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Green Accounting Practices and Sustainable Development Goal Achievement of Listed Manufacturing Firms in Nigeria

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Abstract: This study examined the relationship between green accounting practices and Sustainable Development Goal (SDG) achievement of listed manufacturing firms in Nigeria. The study was motivated by the increasing global emphasis on sustainable development and the growing need for manufacturing firms to integrate environmental accountability into their operational and reporting systems. An ex post facto research design was adopted, utilizing panel data obtained from the audited annual reports and sustainability reports of fifteen (15) listed manufacturing firms quoted on the Nigerian Exchange Group (NGX) over the period 2020–2025. Secondary data were collected through a structured content analysis approach, while the study employed a balanced panel dataset consisting of ninety (90) firm-year observations. Sustainable Development Goal achievement was measured using an SDG Achievement Index, whereas Green Accounting Practices were measured using a Green Accounting Practice Index. Firm size, leverage, and firm age were included as control variables. The data were analysed using descriptive statistics, Pearson correlation analysis, diagnostic tests, and panel regression techniques comprising Pooled Ordinary Least Squares, Random Effects, and Fixed Effects estimators. The Hausman Specification Test indicated that the Fixed Effects model was the most appropriate estimator. The regression results revealed that green accounting practices have a positive and statistically significant relationship with Sustainable Development Goal achievement ($\beta = 0.612$, $p < 0.001$). The findings further showed that firm size and firm age positively influence Sustainable Development Goal achievement, while leverage exerts a significant negative effect. The study concludes that the adoption of green accounting practices enhances corporate environmental accountability and significantly contributes to the achievement of Sustainable Development Goals among listed manufacturing firms in Nigeria. The study recommends that manufacturing firms strengthen environmental accounting systems, improve sustainability disclosures in line with international reporting standards, and increase investments in environmentally sustainable technologies. Regulatory agencies should also strengthen mandatory environmental reporting requirements to improve corporate contribution toward sustainable development.

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1. Introduction

Sustainable Development Goal (SDG) achievement has become a central concern for governments, corporations, international organizations, and other stakeholders seeking to balance economic growth with environmental protection and social inclusion. Since the adoption of the 2030 Agenda for Sustainable Development by the United Nations, organizations have increasingly been expected to contribute to the realization of the 17 Sustainable Development Goals through responsible production, environmental stewardship, and transparent corporate reporting. For business organizations,

particularly manufacturing firms whose operations significantly affect natural ecosystems, achieving the SDGs requires integrating sustainability principles into strategic decision-making and corporate governance. Manufacturing firms play a critical role in national economic development through employment generation, industrial production, export earnings, and technological innovation; however, they are equally recognized as major contributors to environmental degradation arising from greenhouse gas emissions, industrial waste generation, excessive resource consumption, and pollution [1]. Consequently, the extent to which manufacturing firms incorporate environmentally responsible accounting practices has become an important determinant of their contribution to sustainable development.

The growing emphasis on SDG achievement has shifted corporate performance evaluation beyond traditional financial indicators to include environmental and social outcomes. Investors, regulators, consumers, and development partners increasingly assess firms based on their ability to create sustainable value while minimizing environmental impacts. This transition reflects the recognition that long-term corporate success depends not only on profitability but also on responsible environmental management, efficient resource utilization, climate action, and ethical business practices. Consequently, organizations are expected to align their operational activities with SDGs such as Responsible Consumption and Production (SDG 12), Climate Action (SDG 13), Clean Water and Sanitation (SDG 6), Affordable and Clean Energy (SDG 7), and Industry, Innovation and Infrastructure (SDG 9). Firms that successfully integrate sustainability into their business models are more likely to strengthen stakeholder confidence, improve corporate reputation, attract sustainable investments, and maintain long-term competitiveness [2].

