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Carbon Footprint Inventory and Sectoral Emission Analysis of Government Ministries in Akwa Ibom State, Nigeria

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Abstract

Climate change remains a major environmental concern, while information on carbon emissions from public-sector institutions in developing regions remains limited. This study assessed the carbon footprint and emission contributions of selected government ministries and canteens in Akwa Ibom State, Nigeria, to establish a localized baseline for public-sector carbon management. A survey research design was adopted, and activity data were collected between October 2024 and October 2025 from electricity records, fuel records, canteen consumption records, and waste-related records. Carbon dioxide (CO_2) emissions associated with electricity, diesel, petrol, liquefied petroleum gas (LPG), and waste were estimated using activity data and corresponding emission factors within the Greenhouse Gas Protocol framework. The total estimated carbon footprint of the assessed units was 152,081.130 kg CO_2/year, equivalent to approximately 152.08 tonnes CO_2/year. The Ministry of Justice recorded the highest contribution (13.53%), followed by the Ministries of Finance (11.75%), Housing (9.02%), and Works (8.16%). Electricity was the largest individual emission source, accounting for 45.7% of the total carbon footprint, followed by diesel (40.0%), petrol (11.8%), LPG (1.8%), and waste (0.7%). Pearson correlation analysis further examined relationships among the recorded resource-consumption variables. The findings provide localized baseline evidence of ministry-level carbon emissions and identify electricity and diesel consumption as the principal emission sources requiring attention. The study recommends improved energy efficiency, reduced dependence on diesel-powered generators, renewable energy adoption, sustainable transportation practices, and regular institutional carbon-footprint monitoring to support emission reduction and sustainability within the public sector of Akwa Ibom State.

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1.0 Introduction

Climate change has emerged as one of the most significant environmental challenges of the twenty-first century, primarily due to increasing concentrations of greenhouse gases in the atmosphere (Intergovernmental Panel on Climate Change (IPCC, 2023). Carbon dioxide (CO_2), produced mainly through fossil fuel combustion and energy-related activities, is recognized as the largest contributor to global warming and climate change (Intergovernmental Panel on Climate Change, 2021; Friedlingstein et al., 2026). The continued increase in carbon emissions has been associated with rising global temperatures, extreme weather events, sea-level rise, and environmental degradation (Inter-governmental Panel on Climate Change, 2021; United Nations Environment Programme, 2023). A carbon footprint refers to the total quantity of greenhouse gases emitted directly or indirectly by an individual, organization, product, or activity over a given period (Wiedmann & Minx, 2008).

Carbon footprint assessment has become an important tool for quantifying environmental impacts and identifying opportunities for emission reduction (Hertwich & Peters, 2009a; Gao et al., 2014). According to the World Business Council for Sustainable Development and World Resources Institute (2004), carbon accounting enables organizations to monitor emissions and develop strategies for sustainable resource management. Carbon emissions are commonly classified using the Greenhouse Gas (GHG) Protocol according to the nature and source of emissions (World Business Council for Sustainable Development & World Resources Institute, 2004). Scope 1 covers direct emissions from sources owned or controlled by an organization, such as fuel combustion in vehicles and generators. Scope 2 refers to indirect emissions associated with the consumption of purchased electricity. Scope 3 encompasses other indirect emissions arising from activities associated with an organization (World Business Council for Sustainable Development & World Resources Institute, 2004; Hertwich & Wood, 2018). In this study, Scope 1 was used for direct emissions from petrol and diesel combustion while Scope 2 was used for emissions associated with purchased electricity.

LPG consumption and waste generation were assessed separately as additional emission sources in the carbon-footprint inventory and were not designated as a separate emission scope. This approach provided a consistent basis for identifying and comparing the major emission sources considered in the study. Previous carbon-footprint studies have examined emissions at national, industrial, transportation, household, and other organizational levels (Hertwich & Peters, 2009b; Román & Kabir, 2024; Adeniran et al., 2023; Lee et al., 2025; Adhikari et al., 2024; Yakubu et al., 2021). Such studies have demonstrated the importance of energy consumption and fossil-fuel use in determining carbon emissions (Adewuyi & Awodumi, 2017; Yakubu et al., 2021). However, considerably less attention has been given to the distribution of carbon emissions among individual government ministries, particularly within developing-country public-sector institutions. This creates a specific information gap because government ministries undertake administrative, transportation, energy, and service-delivery activities that generate measurable carbon emissions but are not usually examined as separate institutional sectors.

Government ministries consume substantial amounts of electricity, petrol, diesel, and other resources in carrying out administrative and operational activities. These activities generate carbon emissions that contribute to climate change and environmental sustainability challenges (United Nations Environment Programme, 2023; Yakubu et al., 2021). Nigeria's increasing energy demand and dependence on fossil fuels have contributed significantly to greenhouse gas emissions (Adewuyi & Awodumi, 2017). Frequent reliance on diesel-powered generators due to irregular electricity supply further increases carbon emissions from government institutions (Ogunjuyigbe et al., 2016; Yakubu et al., 2021). Consequently, assessing the carbon footprint of government ministries is essential for understanding emission patterns and developing effective mitigation strategies (Yakubu et al., 2021). The focus on government ministries is important because their emission profile differs from that of industrial facilities. While industrial activities may be dominated by production processes, emissions from government ministries are associated largely with purchased electricity, petrol and diesel consumption in generators and official vehicles, LPG use, and waste generation. Assessing these sources provides an opportunity to establish an institutional carbon baseline and identify the specific emission sources that require attention within the public sector (Yakubu et al., 2021). Akwa Ibom State provides an appropriate setting for this assessment because it has a substantial government presence and significant dependence on energy resources for public administration and service delivery.

The state also has extensive fossil-fuel-related activities and a large number of government institutions operating across different administrative functions. Despite these activities, information on the carbon footprint of government ministries and the distribution of emissions among them remains limited. Akwa Ibom State hosts numerous government ministries responsible for administrative, economic, social, and infrastructural development (Akwa Ibom State Government, 2025). The daily operations of these ministries require continuous use of electricity, transportation fuel, generators, and other energy resources that contribute to carbon emissions (Yakubu et al., 2021). However, information on the sectoral distribution of carbon footprint contributions among these ministries remains scarce. This knowledge gap limits the ability of policymakers to identify major emission sources and implement targeted sustainability measures.

The novelty of this study lies primarily in its application of a structured carbon-footprint inventory to government ministries in Akwa Ibom State and its comparison of ministry-level emission contributions and major emission sources. Rather than proposing a new carbon-accounting methodology, the study provides localized baseline evidence that can identify priority emission sources and support targeted energy-management and sustainability measures within the public sector. The use of a structured carbon-footprint inventory is consistent with established approaches to carbon-footprint assessment and greenhouse-gas inventory preparation (Gao et al., 2014; Pandey et al., 2011; Yaman, 2024). Therefore, this study examines the carbon footprint contributions of government ministries in Akwa Ibom State, Nigeria. Specifically, the study assesses the carbon footprint contributions of the ministries, identifies the major emission sources, evaluates the contribution of each emission source to total emissions, and proposes strategies for reducing carbon emissions and improving sustainability within the public sector.

1.1 Literature Review

Carbon footprint assessment provides a framework for quantifying carbon dioxide and other greenhouse gas emissions associated with human activities, organizations, products, and services. Wiedmann and Minx (2008) described the carbon footprint in terms of greenhouse gas emissions associated with a defined activity or entity, while Hertwich and Peters (2009a) examined carbon emissions from broader consumption and economic perspectives. These studies establish the importance of defining the activity or system being assessed when determining its carbon footprint.

The assessment of carbon emissions also depends on the accounting framework and system boundaries adopted. The Greenhouse Gas Protocol developed by the World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI) provides a framework for accounting and reporting organizational greenhouse gas emissions (WBCSD & WRI, 2001, 2004). Gao et al. (2014) examined carbon-footprint assessment standards and highlighted the importance of assessment procedures and standards in carbon accounting. The use of a recognized accounting framework is therefore important when estimating emissions from different sources and comparing their contributions.

Carbon-footprint assessment has been applied to different sectors and activities. Hertwich and Peters (2009b) considered carbon emissions from consumption at a broader level, while Larsen and Hertwich (2009) examined consumption-based greenhouse gas emissions in the context of local climate action. Fenner et al. (2018) reviewed carbon-footprint methodologies and applications in relation to buildings. Chen et al. (2019) also reviewed approaches to city-level carbon accounting. These studies demonstrate that carbon-footprint assessment can be applied at different organizational, urban, and service levels. However, the scale and focus of assessment differ across these contexts, making it necessary to define clearly the organizational boundary and emission sources being considered in a particular study.

