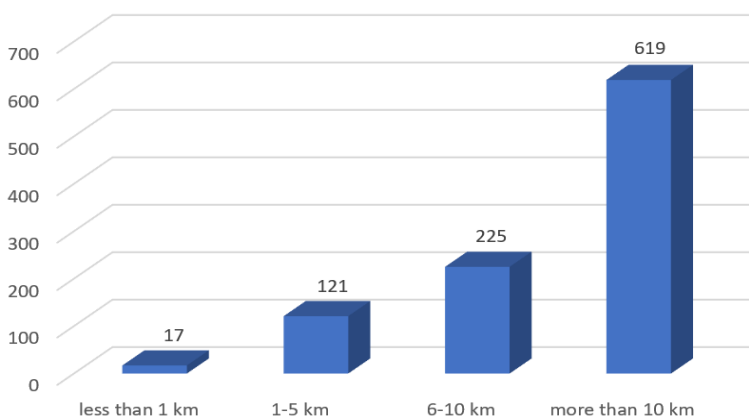

Figure 5. Residence Distance

Overall, the demographic profile of NDDU-Glamang Campus reflects a student-centered institution with a predominantly young population, a higher number of male members, and a significant portion of individuals commuting from outside the immediate campus area.

Carbon Footprint of NDDU–Glamang Campus

Understanding the carbon footprint of NDDU–Glamang Campus is essential in assessing its environmental impact and identifying opportunities for sustainability improvements. A university's carbon footprint is primarily influenced by energy consumption, transportation, water usage, and waste generation. By analyzing emissions from these key areas, the institution can develop strategies to reduce its greenhouse gas (GHG) output and align with global sustainability goals. This section presents the computed emissions from electricity use, transportation, water consumption, and waste management, providing insights into the campus's overall carbon impact.

The Intergovernmental Panel on Climate Change (IPCC) provides emission factors used to calculate the greenhouse gas (GHG) emissions associated with various activities. The emission factors vary based on the type of fuel, activity, and location. Shown in Table 2 are some commonly used emission factors sourced from the IPCC 2021 guidelines for calculating carbon footprints in different sectors.

Table 2. Emission Factors for Key Sectors

Sector	Activity	Emission Factor
Energy	Coal-based electricity	0.95 kg CO_2/kWh
	Natural gas-based electricity	0.45 kg CO_2/kWh
	Renewable energy (e.g., hydro, wind)	0.00 kg CO_2/kWh
	Mixed grid electricity	0.4 - 0.7 kg CO_2/kWh
Transportation	Private vehicle	0.21 kg CO_2/km
	Public transport (bus, jeepney, van)	0.10 - 0.30 kg CO_2/km
	Motorcycle	0.33 kg CO_2/km
	Trains	0.05 - 0.30 kg CO_2/km
Waste	Biodegradable	0.08 kg CO_2/kg
	Recyclable	0.08 kg CO_2/kg
	Residual	0.08 kg CO_2/kg
Water	Water supply and distribution	0.34 kg CO_2/cu.m

These emission factors were used to compute the carbon footprint of NDDU–Glamang Campus in the succeeding sections.

Energy Usage Emissions

The carbon footprint from electricity usage is one of the primary contributors to an institution's carbon footprint, as the generation of electricity often relies on fossil fuels such as coal, oil, and natural gas. The carbon footprint from electricity use is calculated by multiplying the total electricity consumption (kWh) by the corresponding emission factor for the energy source.

$$\text{Carbon Emissions} = \text{Electricity Consumed (kWh)} \times \text{Emission Factor} \left(\frac{\text{kg } CO_2}{\text{kWh}}\right)$$

Table 3 presents the energy consumption and corresponding carbon emissions for NDDU–Glamang Campus over five months, from August to December. The total energy consumption (in kilowatt-hours, kWh) varies each month, reflecting fluctuations in electricity demand. The emission factor used for calculations is 0.63 kg CO_2/kWh, which is based on the local energy grid mix. The Emission per Month column represents the total carbon dioxide (CO_2) emissions generated from electricity usage each month. The highest recorded emission occurred in October (37,476.18 kg CO_2) due to the highest energy consumption (59,486 kWh), while the lowest emission was in August (19,884.69 kg CO_2) with the least energy usage (31,563 kWh).

Table 3. Energy Emission

Month	Total Energy (kWh)	Emission Factor (kg CO_2/kWh)	Emission per Month (kg CO_2)
August	31563	0.63	19,884.69
September	56679	0.63	35,707.77

October	59486	0.63	37,476.18
November	57953	0.63	36,510.39
December	54348	0.63	34,239.24
	Total Emission Per Semester		163,818.27

This data highlights the direct relationship between energy consumption and carbon emissions. The fluctuations in emissions may be influenced by academic schedules, facility operations, and seasonal variations. Understanding these trends can help identify energy-saving strategies to reduce the university's carbon footprint.