Research on energy use and environmental emissions in Nigeria provides further context for institutional carbon assessment. Adewuyi and Awodumi (2017) examined renewable and non-renewable energy consumption, environmental pollution, and economic growth in Nigeria. Ogunjuyigbe et al. (2016) examined the electricity situation in Nigeria and discussed issues associated with electricity supply. These studies provide relevant evidence on the relationship between energy use and environmental challenges in Nigeria. However, they do not specifically provide a ministry-level carbon-footprint inventory for government ministries in Akwa Ibom State.

Other studies have considered carbon emissions in specific Nigerian settings. Gershon and Patricia (2019) examined carbon dioxide footprints among families in Port Harcourt, while Yakubu et al. (2021) assessed carbon emissions associated with energy consumption in selected public institutions in Nigeria. These studies demonstrate the relevance of carbon-emission assessment within Nigerian communities and institutions. Their different study settings, however, indicate that carbon-footprint assessment has been conducted at several levels without establishing a consolidated comparison of emission contributions among government ministries in Akwa Ibom State.

The existing literature therefore covers several levels of carbon assessment, including broader consumption activities, urban and local systems, buildings, households, and selected public institutions (Hertwich & Peters, 2009; Larsen & Hertwich, 2009; Chen et al., 2019; Fenner et al., 2018; Gershon & Patricia, 2019; Yakubu et al., 2021). The studies also demonstrate the importance of energy consumption and appropriate carbon-accounting procedures in assessing environmental emissions (Adewuyi & Awodumi, 2017; Gao et al., 2014; Yakubu et al., 2021). Nevertheless, the literature represented in the present manuscript provides limited evidence on the distribution of carbon-footprint contributions among individual government ministries within a Nigerian state.

This gap is important because government ministries operate through different administrative and service functions and may therefore have different patterns of electricity consumption, fuel use, transportation activity, and waste generation. A ministry-level assessment can provide information on the relative contribution of these institutions and identify the emission sources that account for the largest proportion of their carbon footprint (Yakubu et al., 2021; Gao et al., 2014).

The present study therefore assesses the carbon footprint of government ministries in Akwa Ibom State, Nigeria, using the Greenhouse Gas Protocol as the accounting framework (World Business Council for Sustainable Development & World Resources Institute, 2001, 2004). It examines emissions associated with indirect purchased electricity, diesel, petrol, liquefied petroleum gas, and waste and compares the resulting carbon-footprint contributions among the assessed ministries and canteens. The study consequently provides localized baseline information on the distribution of carbon emissions within the public sector of Akwa Ibom State and identifies the major emission sources that may require attention in public-sector sustainability planning.

1.2 Research Questions

The study was guided by the following research questions:

1. What are the carbon footprint contributions of the government ministries and canteens assessed in Akwa Ibom State?
2. Which emission sources contribute most to the total carbon footprint of the assessed government ministries and canteens?
3. What proportion of the total carbon footprint is contributed by electricity, diesel, petrol, LPG, and waste?
4. What strategies can be adopted to reduce carbon emissions and improve sustainability within the government ministries in Akwa Ibom State?

2.0 Materials and Methods

2.1 Study Design

A survey research design was adopted for the study. According to Groves et al. (2009), survey research provides a systematic approach for collecting information from a sample of entities to develop quantitative descriptions of the characteristics of the population from which the entities are drawn. The design was considered appropriate for this study because the assessment involved collecting and analyzing existing records of electricity consumption, petrol and diesel use, LPG consumption, and waste generation from selected government ministries and canteens. The study did not manipulate the activities or resource-consumption patterns of the assessed units. Instead, activity data were collected from available institutional records and data inventories covering the study period of October 2024 to October 2025. The collected data were subsequently used to estimate carbon dioxide (CO_2) emissions and compare carbon-footprint contributions among the assessed government units.

2.2 Study Area

The study was conducted in Akwa Ibom State, Nigeria, located in the South-South geopolitical zone of the country. The state lies approximately between latitudes 4°32′N and 5°33′N and longitudes 7°25′E and 8°25′E. It covers an area of approximately 7,081 km² and is bounded by Abia State to the north, Cross River State to the east, Rivers State and the Atlantic Ocean to the west and south, respectively. The state comprises 31 Local Government Areas and is administratively divided into three senatorial districts: Akwa Ibom North-East, Akwa Ibom North-West, and Akwa Ibom South.

Akwa Ibom has a tropical climate characterized by relatively high temperatures and substantial seasonal rainfall (George et al., 2020, 2022; Ekanem, 2022; Udosen et al., 2024). These climatic conditions support agricultural activities and contribute to the ecological characteristics of the region. The state has experienced considerable urbanization and infrastructural development, particularly around Uyo, the state capital, where government ministries and other public institutions are concentrated.

The economy of Akwa Ibom State is associated with oil and gas activities, agriculture, public administration, commerce, and other service-sector activities. Petroleum-related activities constitute an important component of the state's economy, while agriculture remains an important source of livelihood for a substantial proportion of the population. The state also has a significant public-sector presence, with numerous government ministries, departments, agencies, and other institutions providing administrative and public services (Akwa Ibom State Government, 2025).

The substantial presence of government institutions makes Akwa Ibom State a relevant setting for assessing the carbon footprint associated with public-sector operations. Government ministries require electricity for lighting, air-conditioning, computing, communication, and other administrative activities. They also consume petrol and diesel for official transportation and generator operation, while canteens utilize LPG for cooking and generate waste through routine activities. These activities provide identifiable sources of carbon dioxide emissions that can be quantified using activity data and appropriate emission factors (Pandey et al., 2011; Yaman, 2024).

The study area was therefore selected because of the concentration of government ministries and associated public-sector activities, the reliance on electricity and fossil fuels for institutional operations, and the need for localized information on carbon emissions from government operations. Assessing these activities provides a basis for establishing a carbon-footprint baseline and identifying major emission sources within the public sector of Akwa Ibom State (Yakubu et al., 2021; Pandey et al., 2011).

2.3 Sampling and Sample Size

The study population comprised the 27 government ministries operating in Akwa Ibom State. The 27 ministries were identified from official state government records, while the creation of four additional ministries in 2025 brought the total number of ministries to 27 (Akwa Ibom State Government, 2025; Frank, 2025). From this population, 13 ministries located in Uyo were purposively selected based on accessibility and the availability of sufficient activity data required for carbon-footprint estimation.

The inclusion criterion was the availability of adequate and accessible information on the major emission sources considered in the study, including electricity, diesel, petrol, LPG, and waste. Ministries for which the required activity data were unavailable or insufficient were excluded because their emissions could not be estimated consistently with the selected accounting procedure. Thus, the 13 ministries constituted a purposive, data-availability-based sample rather than a census of all 27 ministries. The selected ministries were Education, Works, Finance, Housing, Agriculture, Environment, Health, Youth Development, Information, Sports, Transport, Justice, and Culture/Tourism. In addition, 14 canteens operating within the premises of the selected ministries were included because their energy consumption and waste generation formed part of the institutional activities assessed.

The assessment covered the period from October 2024 to October 2025. The sampling approach was adopted to ensure that the carbon-footprint estimates were based on sufficiently available and identifiable activity data and could therefore be compared consistently across the selected ministries.

2.4 Procedure and Data Collection Methods

The study adopted the Greenhouse Gas (GHG) Protocol as the framework for identifying and classifying emission sources that causes environmental discomfort (George et al., 2010). Although the GHG Protocol provides a broader framework for accounting for greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), the present study was restricted to the assessment of carbon dioxide (CO_2) emissions. For the purpose of this study, Scope 1 comprised direct CO_2 emissions from the combustion of petrol and diesel in generators and official vehicles owned or controlled by the assessed government ministries and canteens. Scope 2 comprised indirect CO_2 emissions associated with purchased electricity consumed by the assessed government units (World Resources Institute & World Business Council for Sustainable Development, 2004).

LPG consumption and waste generation were assessed separately as additional emission sources in the carbon-footprint inventory. They were not designated as a separate emission scope. The GHG Protocol was developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) as a framework for greenhouse-gas accounting and reporting (World Resources Institute & World Business Council for Sustainable Development, 2004). The framework was adopted in this study to provide a consistent basis for identifying emission sources and organizing the carbon-footprint assessment. Accordingly, five principal emission sources were considered in the study: electricity, diesel, petrol, LPG, and waste.

Electricity consumption, diesel and petrol utilization, LPG consumption, and waste generation were recorded from the selected government ministries and canteens. The activity data collected were subsequently used to estimate CO_2 emissions using the corresponding emission factors presented in Table 2. The electricity consumption data, diesel and petrol consumption records, LPG consumption data, and waste records were collected as indicated in Table 1. Baseline activity data for energy use and waste generation were obtained for the assessed ministries and canteens to quantify and compare their respective carbon-footprint contributions.

2.5 Data Quality, Uncertainty, Measurement Errors and Assumptions

The study relied primarily on institutional records and available activity data. Consequently, potential sources of uncertainty included incomplete records, variations in the accuracy of recorded fuel and electricity consumption, estimation of quantities where direct measurements were unavailable, and differences in record-keeping practices among the selected ministries (Sakata et al., 2024; Yaman, 2024). These limitations were considered when organizing and interpreting the activity data. Where complete records were available, the reported activity quantities were used directly in the emission calculations. Where records were incomplete or insufficiently documented, the affected data were not replaced with assumed averages or substituted values. Such records were excluded from quantitative estimation where their use could introduce unsupported values. This approach was adopted to minimize potential bias arising from arbitrary assumptions and to maintain consistency in the carbon-footprint calculations (Pandey et al., 2011; Yaman, 2024). Potential measurement errors may arise from differences between recorded and actual fuel consumption, electricity use, generator operating hours, and waste quantities. Since the study was based on existing institutional records, these errors could not be independently quantified in all cases. The estimates should therefore be interpreted as carbon-footprint estimates based on the available institutional activity data rather than as exact physical measurements (Sakata et al., 2024).

The carbon-footprint calculations assumed that the recorded activity data represented the consumption occurring during the assessment period and that the selected emission factors were applicable to the corresponding energy sources. The study also assumed that the institutional records supplied by the selected ministries represented their reported activities during the study period. No numerical uncertainty range was assigned because the available records did not provide sufficient information to quantify the uncertainty associated with each activity variable and emission factor. The potential sources of uncertainty are therefore reported transparently as methodological limitations of the assessment (Sakata et al., 2024; Yaman, 2024).

2.6 Emission Factors

The emission factors used in this study were obtained from established greenhouse gas accounting sources and applied to the corresponding activity data. For grid electricity, this study adopted the Nigeria operating-margin emission factor of 526 g CO_2/kWh (0.526 kg CO_2/kWh) from the *IFI Default Grid Factors 2021 v3.1* published by the International Financial Institutions Technical Working Group on Greenhouse Gas Accounting (IFI TWG, 2022), with the numerical value independently accessible through the Breeze emission-factor database (Breeze, 2022).

Table 1: Emission-Related Activity Data, Data Sources, and Measurement Units Used in the Study

GHG Utilisation Engagement	Activity Subset	Data Source	Unit
Stationary combustion	LPG consumption in canteens	Canteen consumption records/data inventory	kg/yr
Stationary combustion	Diesel/petrol used in generators	Record books	Litre/yr
Purchased electricity	Electricity usage	Monthly electricity bills	kWh/yr
Waste	Materials purchased and stationeries utilized in the ministries	Monthly purchase and repair record books	kg/yr

3.0 Data Analysis

The carbon footprint was calculated using the appropriate emission factors and by totaling the resulting CO_2 emissions. Guidelines for estimating greenhouse gas emissions and selecting appropriate emission factors are provided by the Intergovernmental Panel on Climate Change (IPCC, 2006). Examples of the emission factors used in the study are presented in Table 2. The methodology used to estimate carbon footprint emissions from a particular source was to multiply the respective emission factor by the corresponding fuel quantity (Pandey et al., 2011). Equation 1 was used to calculate the total emissions from conventional fuel resources:

$$E_{fuel} = \sum(FC \times EF) \qquad (1)$$

where E represents the total CO_2 emissions. The variable fuel denotes different types of fuels (including electricity, natural gas, LPG, waste, and diesel), Ef is the emission factor of the fuel and FC indicates the fuel consumption.

3.1 Emission Sources Considered in the Study

To assess the carbon footprint of government ministries and canteens in Akwa Ibom State, the study adopted the emission-source classification framework of the Greenhouse Gas (GHG) Protocol (World Business Council for Sustainable Development & World Resources Institute, 2004). Scope 1 covered direct carbon dioxide (CO_2) emissions arising from the combustion of petrol and diesel in generators and official vehicles owned or controlled by the assessed government units. Scope 2 covered indirect CO_2 emissions associated with purchased electricity consumed by the ministries and canteens. In addition to Scope 1 and Scope 2 emissions, the study separately assessed LPG consumption and waste generation as additional emission sources in the carbon-footprint inventory. These sources were quantified using their respective activity data and emission factors presented in Table 2. They were not designated as a separate "Scope 4," because the GHG Protocol does not recognize Scope 4 as an official emission-accounting category (World Business Council for Sustainable Development & World Resources Institute, 2004). Accordingly, the assessment considered five principal emission sources: electricity, diesel, petrol, LPG, and waste. This classification enabled the study to determine the relative contribution of each source to the total calculated carbon footprint of the assessed government ministries and canteens.

3.2 Estimation of Carbon Dioxide (CO_2) Emissions

Carbon dioxide emissions from each assessed activity were estimated using the recorded activity data and the corresponding emission factors specified in Table 2. Emissions from electricity consumption, petrol, diesel, LPG, and waste were calculated using Equation (2):

$$CO_2\ Emission\ (kg\ CO_2/yr) = Activity\ Data \times Emission\ Factor\ (EF) \quad (2)$$

where, CO_2 Emission represents carbon dioxide emissions expressed in kg CO_2/yr, Activity Data (AD) is the quantity of electricity, petrol, diesel, LPG, or waste consumed or generated during the study period, expressed in the appropriate activity unit, and Emission Factor (EF) is the quantity of CO_2 emitted per unit of activity, expressed as kg CO_2 per unit of activity.

3.3 Statistical Analysis

Descriptive statistics were used to summarize the consumption of electricity, petrol, diesel, LPG, and waste among the assessed government ministries and canteens. Pearson's product-moment correlation analysis was subsequently performed using the activity data presented in Table 4 to determine the strength and direction of linear relationships among the resource-consumption variables.

Table 2: Historical emission factors used in the study and corresponding modern compliance references

Source	Historical EF	Unit	Original Reference
Electricity	0.526	kg CO_2/kWh	International Financial Institutions Technical Working Group on Greenhouse Gas Accounting (2022)
Petrol	2.296	kg CO_2/L	Intergovernmental Panel on Climate Change (2006)
Diesel	2.653	kg CO_2/L	Intergovernmental Panel on Climate Change (2006)
LPG	2.900	kg CO_2/kg	-
Waste	0.182	kg CO_2/kg	-
Transportation	0.564	kg CO_2/km	-

Note. Historical emission factors were retained as the factors used in the original inventory calculations to ensure reproducibility and comparability with the underlying data. Modern compliance alternative references are provided to demonstrate alignment with more recent emission-factor resources and to facilitate future updating of the inventory. The alternative references were not substituted into the historical calculations unless otherwise stated.

The Pearson correlation coefficient was calculated using Equation (3):

$$r = \frac{n\sum(XY)-(\sum X)(\sum Y)}{\sqrt{[n\sum X^2-(\sum X)^2][n\sum Y^2-(\sum Y)^2]}} \quad (3)$$

where r is the Pearson correlation coefficient, n is the number of observations, X is the observations for the first resource-consumption variable, Y is the observations for the second resource-consumption variable, ΣXY is the sum of the products of paired observations , ΣX is the sum of observations for variable X, ΣY is the sum of observations for variable Y, ΣX^2 gives the sum of squared observations for variable X and ΣY^2 is the sum of squared observations for variable Y. The coefficient ranges from −1 to +1. Positive values indicate a positive linear association, whereas negative values indicate an inverse linear association. The magnitude of the coefficient indicates the strength of the linear relationship. Statistical significance was evaluated using a two-tailed test at $p < 0.05$.

3.4 Summary of Carbon Footprint by Emission Classification

The estimated carbon footprint of the assessed government ministries and canteens was summarized according to the emission sources considered in the study. Scope 1 emissions comprised petrol and diesel combustion, while Scope 2 emissions comprised purchased electricity. LPG consumption and waste generation were assessed separately as additional emission sources. The combined carbon footprint from all five emission sources was 152, 081.130 kg CO_2/year. Scope 1 accounted for 51.8 %, Scope 2 accounted for 45.7 %, while LPG and waste contributed 1.8 % and 0.7 %, respectively.

4.0 Results

4.1 Carbon Footprint Contributions of Government Ministries in Akwa Ibom State

The sectoral analysis revealed substantial variation in carbon footprint contributions among the 13 government ministries and canteens assessed in Akwa Ibom State. The differences were associated with variations in electricity consumption, diesel and petrol use, LPG utilization, waste generation, and the operational requirements of the respective units. Ministries with relatively greater energy and fuel requirements generally recorded higher carbon footprint values. Table 3 presents the carbon footprint contributions of the assessed ministries and canteens. The Ministry of Justice recorded the highest contribution (13.53%), followed by the Ministry of Finance (11.75%), Ministry of Housing (9.02%), and Ministry of Works (8.16%). The Ministry of Education contributed 7.96%, while the Ministries of Information and Health accounted for 7.72% and 6.10%, respectively. The remaining ministries recorded contributions ranging from 4.63% to 6.06%, while the canteens recorded the lowest contribution at 3.61%. The relatively high contribution of the Ministry of Justice can be linked to its resource-consumption profile, particularly its 5,000 L of diesel, which was the highest diesel consumption recorded among the assessed ministries. The Ministry of Finance also recorded relatively high electricity consumption (17, 541 kWh) and diesel consumption (2, 500 L), contributing to its comparatively high carbon footprint. Similarly, the Ministry of Housing recorded substantial diesel consumption (2,450 L), while the Ministry of Works had the highest electricity consumption (14, 551 kWh) among the ministries. These patterns indicate that ministry-level carbon footprints are influenced by the combined effect of electricity demand and fossil-fuel consumption rather than by a single resource alone.