Transportation Emissions

Transportation is a significant contributor to carbon emissions, as vehicles powered by fossil fuels release greenhouse gases (GHGs) into the atmosphere. At NDDU–Glamang Campus, students, faculty, and staff rely on various modes of transportation, including private vehicles, public jeepneys, buses, motorcycles, bicycles, and walking. The carbon footprint from transportation is primarily determined by the distance traveled and the type of vehicle used, as different modes of transport have varying fuel efficiencies and emission factors.

$$\text{Carbon Emissions} = P \text{ x } D \text{ x Emission Factor} \left(\frac{\text{kg CO}_2}{\text{km}} \right)$$

where $P = $ No. of Persons

$D = $ Distance Travelled in km

Table 4 presents the estimated carbon emissions from transportation based on the daily commutes of individuals traveling to NDDU–Glamang Campus. The table categorizes transportation emissions by vehicle type, the number of persons using each mode of transport, the average distance traveled, and the corresponding emission factors. The total emissions per day, month, and semester are also computed to provide a comprehensive overview of transportation-related carbon output.

Table 4. Transportation Emission

Type	No. of Persons	Distance Travelled	Emission Factor (kg CO$_2$/kWh)	Emission per Day (kg CO$_2$)
Private Vehicle	38	2.5	0.21	39.9
Private Vehicle	39	7.5	0.21	311.85
Private Vehicle	357	10	0.21	1,499.4
Motorcycle	27	2.5	0.33	44.55
Motorcycle	41	7.5	0.33	202.95
Motorcycle	98	10	0.33	646.8
Public Jeepney/Tricycle	274	23	0.18	2,268.72
Public Bus/Van	182	23	0.20	1674.4
Bicycle	2	1	0.00	0.00

Walking	1	1	0.00	0.00
		Total Emission Per Day	6,688.57	
		Total Emission Per Month	160,525.68	
		Total Emission Per Semester	802,628.40	

*Distance Travelled from NDDU Main to Glamang

The data shows that public jeepneys/tricycles contribute the highest emissions at 2,268.72 kg CO_2 per day, followed by public buses/vans at 1,674.40 kg CO_2 per day. Among private modes of transport, private vehicles with a travel distance of 10 km account for a significant share, emitting 1,499.4 kg CO_2 per day. Motorcycles, with a higher emission factor per kilometer, also contribute notably to the total emissions.

Non-motorized transportation modes, such as bicycles and walking, have zero emissions, highlighting sustainability. The total daily transportation emissions amount to 6,688.57 kg CO_2, which accumulates to 160,525.68 kg CO_2 per month and 802,628.40 kg CO_2 per semester.

These findings emphasize the substantial carbon footprint associated with transportation to the campus. Encouraging carpooling, the use of low-emission vehicles, and improvements in public transportation efficiency can be potential strategies for reducing emissions and promoting sustainable mobility.

Waste Management Emissions

Waste management is a critical issue for educational institutions, as campuses generate significant amounts of waste from academic and administrative activities. At Notre Dame of Dadiangas University (NDDU) - Glamang Campus, effective waste management is essential not only for maintaining a clean and healthy environment but also for reducing the campus's carbon footprint and contributing to global climate change mitigation efforts. According to the National Solid Waste Management Commission (NSWMC, 2022), the Philippines generates approximately 0.5 kg of waste per person daily, and educational institutions like NDDU-Glamang Campus are no exception to this trend. The improper disposal of waste, particularly in open dumps or poorly managed landfills, leads to the release of methane (CH_4), a greenhouse gas with a global warming potential 28–34 times greater than carbon dioxide (CO_2) over a 100-year period (Intergovernmental Panel on Climate Change [IPCC], 2021). Methane emissions from decomposing organic waste, such as food scraps and paper, are a significant concern for institutions like NDDU-Glamang Campus, where waste segregation and recycling programs are still in the process of optimization (Clean Air Asia, 2020).

To estimate carbon emissions from waste generation, the daily waste production per person is multiplied by the total population and the emission factors associated with waste disposal methods. Since landfilling is a primary waste management approach, methane emissions from organic waste decomposition are converted into their carbon dioxide (CO_2) equivalent using established global warming potential (GWP) values. This approach provides an accurate assessment of the environmental impact of campus waste disposal practices. The following section presents the calculated emissions based on recorded waste generation data and corresponding emission factors.

Daily Waste Generation

The first step in calculating waste-related emissions is to determine the amount of waste generated. For NDDU-Glamang Campus, an average waste generation rate of 0.5 kg/person/day is assumed, based on data from the National Solid Waste Management Commission (NSWMC, 2022). With a campus population of 982 students and staff, the total daily waste generation is calculated as:

$$\text{Daily Waste Generation} = \frac{0.5\,\dfrac{\text{kg}}{\text{person}}}{\text{day}} \times 982 \text{ persons} = 491\,\frac{\text{kg}}{\text{day}}$$

Waste Composition

Waste composition plays a critical role in determining emissions. Organic waste (e.g., food scraps, paper) is a major source of methane when disposed of in landfills. Table 5 shows the waste composition assumed for NDDU-Glamang Campus:

Table 5. Waste Composition

Type	Percentage	Waste per Day (kg/day)
Organic Waste	50	245.5
Recyclable Waste	30	147.3
Residual Waste	20	98.2

Only organic waste is considered for methane emissions, as recyclable and residual waste typically do not decompose anaerobically in landfills.