Table 3: Carbon Footprint Contributions of Government Ministries and Canteens in Akwa Ibom State

Ministry	Carbon footprint (kg CO_2/year)	Contribution (%)
Justice	20,583.240	13.53
Finance	17,872.506	11.75
Housing	13,723.956	9.02
Works	12,414.906	8.16
Education	12,104.346	7.96
Information	11,736.966	7.72
Health	9,277.530	6.10
Transport	9,215.446	6.06
Sports	9,110.832	5.99
Agriculture	8,740.674	5.75
Youth Development	7,601.932	5.00
Environment	7,175.228	4.72
Culture/Tourism	7,038.554	4.63
Canteens	5,485.014	3.61
Total	**152,081.130**	**100.00**

The lower contributions recorded by Culture/Tourism (4.63%), Environment (4.72%), Youth Development (5.00%), and the canteens (3.61%) correspond generally with their lower overall resource-use profiles. However, the results also demonstrate that the relationship between individual resource consumption and total carbon footprint is not uniform across all units because the different emission sources have different emission factors. For example, a relatively smaller quantity of diesel can produce a substantial carbon contribution because diesel has a higher emission factor than purchased electricity under the factors adopted in this study. The total carbon footprint of the assessed ministries and canteens was 152,081.130 kg CO_2/year, equivalent to approximately 152.08 tonnes CO_2/year.

Figure 1 shows that emissions were unevenly distributed across the assessed units, with the four highest-contributing units, Justice, Finance, Housing, and Works, collectively accounting for approximately 42.46% of the total carbon footprint. This concentration indicates that targeted interventions in a relatively small number of high-emitting units could provide a substantial reduction in the overall carbon footprint.

From an energy-management perspective, the findings suggest that emission-reduction measures should be prioritized according to the dominant resource-use characteristics of individual ministries. Units with high diesel consumption require measures aimed at reducing generator dependence, while units with high electricity consumption would benefit from energy-efficiency measures and renewable-energy integration. This ministry-specific approach would allow carbon-reduction policies to address the principal sources of emissions identified within each institutional setting (Pandey et al., 2011; Yaman, 2024).

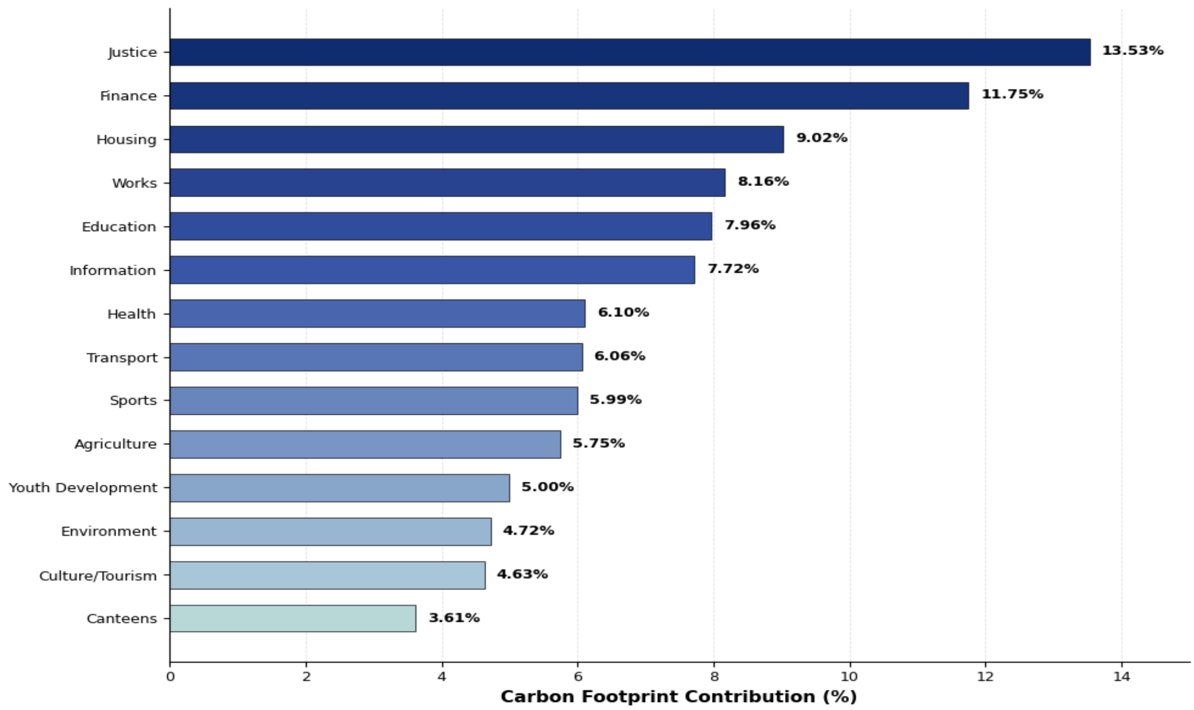

Figure 1: Carbon footprint contributions among government ministries and canteens in Akwa Ibom State, Nigeria

4.2 Resource Consumption among Government Ministries

Resource consumption is an important determinant of carbon footprint generation within organizations and institutions. Government ministries require electricity, liquid fuels, LPG, and other resources to support administrative, operational, transportation, and service-delivery activities. Differences in the quantity and type of resources consumed therefore contribute to variations in the carbon footprint of individual government units. Assessment of these resource-use patterns provides a basis for interpreting the differences in emissions observed among the assessed ministries and canteens.

The resource-consumption data presented in Table 4 show considerable variation among the assessed units. Electricity recorded the highest total activity quantity, with annual consumption of 132,044 kWh. The widespread use of electricity reflects the dependence of government offices on lighting, air-conditioning systems, computers, printers, photocopiers, communication equipment, and other electrical appliances. The high electricity demand across the assessed units therefore reflects the central role of purchased electricity in routine government operations.

Diesel consumption amounted to 22,950 L during the study period and was associated primarily with the operation of generators. Although the quantity of diesel consumed was substantially lower than the electricity activity quantity, diesel made a particularly large contribution to the carbon footprint because its emission factor was 2.653 kg CO_2/L. The substantial diesel consumption therefore indicates that generator operation was an important source of direct CO_2 emissions within the assessed institutions. Petrol consumption totaled 7,822 L and was associated principally with official transportation and other petrol-powered activities recorded by the assessed units. Petrol had an emission factor of 2.296 kg CO_2/L, resulting in a measurable contribution to the total carbon footprint. Differences in petrol consumption among the ministries may reflect differences in transportation requirements and the extent of field and administrative activities involving official vehicles.

LPG consumption was comparatively low at 925 kg and was associated mainly with cooking activities in the assessed canteens. Although the quantity was substantially lower than the electricity and liquid-fuel activity data, its emission factor of 2.9 kg CO_2/kg resulted in a measurable contribution to the carbon footprint. The inclusion of LPG therefore demonstrates the importance of considering both activity quantity and emission factor when interpreting emission contributions (Pandey et al., 2011). Waste generation amounted to 6,032 kg during the study period. Waste represented a relatively small component of the overall carbon footprint, contributing 0.7% of total emissions according to Table 5. Its relatively small contribution indicates that, within the boundary and emission factor adopted in this study, energy and fuel-related activities were substantially more important determinants of the calculated carbon footprint than waste generation. The relationship between resource consumption and emissions is further demonstrated in Table 5. Electricity accounted for 45.7% of total emissions, while diesel contributed 40.0% and petrol contributed 11.8%. LPG and waste contributed 1.8% and 0.7%, respectively. Thus, the resource with the largest activity quantity, electricity, also produced the largest emission contribution, while diesel generated a similarly substantial emission contribution despite having a much smaller activity quantity. This pattern illustrates the importance of considering the emission factor of each resource alongside its consumption level (Pandey et al., 2011).

Table 4: Consumption of Greenhouse Gas Emission Resources by Government Ministries

Ministry	Electricity (kWh)	Petrol (L)	Waste (kg)	Diesel (L)	LPG (kg)
Education	13,251	420	250	1,500	50
Works	14,551	680	750	1,100	50
Finance	17,541	790	300	2,500	50
Housing	11,201	480	150	2,450	70
Agriculture	7,101	443	710	1,400	50
Environment	7,002	406	150	900	50
Health	8,942	878	550	850	70
Youth Development	5,110	332	150	1,500	50
Information	14,201	920	760	700	55
Sports	4,901	341	185	2,100	50
Transport	10,216	730	250	750	45
Justice	10,021	820	107	5,000	50
Culture/Tourism	4,003	341	220	1,500	45
Canteens	4,003	241	1,500	700	240
Total	**132,044**	**7,822**	**6,032**	**22,950**	**925**

Source: Field Survey (October 2024–October 2025)

The findings indicate that electricity and diesel were the two most important resource categories in determining the carbon footprint of the assessed government ministries and canteens. Their combined contribution of 85.7% of total emissions identifies electricity demand and generator dependence as the principal areas for emission-reduction intervention. Consequently, measures such as improved energy efficiency, reduction of unnecessary electricity consumption, renewable-energy integration, and reduced dependence on diesel generators would have greater potential for reducing the overall carbon footprint than interventions directed solely toward the lower-contributing sources (Yaman, 2024; Osabohien et al., 2026).

4.3 Major Sources of Carbon Footprint Emissions among Government Ministries

Carbon emissions associated with the assessed government ministries and canteens originated from activities involving electricity consumption, diesel consumption, petrol consumption, liquefied petroleum gas (LPG) utilization, and waste generation. These activity categories represented the principal emission sources considered in the carbon-footprint assessment and collectively determined the calculated CO_2 emissions of the assessed units. Electricity consumption constituted an important component of the emission profile because it was required to support routine administrative and operational activities. Diesel consumption was associated primarily with generator use, while petrol consumption was associated with official transportation and other petrol-powered activities. LPG consumption was recorded mainly in the assessed canteens, while waste generation represented the waste-related activity included in the assessment. The quantities of electricity, diesel, petrol, LPG, and waste recorded for the assessed ministries and canteens were multiplied by their respective emission factors to estimate the carbon footprint associated with each source (Pandey et al., 2011). The resulting contributions are presented in Table 5. The results show that electricity was the largest individual source of carbon emissions, contributing 45.7% of the total carbon footprint, equivalent to 69,455.144 kg CO_2/year. Diesel was the second-largest source, contributing 40.0%, equivalent to 60,886.350 kg CO_2/year. Petrol accounted for 11.8%, corresponding to 17,959.312 kg CO_2/year. LPG and waste made comparatively smaller contributions of 1.8% and 0.7%, corresponding to 2,682.500 kg CO_2/year and 1,097.824 kg CO_2/year, respectively.

Electricity and diesel together accounted for approximately 85.7% of the total calculated carbon footprint. This indicates that electricity consumption and diesel use were the dominant emission sources within the assessed government ministries and canteens. The result also shows that both purchased electricity and fuel combustion associated with generator use are important components of the carbon-emission profile of the assessed public-sector operations. The relatively large contribution of electricity reflects the quantity of electricity consumed across the assessed units and the emission factor applied to purchased electricity. The substantial contribution from diesel reflects the quantity of diesel recorded in the activity inventory and its corresponding emission factor. Petrol, LPG, and waste contributed smaller proportions of the total calculated footprint, although they remained relevant emission sources within the study boundary.

Table 5: Major Sources of Carbon Footprint Emissions Among Government Ministries

Emission Source	**Carbon Footprint (kg CO_2/year)**	**Contribution (%)**
Electricity	69,455.144	45.7
Diesel	60,886.350	40.0
Petrol	17,959.312	11.8
LPG	2,682.500	1.8
Waste	1,097.824	0.7
Total	**152,081.130**	**100.0**

The assessment of emission sources showed that electricity consumption remained the largest individual source of carbon emissions, accounting for 45.7% of the total carbon footprint, followed by diesel consumption at 40.0%. Petrol contributed 11.8%, while LPG and waste accounted for 1.8% and 0.7%, respectively. Electricity and diesel together accounted for approximately 85.7% of total emissions. This finding demonstrates that both purchased electricity and fossil-fuel-based backup power are major contributors to the carbon footprint of government ministries in Akwa Ibom State. The substantial contribution from diesel reflects the reliance on generator-based electricity supply, while the electricity contribution reflects emissions associated with purchased grid electricity.

Figure 2 illustrates the percentage contribution of the major emission sources to the total carbon footprint generated by the assessed government ministries and canteens in Akwa Ibom State. The figure shows that electricity consumption was the largest individual source of carbon emissions, contributing 45.7% of the total carbon footprint. This was followed by diesel consumption, which accounted for 40.0%, while petrol consumption contributed 11.8%. LPG utilization and waste generation contributed 1.8% and 0.7%, respectively.

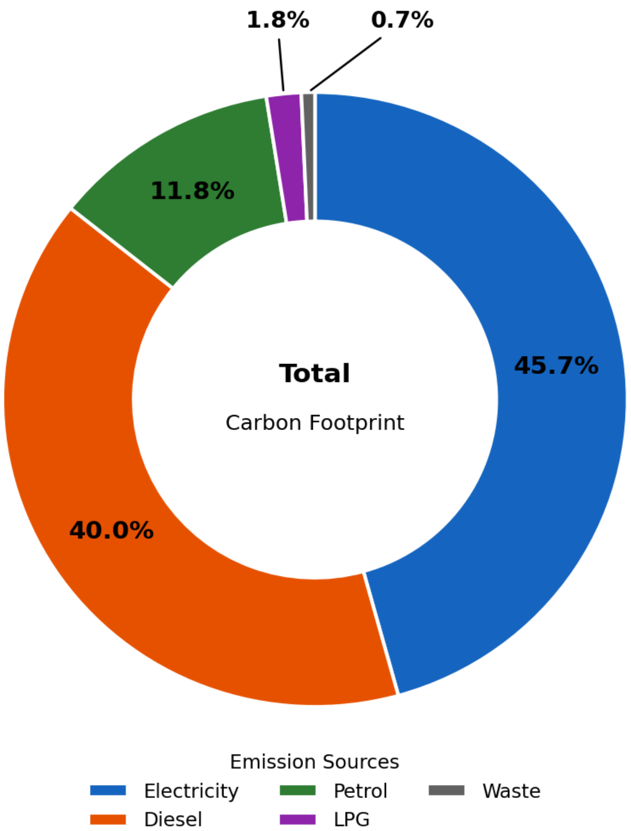

Figure 2: Percentage Contribution of Emission Sources to the Total Carbon Footprint of Government Ministries and Canteens in Akwa Ibom State, Nigeria

The large contribution associated with electricity reflects the substantial quantity of electricity consumed across the assessed ministries and canteens. Electricity was required for lighting, air-conditioning, computing, and other routine administrative and operational activities. Although the emissions associated with purchased electricity occur indirectly from the perspective of the consuming ministries, they were included in the carbon-footprint assessment using the adopted electricity emission factor (World Business Council for Sustainable Development & World Resources Institute, 2004).

Diesel consumption constituted the second-largest emission source, accounting for 40.0% of the total calculated carbon footprint. The substantial contribution of diesel reflects the quantity of diesel recorded in the activity inventory and its associated emission factor. Diesel use was primarily associated with generator operation within the assessed government units. Petrol consumption contributed 11.8% of the total carbon footprint. The contribution was associated with petrol use recorded for official transportation and other relevant activities within the assessed units. Although its contribution was considerably lower than those of electricity and diesel, petrol remained an important component of the overall emission profile.

LPG and waste contributed relatively small proportions of the total carbon footprint, accounting for 1.8% and 0.7%, respectively. Their smaller contributions reflect the comparatively lower quantities recorded in the activity inventory and the corresponding emission factors applied in the calculations. Figure 2 demonstrates that electricity and diesel were the dominant emission sources, jointly accounting for 85.7% of the total calculated carbon footprint. This result indicates that measures directed towards electricity efficiency, improved generator and fuel management, reduced dependence on fossil-fuel-based backup generation, and appropriate renewable-energy interventions could address a substantial proportion of the calculated emissions within the assessed government units (Yaman, 2024; Osabohien et al., 2026). The emission signature in Figure 3 shows a pronounced contribution from electricity and diesel, which accounted for 45.7% and 40.0% of the total calculated carbon footprint, respectively. Petrol contributed 11.8%, whereas LPG and waste represented comparatively small contributions of 1.8% and 0.7%. The profile therefore confirms that electricity and diesel as the two dominant emission sources within the assessed government units.