Emission Factors for Landfilling

The Intergovernmental Panel on Climate Change (IPCC, 2021) provides emission factors for landfilling organic waste. The key factors include:

- Methane Generation Potential: ~0.1–0.3 kg CH_4/kg organic waste (depending on waste composition and landfill conditions).

- Methane Correction Factor (MCF): Accounts for the proportion of organic waste that decomposes anaerobically (typically 0.6 for managed landfills).

- Oxidation Factor: Accounts for methane oxidation in landfill cover soil (typically 0.1).

For this study, the following values are used:

- Methane Generation Potential: 0.2 kg CH_4/kg organic waste

- Methane Correction Factor: 0.6

- Oxidation Factor: 0.1

Calculating Methane Emissions

The methane emissions from landfilling organic waste are calculated using the formula:

$$\text{Methane Emissions} = \text{OW} \times \text{MGP} \times \text{MCF} \times (1 - \text{OF}) \qquad \left(\text{kg}\,\frac{CH_4}{\text{day}}\right)$$

Where: $\text{OW} = \text{Organic Waste}\left(\frac{\text{kg}}{\text{day}}\right)$

$\text{MGP} = \text{Methane Generation Potential}\left(\frac{\text{kg }CH_4}{\text{kg waste}}\right)$

MCF = Methane Correction Factor , landfill = 0.6

OF = Oxidation Factor = 0.1

$$\text{Methane Emissions} = 245.5 \frac{kg}{day} \text{ x } 0.2 \frac{kg\ CH_4}{kg\ waste} \text{ x } 0.6 \text{ x } (1 - 0.1)$$

$$\text{Methane Emissions} = 26.51 \text{ kg} \frac{CH_4}{day}$$

Converting Methane to CO₂ Equivalent

Methane is a potent greenhouse gas with a global warming potential (GWP) 28–34 times greater than CO_2 over a 100-year period (IPCC, 2021). To express methane emissions in CO_2-equivalent terms, the methane emissions are multiplied by the GWP factor. Using a GWP of 28:

$$CO_2 \text{ Equivalent Emissions} = \text{Methane Emissions} \left(kg \frac{CH_4}{day} \right) \text{ x GWP}$$

$$CO_2 \text{ Equivalent Emissions} = 26.51 \text{ kg} \frac{CH_4}{day} \text{ x } 28$$

$$CO_2 \text{ Equivalent Emissions} = 742.28 \text{ kg} \frac{CO_{2-eq}}{day}$$

Table 6 presents the waste-equivalent emissions at NDDU–Glamang Campus, calculated based on daily waste generation and methane emissions from landfill decomposition. The total emissions produced per day amount to 742.28 kg CO₂-equivalent, which accumulates to 17,814.72 kg CO₂-equivalent per month and 89,073.60 kg CO₂-equivalent per semester. These values highlight the substantial environmental impact of waste disposal over time, reinforcing the need for improved waste management strategies such as waste reduction, composting, and recycling. Implementing sustainable practices can help minimize methane emissions and reduce the campus's overall carbon footprint.

Table 6. Waste Equivalent Emission

Generated	Quantity (kg CO_{2-eq})
Per Day	742.28
Per Month	17,814.72
Per Semester	89,073.60

Water Usage Emissions

Water consumption contributes to carbon emissions primarily through the energy required for its extraction, treatment, and distribution. The processes of pumping, purifying, and heating water require electricity, which, depending on the energy source, leads to greenhouse gas (GHG) emissions. The carbon footprint of water usage is typically calculated based on the volume of water consumed and the associated emission factor for water supply systems.

At NDDU–Glamang Campus, water is used for various purposes, including drinking, sanitation, cleaning, and facility maintenance. To assess the environmental impact, it is essential to quantify the total water consumption and apply the appropriate emission factor to determine the resulting carbon emissions. Understanding these

emissions can help in developing water conservation strategies, reducing energy consumption, and promoting sustainable campus operations.

$$\text{Carbon Emissions} = \text{Water Consumed (cu. m)} \times \text{Emission Factor} \left(\frac{\text{kg CO}_2}{\text{cu. m}}\right)$$

Table 7 presents the computed emissions from water usage at the campus, based on recorded water consumption and emission factors derived from established guidelines. The data indicate a steady increase in water consumption, with the highest usage in December at 419 cubic meters, contributing to 142.46 kg CO$_2$ emissions. The total emissions for the semester amount to 386.86 kg CO$_2$. These figures highlight the environmental impact of water usage, emphasizing the importance of conservation efforts such as efficient water management, leak prevention, and promoting water-saving practices on campus.