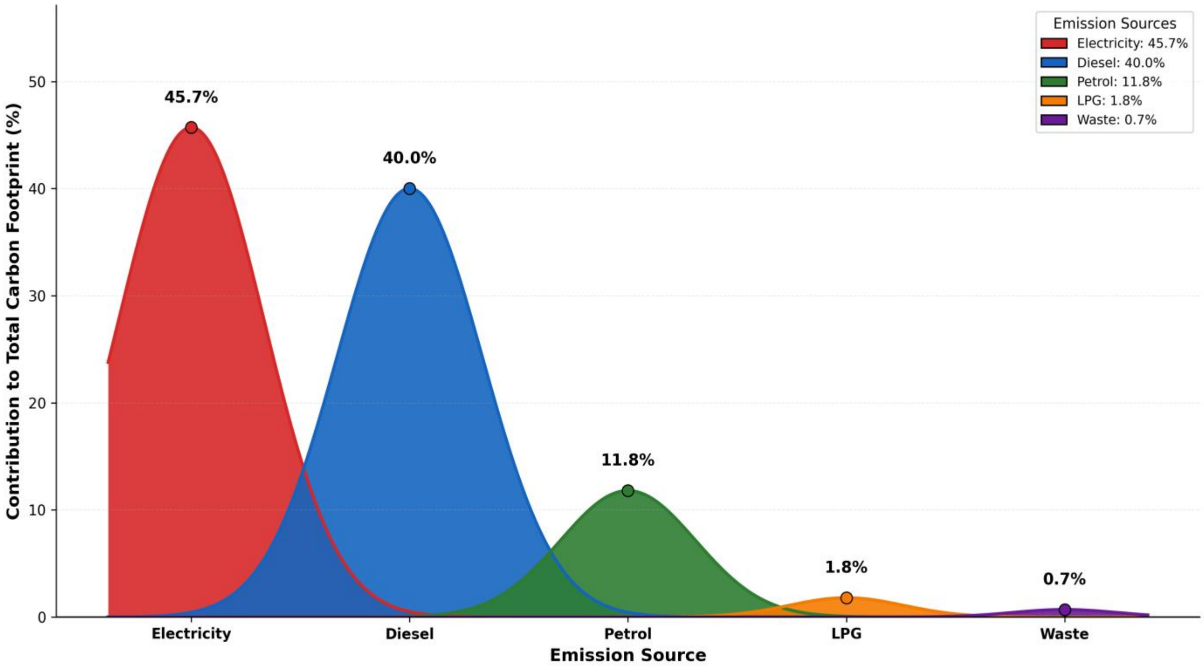

Figure 3: Emission signature of major carbon footprint sources among the assessed government ministries and canteens in Akwa Ibom State

Table 6: Pearson Correlation Matrix of Resource Consumption Among Government Ministries and Canteens

Variable	Electricity	Petrol	Diesel	LPG	Waste
Electricity	1.000	**0.701**	0.140	-0.337	-0.079
Petrol	**0.701**	1.000	0.180	-0.348	-0.058
Diesel	0.140	0.180	1.000	-0.236	-0.470
LPG	-0.337	-0.348	-0.236	1.000	**0.793**
Waste	-0.079	-0.058	-0.470	**0.793**	1.000

Note: Values are Pearson's *r*. p < 0.01. *n* = 14.

Table 7: Statistical Significance of Pearson Correlations Among Resource Consumption Variables

Relationship	Pearson's *r*	*p*-value	Interpretation
Electricity–Petrol	0.701	**0.005**	Significant positive
Electricity–Diesel	0.140	0.632	Not significant

Relationship	Pearson's *r*	*p*-value	Interpretation
Electricity–LPG	−0.337	0.239	Not significant
Electricity–Waste	−0.079	0.788	Not significant
Petrol–Diesel	0.180	0.539	Not significant
Petrol–LPG	−0.348	0.222	Not significant
Petrol–Waste	−0.058	0.843	Not significant
Diesel–LPG	−0.236	0.417	Not significant
Diesel–Waste	−0.470	0.090	Not significant
LPG–Waste	**0.793**	**0.001**	**Significant positive**

Note: Pearson's correlation coefficient was calculated using the 14 observations reported in Table 4. Statistical significance was evaluated using a two-tailed test at $p < 0.05$.

4.4 Pearson Correlation Analysis of Resource Consumption

Pearson correlation analysis was performed to examine the relationships among electricity, petrol, diesel, LPG, and waste consumption across the 14 assessed units. The results in Table 6 showed a strong and statistically significant positive correlation between electricity and petrol consumption ($r = 0.701$, $p = 0.005$). This indicates that units with higher electricity consumption also tended to record higher petrol consumption. The relationship may reflect similarities in the operational intensity of the assessed units, where greater administrative or field activities require both higher electricity use and greater use of official vehicles. A strong positive and statistically significant relationship was also observed between LPG and waste consumption ($r = 0.793$, $p = 0.001$). This association is consistent with the role of canteen-related activities in the dataset, where LPG consumption is linked to cooking activities and may occur alongside the generation of food and packaging waste. The relationships between electricity and diesel ($r = 0.140$, $p = 0.632$), electricity and LPG ($r = -0.337$, $p = 0.239$), and electricity and waste ($r = -0.079$, $p = 0.788$) were not statistically significant. Similarly, petrol showed no statistically significant relationships with diesel ($r = 0.180$, $p = 0.539$), LPG ($r = -0.348$, $p = 0.222$), or waste ($r = -0.058$, $p = 0.843$). Diesel also showed no statistically significant association with LPG ($r = -0.236$, $p = 0.417$) or waste ($r = -0.470$, $p = 0.090$). Subsequently, the Correlation Heatmap in Figure 4 shows that electricity and petrol have a strong positive relationship ($r = 0.701$), while LPG and waste exhibit the strongest positive correlation ($r = 0.793$). In contrast, most other variables show weak to moderate correlations, with diesel and waste displaying a moderate negative association ($r = -0.470$).

The correlation results in Tables 6 and 7 indicate that resource consumption patterns were not uniformly related across the assessed units. Only electricity–petrol and LPG–waste relationships reached statistical significance at the 5 % level. The findings suggest that some resource-use patterns may be associated with common operational characteristics, whereas other resources appear to be influenced by more specific activities within individual ministries and canteens.

4.5 Strategies for Reducing Carbon Emissions and Improving Sustainability Among Government Ministries in Akwa Ibom State

The findings of this study showed that electricity consumption and diesel utilization were the two largest sources of carbon emissions among the assessed government ministries and canteens, accounting for 45.7% and 40.0% of the total carbon footprint, respectively. Petrol contributed 11.8%, while LPG and waste contributed 1.8% and 0.7%, respectively. Consequently, emission-reduction strategies should prioritize electricity efficiency, reduction of dependence on diesel-powered generators, improved transportation management, and sustainable resource-use practices. The following strategies could contribute to reducing carbon emissions and improving environmental sustainability within the public sector.

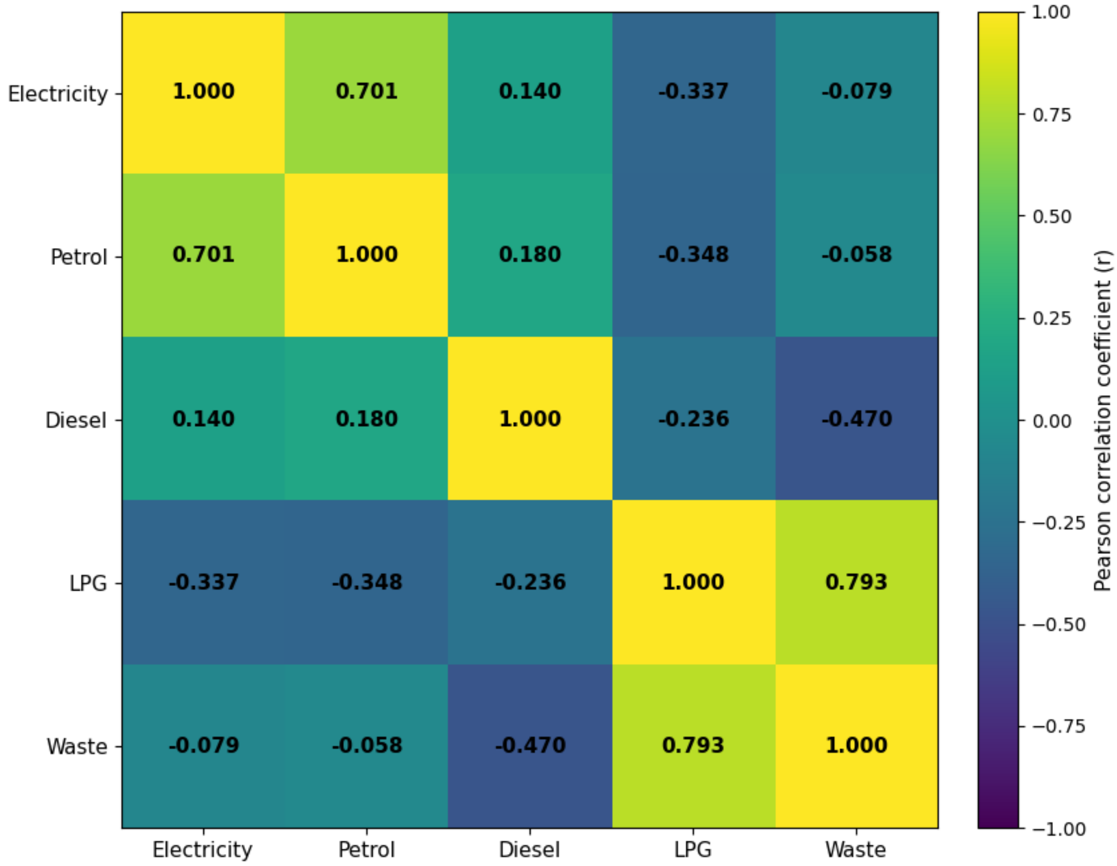

Figure 4: Pearson correlation matrix of resource consumption among the assessed government ministries and canteens in Akwa Ibom State, Nigeria

4.5.1 Adoption of Renewable Energy Technologies

The installation of solar photovoltaic (PV) systems in government ministries could reduce dependence on grid electricity and diesel-powered generators. Solar energy produces no direct CO_2 emissions during operation. The adoption of solar power for office buildings, lighting, and other public facilities could therefore reduce emissions while improving the reliability of electricity supply. Priority could be given to ministries with relatively high electricity and diesel consumption (Dong et al., 2024).