Table 7. Water Usage Emission

Month	Total Water (cu. m)	Emission Factor (kg CO$_2$/cu.m)	Emission per Month (kg CO$_2$)
August	110	0.34	37.4
September	171	0.34	58.14
October	194	0.34	65.96
November	235	0.34	79.90
December	419	0.34	142.46
	Total Emission Per Semester		383.86

Total Carbon Emissions

Understanding the total carbon emissions from various sources is essential for assessing the environmental impact of campus activities. This summary integrates emissions from energy consumption, transportation, waste generation, and water usage, providing a comprehensive view of the institution's carbon footprint. Each category contributes differently, with transportation and energy usage being the dominant sources, followed by waste-related emissions and water consumption. By quantifying these emissions, this analysis highlights key areas where sustainable interventions can be implemented to minimize the university's overall carbon footprint.

$$Total \ CO_2 = E_{energy} + E_{transport} + E_{waste} + E_{water}$$

Table 8 presents a comprehensive summary of the total carbon emissions generated from four key sources: energy consumption, transportation, waste generation, and water usage. The data is categorized into emissions per day, per month, and per semester and per year, highlighting the significant contributions of each sector to the institution's overall carbon footprint.

Table 8. Total Carbon Emissions

Source	Emission per Day (kg CO$_2$)	Emission per Month (kg CO$_2$)	Emission per Semester (kg CO$_2$)	Emission per Year (kg CO$_2$)
Energy	1,365.15	32,763.65	163,818.27	354,939.59
Transportation	6,688.57	160,525.68	802,628.40	1,739,028.20
Waste	742.28	17,814.72	89,073.60	10,212.80

Water	3.20	76.77	383.86	522.30
TOTAL	**8,799.20**	**194,280.27**	**971,401.33**	**2,104,702.88**

The annual carbon emissions of NDDU Glamang Campus are approximately 2,104,702.88 kg CO_2. In contrast, the University of Florida (UF) reported emissions of 367,464 metric tons of CO_2 equivalent (MTCO$_2$e) for the fiscal year 2018-19 (University of Florida, 2019). This significant difference can be attributed to the larger scale and population of UF compared to NDDU.

Breaking down emissions by source, transportation at NDDU contributes 82.6% of total emissions, equating to 1,739,028.20 kg CO_2 annually. In comparison, UF's employee and student transportation account for 14.9% and 5.5% of total emissions, respectively (University of Florida, 2019). This disparity suggests that NDDU's transportation emissions are disproportionately high, possibly due to a lack of on-campus housing and reliance on personal vehicles. Studies indicate that in China, students' greenhouse gas (GHG) emissions are four times those of the general population. However, Chinese students have a smaller carbon footprint compared to those in developed countries, primarily due to on-campus living and walking, reducing transportation emissions (Li & Tan, 2015).

Energy consumption at NDDU accounts for 16.9% of total emissions, approximately 354,939.59 kg CO_2 annually. In contrast, UF's energy-related emissions constitute 76.3% of the university's total emissions (University of Florida, 2019). This indicates that while energy use is a significant contributor at both institutions, UF's larger infrastructure and energy demands result in a higher percentage of emissions from this source.

This summary underscores the need for targeted sustainability strategies, particularly in reducing transportation and energy emissions, which constitute the majority of the institution's carbon footprint. Implementing energy-efficient technologies, promoting sustainable transportation options, and enhancing waste management practices can significantly lower emissions and contribute to a more sustainable campus environment.

Respondents' Awareness of the Environmental Sustainability Programs

Based on the survey results, 816 respondents (83.10%) indicated awareness of the environmental sustainability programs, while 166 respondents (16.90%) were not aware. Referring to Table 1, which categorizes awareness levels based on percentage ranges, this places the respondents' awareness within the "Very High Extent" (81-100%) category. This suggests that a significant majority of the respondents are well-informed about the institution's environmental sustainability initiatives.

The high level of awareness indicates that the institution's sustainability efforts, communication strategies, and engagement activities have been effective in reaching the majority of the population. This may be attributed to educational campaigns, institutional policies, or visible implementation of sustainability initiatives such as waste management, energy conservation, and carbon footprint reduction. The presence of sustainability-related programs, seminars, or campus activities may have contributed to this heightened level of awareness.

However, the 16.90% of respondents who are unaware of these programs highlight the need for further dissemination of information. This gap suggests an opportunity to enhance outreach efforts, such as incorporating sustainability topics into curricula, increasing signage and informational materials around the campus, leveraging digital platforms for awareness campaigns, and engaging students and staff through interactive initiatives. Addressing this gap will help ensure that all members of the institution, regardless of their level of engagement, are informed and encouraged to participate in environmental sustainability programs.

Respondents' Support to Sustainability Initiatives

Sustainability initiatives play a crucial role in reducing environmental impact and fostering a culture of responsibility within institutions. Understanding the level of support for these initiatives helps in identifying strengths and areas for improvement in promoting sustainable practices. This study evaluates respondents' willingness to participate in key sustainability programs, including carpooling, renewable energy usage, waste

reduction, and water conservation. By categorizing responses based on Table 1, which measures awareness, support, and willingness on a scale of extent, the level of commitment toward these initiatives is assessed.

The survey results reveal varying levels of support for different sustainability initiatives among respondents. Based on Table 1, which categorizes responses into different levels of extent, Table 9 presents the respondents' level of support for various sustainability initiatives, categorized based on their percentage of support. Among the initiatives, renewable energy usage received the highest level of support, with 86.76% of respondents endorsing it, placing it under the "Very High Extent" category. Waste reduction followed closely, with 80.75% support, and water conservation programs received 72.20% support, both of which fall under the "High Extent" category. Meanwhile, carpooling had the lowest level of support at 57.74%, categorized under "Moderate Extent."

Table 9. Supports for Sustainability Efforts

Sustainability Initiatives	Percentage of Support	Interpretation Category
Renewable Energy Usage	86.76	Very High Extent (81-100%)
Waste Reduction	80.75	High Extent (61-80%)
Water Conservation Programs	72.20	High Extent (61-80%)
Carpooling	57.74	Moderate Extent (41-60%)

These findings indicate that respondents are generally supportive of sustainability initiatives, particularly those related to energy conservation and waste management, while carpooling, despite being beneficial for reducing carbon emissions, has comparatively lower participation. The data highlights areas where awareness and engagement strategies may be needed to further enhance participation in sustainability efforts.

Respondents' Willingness to Reduce Carbon Footprint

The willingness of individuals to actively reduce their carbon footprint is a crucial factor in the success of sustainability programs. Based on the survey results, 93.48% of respondents indicated their willingness to engage in carbon footprint reduction efforts, while only 6.52% expressed unwillingness. According to the interpretation scale in Table 1, this level of willingness falls under the "Very High Extent" (81-100%) category, signifying strong support for sustainability initiatives.

This overwhelming willingness suggests a heightened awareness among respondents regarding the environmental impact of their daily activities. It also reflects a positive attitude toward adopting greener practices, such as energy conservation, sustainable transportation, and waste reduction. The minimal percentage of unwilling respondents implies that resistance to sustainability efforts is low, indicating an opportunity for institutions to introduce more structured programs that encourage and facilitate carbon footprint reduction.

With such a high level of willingness, organizations and policymakers can build upon this positive sentiment by implementing targeted interventions, such as awareness campaigns, incentive programs, and sustainable infrastructure developments. Encouraging behavioral changes and providing accessible options for sustainable living can further strengthen the commitment of individuals to reducing their carbon emissions.

Proposed Strategies to Integrate Sustainable Practices

To mitigate the environmental impact of the university's operations, a set of sustainable strategies has been proposed. These strategies focus on energy efficiency, sustainable transportation, waste management, and water conservation. Table 10 presents the recommended initiatives to integrate sustainable practices into campus operations.

In terms of energy sustainability, NDDU can intensify the use of solar energy by installing additional solar panels, particularly at the Glamang Campus. Implementing an energy management system and promoting practices such as Earth Hour in offices and classrooms can further optimize electricity usage.

Table 10. Proposed Sustainable Practices

Sustainability Area	Proposed Strategies
Energy Efficiency	- Install more solar panels, including at Glamang Campus. - Implement smart energy management systems. - Observe Earth Hour for the first two hours in offices. - Use LED lighting and energy-efficient appliances.
Sustainable Transportation	- Introduce campus e-vehicles (jeepney, bus, van, etc.) - Provision of on-campus dormitories - Improve walkway lighting and add covered walkways. - Encourage carpooling initiatives.
Waste Management	- Establish a Material Recovery Facility (MRF) for recycling. - Install more labeled trash bins on every floor. - Implement a "Zero-Waste Campus" initiative. - Reduce single-use plastics and encourage digital submissions.
Water Conservation	- Install rainwater harvesting systems for irrigation and restrooms. - Use low-flow faucets and sensor-based taps. - Conduct regular leak detection and maintenance. - Promote awareness campaigns on water conservation.

For sustainable transportation, the university can introduce shared transport options such as campus shuttle buses or designated carpooling systems. Encouraging bicycle use by adding bike racks and lanes will also help reduce emissions. Improved pathway lighting and covered walkways will promote walking as a safer and more viable alternative.

To enhance waste management, establishing a Material Recovery Facility (MRF) is crucial for segregating and recycling waste efficiently. The campus should also install more labeled trash bins across all buildings and floors. A "Zero-Waste Campus" initiative can be introduced, advocating for the reduction of single-use plastics and promoting recycling. Additionally, sustainability programs can educate students and staff on proper waste disposal practices.

For water conservation, NDDU can integrate rainwater harvesting systems to be used for irrigation and restroom flushing. Upgrading to low-flow water fixtures and sensor-based faucets will significantly reduce water waste. Regular leak detection and maintenance will prevent unnecessary water loss. Further, awareness campaigns on water conservation will ensure community-wide participation.

By implementing these initiatives, NDDU can strengthen its commitment to sustainability, reduce its environmental impact, and inspire a culture of environmental responsibility across the institution.

Textual Presentation of Key Findings

This study examined the carbon footprint of Notre Dame of Dadiangas University (NDDU), focusing on emissions from energy consumption, transportation, waste generation, and water usage. The key findings are summarized as follows:

1. Energy Consumption

   o Electricity usage accounts for a significant portion of the university's emissions, primarily from lighting, air conditioning, and laboratory equipment.

   o The reliance on grid electricity highlights the need for renewable energy alternatives, such as solar panels, to reduce dependency on fossil fuels.