4.5.2 Improvement of Energy Efficiency

Energy-efficiency measures provide an important opportunity for reducing electricity-related emissions. Government ministries should consider replacing inefficient electrical equipment with energy-efficient alternatives, including LED lighting, energy-efficient air-conditioning systems, computers, and office appliances. Regular maintenance of electrical equipment should also be encouraged to improve performance and minimize energy wastage. These measures could reduce electricity consumption and the associated indirect carbon emissions (Yaman, 2024; Lackner et al., 2025).

4.5.3 Reduction in Generator Dependence

Diesel accounted for 40.0% of the total carbon footprint and was the second-largest individual emission source after electricity. Government ministries should therefore reduce dependence on diesel-powered generators through improved electricity management and increased adoption of renewable-energy systems. Where generators remain necessary, properly maintained and fuel-efficient units should be used to minimize fuel consumption and associated emissions. Particular attention should be given to units with relatively high diesel consumption (Yaman, 2024; Dong et al., 2024).

4.5.4 Sustainable Transportation Management

Petrol accounted for 11.8% of the total carbon footprint and represents an important source of emissions associated with transportation and fuel use. Ministries should promote efficient transportation practices, including appropriate official transport scheduling, vehicle pooling where practicable, and regular vehicle maintenance. The gradual adoption of lower-emission vehicles could further reduce fuel consumption. Virtual meetings and digital communication should also be encouraged where they can reduce unnecessary official travel (Jahami et al., 2025).

4.5.5 Promotion of Energy Conservation Practices

Staff practices can influence electricity consumption within government institutions. Government employees should be encouraged to switch off lights, air conditioners, computers, and other electrical appliances when they are not required. Energy-conservation awareness programmes and staff training could help promote responsible energy use and support institutional energy-management programmes.

5.5.6 Improved Waste Management Practices

Waste contributed 0.7% of the total carbon footprint. Although its contribution was relatively small compared with electricity and diesel, effective waste management remains important for environmental sustainability. Ministries should implement waste reduction, reuse, recycling, and appropriate waste-segregation practices. The separation of paper, plastics, food waste, and other recyclable materials could improve resource recovery and reduce the environmental impacts associated with waste disposal (Wikurendra et al., 2024).

5.5.7 Institutional Carbon Footprint Monitoring

Regular carbon-footprint assessment should be incorporated into government environmental-management programmes. Continuous monitoring of electricity, diesel, petrol, LPG, and waste activity data would enable ministries to identify major emission sources, track changes in their carbon footprint, and evaluate the effectiveness of emission-reduction measures. Institutional carbon accounting could also support evidence-based environmental planning, reporting, and target setting.

5.5.8 Development of Sustainability Policies

Comprehensive sustainability policies are important for supporting long-term emission reduction. Government ministries should develop and implement policies addressing energy efficiency, renewable-energy adoption, sustainable procurement, transportation management, waste reduction, and responsible resource use. Such policies would provide an institutional framework for integrating environmental considerations into routine operations and strategic planning.

5.5.9 Implications for Sustainability

Implementation of these measures could provide environmental, economic, and operational benefits. Reduced electricity and fuel consumption would lower carbon emissions and could reduce energy expenditure. Renewable-energy adoption could improve energy reliability and reduce dependence on fossil-fuel-based backup generation. Improved transportation and resource-management practices could provide additional emission reductions, while institutional monitoring would allow progress to be measured over time (Yaman, 2024; Dong et al., 2024).

Reducing carbon emissions among government ministries requires coordinated measures involving renewable-energy adoption, energy efficiency, reduced generator dependence, transportation management, staff practices, waste management, institutional monitoring, and supportive sustainability policies. Given that electricity and diesel together accounted for 85.7% of the total carbon footprint, these two areas should receive particular attention in efforts to reduce the overall carbon footprint of public-sector operations in Akwa Ibom State.

5.0 Discussion

The study assessed the carbon footprint contributions of government ministries and canteens in Akwa Ibom State, Nigeria, using activity data on electricity consumption, diesel consumption, petrol consumption, LPG utilization, and waste generation. The results revealed substantial variation in carbon footprint contributions among the assessed units, reflecting differences in resource-use patterns and operational requirements. The ministry-level results presented in Table 4 show that the Ministry of Justice recorded the highest carbon footprint contribution (13.53%), followed by the Ministry of Finance (11.75%), Ministry of Housing (9.02%), and Ministry of Works (8.16%). The Ministry of Education contributed 7.96%, while the Ministries of Information and Health accounted for 7.72% and 6.10%, respectively. In contrast, Culture/Tourism and the canteens recorded comparatively lower contributions of 4.63% and 3.61%, respectively. These differences demonstrate that carbon emissions were unevenly distributed among the assessed government units.

The relatively high contribution of the Ministry of Justice is particularly noteworthy because the resource-consumption data in Table 4 show that it recorded the highest diesel consumption among the assessed ministries, at 5,000 L. Since diesel has an emission factor of 2.653 kg CO_2/L, its relatively high consumption had a substantial influence on the ministry's overall carbon footprint. The Ministry of Finance also recorded substantial electricity consumption (17,541 kWh) and diesel consumption (2,500 L), which helps explain its relatively high contribution. The Ministry of Housing recorded 11,201 kWh of electricity and 2,450 L of diesel, while the Ministry of Works recorded the highest electricity consumption among the ministries (14,551 kWh) together with 1,100 L of diesel. These results indicate that ministry-level carbon footprints were influenced by the combined effects of electricity and fossil-fuel consumption rather than by a single activity.

The activity data in Table 4 further show that the assessed units recorded a total annual electricity consumption of 132,044 kWh, diesel consumption of 22,950 L, petrol consumption of 7,822 L, LPG consumption of 925 kg, and waste generation of 6,032 kg. These quantities should be interpreted within their respective measurement units because electricity, liquid fuels, LPG, and waste represent different forms of activity data. Their environmental significance is better evaluated after applying the appropriate emission factors. This distinction is important because the quantity of a resource consumed does not, by itself, determine its contribution to the total carbon footprint.

The emission-source results presented in Table 5 demonstrate this relationship more clearly. Electricity generated the largest calculated carbon footprint, contributing 45.7% of total emissions, equivalent to 69,455.144 kg CO_2/year. This result reflects the substantial electricity demand of the assessed institutions and the application of the adopted grid emission factor of 0.526 kg CO_2/kWh. Although electricity consumption produces no direct CO_2 emissions at the point of use, its associated indirect emissions arise from electricity generation and supply (World Business Council for Sustainable Development & World Resources Institute [WBCSD & WRI], 2004). The result therefore identifies purchased electricity as the largest individual emission source within the assessment. Diesel was the second-largest emission source, contributing 40.0%, equivalent to 60,886.350 kg CO_2/year.

Its contribution is particularly important because the diesel activity quantity was considerably lower than the numerical electricity activity quantity, yet diesel produced a carbon footprint almost as large as that of electricity. This pattern is explained by the substantially higher emission factor assigned to diesel. It also indicates that generator operation represents an important source of direct emissions within the assessed institutions. The combined contribution of electricity and diesel was 85.7% of the total carbon footprint, identifying electricity use and diesel-based backup power as the principal emission sources.

Petrol contributed 11.8%, equivalent to 17,959.312 kg CO_2/year. Its contribution reflects fuel use associated primarily with official transportation and other petrol-powered activities recorded during the assessment. Although its contribution was substantially lower than those of electricity and diesel, petrol remains an important emission source because transportation activities are directly linked to fuel combustion. LPG and waste contributed 1.8% and 0.7%, respectively. Their relatively small contributions indicate that, within the assessment boundary and emission factors adopted in this study, these sources had a considerably smaller influence on the total carbon footprint than electricity and liquid fossil fuels.