2. Transportation Emissions

   o The majority of transportation-related emissions stem from private vehicles used by students, faculty, and staff.

   o Carpooling, bicycle-friendly infrastructure, and the use of public transportation can help reduce emissions from daily commutes.

3. Waste Generation and Management

   o A considerable amount of waste is generated daily, with inadequate waste segregation and recycling facilities contributing to higher emissions.

   o The establishment of a Material Recovery Facility (MRF) can improve waste diversion and reduce methane emissions from landfills.

4. Water Usage and Conservation

   o Water consumption contributes to the university's overall environmental impact, particularly in restrooms, laboratories, and cafeterias.

   o Rainwater harvesting, leak detection systems, and low-flow fixtures are recommended to enhance water efficiency.

These findings emphasize the need for integrated sustainability initiatives, including renewable energy adoption, enhanced waste management, water conservation efforts, and sustainable transportation solutions. Implementing these strategies can significantly reduce the university's carbon footprint and promote an eco-friendlier campus.

Justification of Results

The findings of this study highlight the urgent need for sustainable practices at NDDU, with key results indicating a high willingness (93.48%) among respondents to reduce their carbon footprint. This aligns with the growing global awareness of climate change and sustainability efforts, particularly among students who are increasingly engaged in environmental advocacy. Additionally, the identification of energy, transportation, and waste as the primary sources of carbon emissions is consistent with existing research on university sustainability challenges. The high contribution of energy consumption can be attributed to the widespread use of lighting, air conditioning, and other electrical appliances within the institution. Transportation emissions are also expected, given that many students and faculty rely on personal vehicles or inefficient transport systems. Furthermore,

waste generation, particularly from plastic use and paper-based submissions, significantly adds to the institution's carbon footprint.

The proposed sustainable practices are both practical and necessary to address these concerns. Strategies such as installing additional solar panels, implementing smart energy management systems, and transitioning to LED lighting align with global best practices in energy efficiency. Transportation-related recommendations, including the introduction of campus shuttle buses, the promotion of bicycle-friendly infrastructure, and carpooling initiatives, have been successfully implemented in other academic and urban settings to reduce emissions. Waste management solutions, particularly the establishment of a Material Recovery Facility (MRF), are crucial for improving recycling efficiency and achieving a Zero-Waste Campus. Similarly, water conservation measures such as rainwater harvesting, the use of low-flow faucets, and regular leak detection can significantly minimize water wastage. These strategies have been successfully adopted by other institutions and demonstrate clear environmental and economic benefits.

While the findings strongly support sustainability initiatives, potential challenges in implementation must be acknowledged. Budget constraints, behavioral resistance, and the long-term investment required for certain strategies, such as increasing renewable energy sources, may affect their immediate adoption. Additionally, the effectiveness of these initiatives depends on consistent enforcement and awareness campaigns to encourage participation from students, faculty, and staff. However, given the strong community support reflected in the study, these challenges can be mitigated through strategic planning and institutional commitment. Ultimately, the results of this study justify that sustainability initiatives at NDDU are both necessary and feasible. By implementing evidence-based strategies, the university can significantly reduce its carbon footprint while serving as a model for other educational institutions committed to environmental responsibility.

Implication of Findings

The results of this study provide significant insights into the sustainability challenges and opportunities at NDDU. The high carbon emissions from energy consumption, transportation, and waste management underscore the need for institutional policies that prioritize sustainable practices. If left unaddressed, these issues will not only contribute to environmental degradation but may also lead to increased operational costs for the university due to rising energy expenses and inefficient resource use. The findings suggest that integrating renewable energy, improving transportation systems, and strengthening waste management strategies will be crucial in mitigating these environmental impacts while fostering a more sustainable academic environment.

One of the most critical implications is the role of institutional leadership in driving sustainability initiatives. The strong willingness of the NDDU community to adopt sustainable practices indicates that with proper guidance, policies, and infrastructure, behavioral changes can be effectively implemented. For instance, the successful adoption of a Material Recovery Facility (MRF) for waste segregation and recycling could serve as a model for other universities aiming to transition towards a zero-waste campus. Similarly, increasing the use of solar panels and implementing smart energy management systems will not only reduce energy costs but also position NDDU as a leader in renewable energy adoption among educational institutions.

Additionally, the findings highlight the importance of education and awareness in fostering long-term sustainability. The university can leverage this by integrating sustainability into academic curricula, organizing workshops, and launching campus-wide campaigns to reinforce the importance of environmental stewardship. Encouraging digital submissions, reducing single-use plastics, and promoting sustainable transportation options will require collective participation, but these efforts will significantly reduce NDDU's overall carbon footprint.

Another implication is the potential for partnerships with government agencies, private organizations, and environmental advocacy groups. Collaboration with local businesses and non-governmental organizations can help NDDU access funding opportunities, technological expertise, and additional resources for sustainability projects. Furthermore, these partnerships could lead to internship programs, research opportunities, and community-based sustainability initiatives that benefit both students and the wider society.

Overall, the findings of this study emphasize that sustainability is not just an institutional responsibility but a collective effort that requires the active participation of students, faculty, and administrators. By implementing the proposed strategies, NDDU can significantly improve its environmental impact, reduce costs, and create a healthier and more sustainable learning environment for future generations. These results also serve as a call to action for other educational institutions, demonstrating that sustainability in academia is both necessary and achievable through commitment, innovation, and collaboration.

CONCLUSIONS

The integration of sustainable practices at NDDU is not just a necessity but an opportunity to lead by example in the academic sector. Through a holistic approach that combines policy enforcement, infrastructure improvements, and active participation from the university community, NDDU can successfully create a greener, more sustainable learning environment. By taking decisive action today, the university will not only contribute to global environmental goals but also ensure a more resilient and sustainable future for generations to come. A strong commitment to sustainability will allow NDDU to serve as a model institution, inspiring other universities and organizations to follow suit in prioritizing environmental stewardship and social responsibility.

RECOMMENDATIONS

Based on the conclusions drawn from the findings, the following recommendations can be made:

1. There is a need to enhance the use of renewable energy by expanding the installation of solar panels across all campuses, including the Glamang Campus, to reduce reliance on grid electricity and lower carbon emissions.

2. There is a need to promote sustainable and eco-friendly transportation options, including the adoption of e-transportation such as electric jeepneys, buses, and vans for student and faculty transport. This will reduce fuel-based emissions and contribute to a greener campus.

3. There is a need to develop on-campus dormitories to minimize the daily transportation emissions of students and faculty commuting long distances. Dormitories will not only reduce carbon emissions but also provide a more convenient and cost-effective housing solution for students.

4. There is a need to establish a Material Recovery Facility (MRF) to ensure proper waste segregation, recycling, and composting. This will help divert waste from landfills and significantly lower methane emissions.

5. There is a need to intensify water conservation initiatives, including the installation of rainwater harvesting systems, regular leak inspections, and the use of low-flow fixtures in restrooms and laboratories.

6. There is a need to strengthen awareness and education campaigns on sustainability through workshops, student-led initiatives, and digital platforms to instill long-term environmental responsibility among students and staff.

7. There is a need to expand green infrastructure and campus vegetation, including planting more shade trees, implementing green roofs, and developing eco-friendly walkways to improve campus sustainability.

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APPENDIX A

Rubric for Validators

Instructions for Questionnaire Validators:

Thank you for taking the time to review and provide feedback on the questionnaire. Your input is valuable in ensuring the quality and effectiveness of the questionnaire.

Please carefully review the questionnaire and assess its various aspects based on the provided rubric. Consider the following points when evaluating each criterion:

a. Accuracy and Completeness: Assess if the questions are clear, relevant, and aligned with the objectives of the SOP. Check if the options and choices provided are appropriate and inclusive. Ensure that the questionnaire covers all necessary aspects without significant gaps.

b. Clarity and Readability: Evaluate the clarity and readability of the questions. Assess if they are phrased concisely and easy to understand. Consider the logical flow of the questions and check if instructions or explanations, if provided, are clear and helpful.

c. Relevance and Appropriateness: Assess if the questions address the specific information needed for the SOP. Consider if the questionnaire is tailored to the target group (Electronics Engineering graduates) and avoid unnecessary or irrelevant questions.

Use the rubric provided to rate each criterion on a scale of 1 to 4, with 4 being the highest (Excellent) and 1 being the lowest (Poor).

Please provide constructive feedback, suggestions for improvements, or any specific comments in the designated section of the rubric. Your feedback will be valuable in refining the questionnaire.

Once you have completed the rubric, please sign and date it. Your evaluation will remain confidential. Submit the completed rubric within the specified timeframe, and feel free to reach out if you have any questions or need further clarification.

Thank you once again for your contribution and dedication to ensuring the quality of the questionnaire. Your input is greatly appreciated!

Survey Questionnaire Rubric

	4	3	2	1
1. Accuracy and Completeness:				
All questions are clear, relevant, and aligned with the objectives of the SOP.				
All options and choices provided are appropriate and inclusive.				
The questionnaire covers all necessary aspects and leaves no significant gaps.				
2. Clarity and Readability:				
Questions are phrased in a concise and easy-to-understand manner.				
The flow of questions is logical and follows a clear structure.				
Instructions or explanations, if provided, are clear and helpful.				
3. Relevance and Appropriateness:				

	4	3	2	1
Questions address the specific information needed for the SOP.				
The questionnaire is tailored to the target group (Electronics Engineering graduates).				
The questionnaire avoids any unnecessary or irrelevant questions.				
4. Overall Evaluation:	4	3	2	1
The questionnaire is well-designed and suitable for collecting the desired data.				
Suggestions for improvements or enhancements are provided where necessary.				
Comments or feedback are constructive and helpful.				