The concentration of emissions in electricity and diesel has important implications for public-sector energy management. The findings suggest that interventions directed toward electricity efficiency and generator dependence are likely to address the largest components of the measured carbon footprint. Energy-efficient equipment, improved electricity management, renewable-energy systems, and measures that reduce unnecessary generator operation could therefore be prioritized (Lackner et al., 2025; Hebala et al., 2025; International Renewable Energy Agency [IRENA], 2023). For ministries with high diesel consumption, such as Justice and Finance, reducing generator dependence may be particularly important. Similarly, units with relatively high electricity consumption could benefit from energy-efficiency measures and renewable-energy integration.

The findings also provide a basis for interpreting differences among ministries. The results do not imply that the administrative function of a ministry alone determines its carbon footprint. Rather, the observed differences appear to reflect the interaction between the resources required by each unit and the emission factors associated with those resources. This is important for policy because emission-reduction measures can be targeted according to the actual resource-use profile of individual ministries rather than applying identical interventions across all government units. The estimated total carbon footprint of 152,081.130 kg CO_2/year, equivalent to approximately 152.08 tonnes CO_2/year, demonstrates the measurable environmental impact associated with routine public-sector energy and resource use. The results support a targeted approach to carbon management in which electricity consumption, diesel-powered generation, and other significant sources are monitored regularly and addressed according to their contribution to the institutional carbon footprint.

5.1 Relationship Among Resource Consumption Variables

The Pearson correlation analysis provided additional insight into the relationships among the resource-consumption variables. A strong positive and statistically significant correlation was observed between electricity and petrol consumption ($r = 0.701$, $p = 0.005$). This relationship indicates that assessed units with higher electricity consumption tended to also record higher petrol consumption. The association may reflect differences in the operational intensity of the units, particularly where greater administrative, field, or service-delivery activities require both electricity and official transportation. A second strong positive and statistically significant relationship was observed between LPG and waste consumption ($r = 0.793$, $p = 0.001$). This relationship is particularly relevant to the inclusion of canteen activities in the assessment. LPG consumption was primarily associated with cooking activities, while waste generation included food-related and other institutional waste. The significant positive association suggests that units with greater LPG utilization also tended to generate greater quantities of waste within the assessed dataset. The remaining relationships were not statistically significant at the 5% level. Electricity consumption showed no significant relationship with diesel consumption ($r = 0.140$, $p = 0.632$), LPG consumption ($r = -0.337$, $p = 0.239$), or waste generation ($r = -0.079$, $p = 0.788$). Similarly, petrol consumption was not significantly associated with diesel ($r = 0.180$, $p = 0.539$), LPG ($r = -0.348$, $p = 0.222$), or waste ($r = -0.058$, $p = 0.843$). Diesel consumption also showed no statistically significant relationship with LPG ($r = -0.236$, $p = 0.417$) or waste ($r = -0.470$, $p = 0.090$).

The correlation results therefore indicate that the consumption variables did not exhibit a uniform pattern of association across the assessed units. The significant electricity–petrol relationship suggests a possible connection between electricity demand and transportation-related activity, while the LPG–waste relationship is consistent with the resource-use characteristics of units involving food preparation. However, the non-significant relationships indicate that consumption of one resource cannot generally be assumed to predict consumption of another across the assessed ministries and canteens. These results provide an additional statistical perspective to the descriptive findings and demonstrate that the observed carbon footprint is influenced by distinct resource-use patterns across the assessed units.

The study estimated a total carbon footprint of 152,081.130 kg CO_2 per year, equivalent to approximately 152.08 tonnes CO_2 per year, for the assessed ministries and canteens. This estimate provides a localized baseline for understanding carbon emissions associated with routine government operations in Akwa Ibom State. The ministry-level variation further demonstrates that carbon accounting can identify units with relatively greater emission contributions and therefore assist in prioritizing emission-reduction interventions. The implications of these findings are important for environmental sustainability and climate change mitigation. Since electricity and diesel together accounted for 85.7% of the total carbon footprint, emission-reduction efforts should give priority to improving electricity efficiency and reducing dependence on diesel-powered generators. The adoption of renewable energy technologies, particularly solar photovoltaic systems, could reduce dependence on conventional electricity and generator-based power (International Renewable Energy Agency [IRENA], 2023). Additional measures such as replacing inefficient appliances with energy-efficient alternatives, improving equipment maintenance, promoting energy conservation practices, and strengthening energy management could further reduce electricity-related emissions (Lackner et al., 2025; Hebala et al., 2025).

The substantial contribution from diesel also indicates the need for measures that reduce generator dependence. Improved electricity management, integration of renewable energy systems, and the use of properly maintained and fuel-efficient generators where backup generation remains necessary could help reduce diesel consumption and associated emissions (Ogunjuyigbe et al., 2016; IRENA, 2023; Lackner et al., 2025). Given the contribution of petrol to the overall footprint, sustainable transportation practices, including efficient vehicle use, regular vehicle maintenance, appropriate transport scheduling, and reduced unnecessary official travel, could provide additional emission reductions (Jahami et al., 2025). Furthermore, regular carbon footprint monitoring would enable government ministries to track changes in electricity and fuel consumption, identify major emission sources, assess the effectiveness of mitigation measures, and support evidence-based environmental decision-making (Yaman, 2024). Establishing institutional carbon accounting practices could also provide a basis for setting emission-reduction targets and evaluating progress over time.

The findings demonstrate that government ministries in Akwa Ibom State generate measurable carbon emissions through routine energy and resource consumption. The results also show that emission contributions differ considerably among ministries, with the highest contributions concentrated in a relatively small number of assessed units. The correlation analysis further demonstrates that some resource-use variables are significantly associated, while others operate relatively independently across the assessed units. Consequently, targeted energy-management measures, renewable energy adoption, reduced generator dependence, sustainable transportation practices, and continuous carbon-footprint monitoring are important for reducing the environmental impact of public-sector operations and supporting more sustainable development in the state (WBCSD & WRI, 2004; IRENA, 2023; Yaman, 2024).

6.0 Conclusion

This study assessed the carbon footprint of selected government ministries and canteens in Akwa Ibom State, Nigeria, using activity data on electricity consumption, diesel and petrol use, LPG consumption, and waste generation. The estimated total carbon footprint was 152,081.130 kg CO_2/year (152.08 tonnes CO_2/year). The results demonstrated substantial variation in carbon-footprint contributions among the assessed government units, reflecting differences in resource consumption and operational requirements. Electricity and diesel were the principal emission sources, contributing 45.7% and 40.0%, respectively, of the total carbon footprint.

The scientific contribution of the study lies in establishing a localized carbon-footprint inventory for government ministries and canteens in Akwa Ibom State. The study provides ministry-level evidence on the distribution of carbon emissions and identifies the principal activity sources responsible for the observed footprint. The incorporation of Pearson correlation analysis further provides an assessment of relationships among the major resource-consumption variables. The resulting inventory can serve as a baseline against which future changes in public-sector resource use and carbon emissions can be evaluated.

The findings have important policy implications for public-sector energy and environmental management. Since electricity and diesel together accounted for 85.7% of the estimated carbon footprint, emission-reduction efforts should prioritize electricity efficiency, reduction of dependence on diesel-powered generators, and increased adoption of renewable energy technologies. Energy-efficient equipment, improved generator management, sustainable transportation practices, waste-reduction measures, and regular institutional carbon-footprint monitoring could further support emission reduction. Government agencies can use ministry-level carbon inventories to identify high-emission units and develop targeted rather than uniform interventions.

The study has some limitations. The assessment was based on available institutional activity records and therefore depended on the completeness and quality of the records obtained from the assessed units. The study was also limited to selected ministries and canteens and to the activity categories included in the inventory. In addition, the assessment quantified CO_2 emissions only and did not quantify other greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O). The estimated emissions were also dependent on the emission factors adopted for the respective activity sources. The statistical analysis was based on the available 14-row activity dataset, which limits the extent to which more complex statistical methods can be applied and the generalizability of statistical relationships.

Future research should expand the inventory to include a larger number of government institutions and longer observation periods to assess temporal changes in emissions. Future studies could incorporate more comprehensive Scope 3 emission categories, where reliable activity data are available, together with uncertainty analysis and additional institutional characteristics that may explain differences in emissions among ministries. Repeated carbon-footprint assessments would also allow the effectiveness of renewable-energy adoption, energy-efficiency programmes, and generator-reduction measures to be evaluated over time.

This study demonstrates that government operations generate measurable carbon emissions and that a substantial proportion of the assessed footprint is associated with electricity consumption and diesel use. Establishing routine institutional carbon accounting, improving energy efficiency, reducing fossil-fuel dependence, and integrating renewable energy into public-sector operations can provide practical pathways for reducing emissions and improving environmental sustainability in Akwa Ibom State.

Conflict of Interest

The authors declare no conflict of interest.

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