Comments/Feedback: _____

_____

_____

Evaluator's Name: _____

Evaluator's Signature: _____

Date: _____

APPENDIX B

Survey Questionnaire

Questionnaire

This survey aims to gather data on the commuting habits, energy usage, and waste management practices of students, faculty, and staff to estimate the carbon footprint of Notre Dame of Dadiangas University (NDDU) – Glamang Campus. Your responses will contribute to sustainability initiatives and environmental stewardship within the campus.

Please consider each item carefully. Your honest response will be very valuable in meeting the objectives of this research. Rest assured that all your answers will be respected and dealt with confidentiality.

A. Demographics

1. **Role at NDDU:**

2. ☐ Student

3. ☐ Faculty

4. ☐ Staff

5. **Age Group:**

6. ☐ 18-24

7. ☐ 25-34

8. ☐ 35-44

9. ☐ 45-54

10. ☐ 55 and above

11. **Sex:**
☐ Male

12. ☐ Female

13. **Residence Distance from Campus (in km):**

14. ☐ Less than 1 km

15. ☐ 1-5 km

16. ☐ 6-10 km

17. ☐ More than 10 km

B. Transportation

1. **Primary Mode of Transportation to Campus:**

2. ☐ Private vehicle

3. ☐ Public jeepney/tricycle

4. ☐ Public bus/van

5. ☐ Motorcycle

6. ☐ Bicycle

7. ☐ Walking

8. **If you use a private vehicle or motorcycle, how often do you carpool?**

9. ☐ Never

10. ☐ Occasionally (1-2 times per week)

11. ☐ Frequently (3-5 times per week)

C. Awareness

1. **Are you aware of NDDU's environmental sustainability programs?**

2. ☐ Yes

3. ☐ No

4. **Would you support sustainability initiatives such as: (Select all that apply)**

5. ☐ Carpooling programs

6. ☐ Use of renewable energy (e.g., solar panels)

7. ☐ Waste reduction and recycling drives

8. ☐ Water conservation programs

9. **Are you familiar with the environmental impact of the university's energy consumption, transportation, and waste management?**

   ☐ Yes

   ☐ No

D. Willingness

1. **Would you be willing to change your daily habits to reduce your carbon footprint?**

2. ☐ Yes

3. ☐ No

4. **Would you be willing to participate in sustainability programs or initiatives on campus?**

☐ Yes

☐ No

5. **Do you have any suggestions to improve sustainability at NDDU?***(Please specify):*

Thank You!

Your participation in this survey is highly appreciated and will contribute significantly to NDDU's efforts to promote sustainability and reduce its carbon footprint.

Appendix C

Letter for Registrar

January 25, 2025

To: Dr. Jose C. Dagoc, RN

VP-Academics

Thru: Ms. Lorelyn F. Adrales, MCS, MBA

Registrar

Subject: Request for List of Enrolled Students of College of Engineering, Architecture, and Technology (2nd Semester 2024-2025)

Dear Dr. Dagoc:

We hope this message finds you well. We are writing to formally request a soft copy of the list of students currently enrolled in the College of Engineering, Architecture, and Technology for the 2nd semester of the academic year 2024–2025.

To support our faculty research titled "Carbon Footprints at Notre Dame of Dadiangas University: A Step Toward Sustainability," we kindly request that the list include the following details for each student:

1. Complete Name

2. Course

3. Year Level

The data will be used exclusively for academic and research purposes, specifically in calculating the carbon footprint associated with the student population. I assure you that all information will be handled with strict confidentiality and in compliance with the university's data privacy policies.

Please let us know if additional documents or approvals are required to facilitate this request. Thank you for your kind assistance and support of this research endeavor.

Yours sincerely,

Feln Lily F. Canonigo, MEP-ECE Researcher	Edgar B. Manubag, PhD Researcher

Noted by:

Engr. Shiela Jingle A. Soriño, MEE-CE, EnP

Adviser

Appendix D

Letter for Finance

February 3, 2025

To: Dr. Jovir C. Ignacio, RGC, RPsy

VP-Administrator

Thru: Dr. Joanne J. Java

Finance Officer

Subject: Request for Electricity and Water Billing Statements

Dear Dr. Ignacio:

We hope this letter finds you well. We are writing to formally request copies of the electricity and water billing statements for research and analysis purposes. Specifically, we require the following:

1. NDDU Main Campus – Electricity billing statements for the past six (6) months.

2. NDDU Glamang Campus – Electricity and water billing statements for the past six (6) months.

The electricity and water billing data will be used exclusively for academic and research purposes. All information will be handled with utmost confidentiality and in compliance with the university's data privacy policies.

We would appreciate it if you could process our request as soon as possible. Thank you very much for your attention to this matter. Your support and cooperation will significantly contribute to the success of this research project and the overall academic growth of our institution. We look forward to receiving a positive response.

Should you require any additional information or have any questions, please do not hesitate to contact us. Thank you for your time and consideration.

Yours sincerely,

Feln Lily F. Canonigo, MEP-ECE Researcher	Edgar B. Manubag, PhD Researcher

Noted by:

Engr. Shiela Jingle A. Soriño, MEE-CE, EnP

Adviser