Despite increasing awareness of sustainable development, achieving the SDGs remains challenging for many developing economies, including Nigeria. Environmental pollution, inefficient waste management systems, weak environmental governance, inadequate sustainability reporting, and inconsistent enforcement of environmental regulations continue to hinder corporate contributions toward sustainable development objectives. Nigeria's manufacturing sector, while contributing substantially to economic growth and industrialization, also accounts for significant environmental externalities through carbon emissions, hazardous waste disposal, energy-intensive production processes, and depletion of natural resources. These challenges have intensified calls for organizations to adopt accounting systems capable of measuring, recognizing, reporting, and managing environmental costs alongside conventional financial information [3].

Green accounting practices have therefore emerged as one of the most significant corporate mechanisms for promoting sustainable development. Green accounting extends the traditional accounting framework by incorporating environmental costs, ecological liabilities, pollution prevention expenditures, waste management costs, carbon reduction investments, and environmental restoration activities into financial reporting and managerial decision-making. Unlike conventional accounting, which primarily focuses on financial profitability, green accounting recognizes that environmental resources possess measurable economic value and that corporate environmental impacts should be adequately identified, quantified, disclosed, and managed. The adoption of green accounting practices enables organizations to evaluate environmental performance, improve resource efficiency, reduce operational waste, enhance regulatory compliance, and support sustainability-oriented strategic planning [4].

Globally, increasing environmental regulations and stakeholder expectations have encouraged firms to integrate green accounting into corporate reporting systems. The emergence of sustainability reporting frameworks such as the Global Reporting Initiative (GRI), the International Sustainability Standards Board (ISSB), and enhanced environmental disclosure requirements has reinforced the need for organizations to account for environmental costs transparently. Green accounting facilitates informed managerial decisions regarding pollution control, environmental investments, waste recycling, renewable energy adoption, and efficient utilization of natural resources. These practices improve organizational accountability while supporting national and

international sustainability targets. Furthermore, transparent environmental reporting reduces information asymmetry between firms and stakeholders, thereby strengthening investor confidence and improving access to environmentally responsible financing [5].

Within Nigeria, the adoption of green accounting remains relatively uneven among listed manufacturing firms. Although environmental disclosure has improved following increased regulatory attention by the Nigerian Exchange Group and sustainability reporting initiatives, many firms still provide limited information regarding environmental expenditures, pollution control measures, carbon management strategies, environmental restoration activities, and ecological risk management. In several instances, environmental disclosures remain largely voluntary and lack consistency, comparability, and comprehensiveness. Consequently, stakeholders often encounter difficulties in evaluating the actual environmental performance of manufacturing firms and their contribution toward SDG achievement. This inconsistency limits the effectiveness of sustainability reporting as a mechanism for promoting environmental accountability and sustainable industrial development [6].

Empirical evidence regarding the relationship between green accounting practices and sustainable outcomes has also produced mixed findings. While some studies report that environmental accounting practices improve organizational sustainability, environmental performance, and financial outcomes through enhanced operational efficiency and stakeholder confidence, others find weak or insignificant relationships, particularly where sustainability reporting lacks standardization or effective regulatory enforcement. Moreover, much of the Nigerian literature has concentrated on financial performance indicators such as return on assets, profitability, firm value, or market performance, with relatively limited attention devoted to Sustainable Development Goal achievement as a multidimensional outcome variable. Similarly, many previous studies have examined environmental disclosure or sustainability reporting broadly without specifically investigating the comprehensive role of green accounting practices in advancing SDG achievement among listed manufacturing firms in Nigeria [7].

It is against this background that this study investigates the relationship between green accounting practices and Sustainable Development Goal achievement of listed manufacturing firms in Nigeria. Specifically, the study seeks to provide empirical evidence on how the adoption of green accounting practices contributes to corporate sustainability performance and supports the realization of national and global sustainable development objectives. The findings are expected to contribute to the growing literature on environmental accounting and sustainability, provide useful insights for policymakers and regulatory agencies, assist corporate managers in strengthening environmental management strategies, and support investors and other stakeholders in evaluating firms' commitment to sustainable development [8].

2. Materials and Methods

This study adopted an ex post facto research design because it relied on historical data obtained from the published annual reports and sustainability reports of listed manufacturing firms in Nigeria. The ex post facto design is appropriate for studies where the researcher has no control over the independent variables but seeks to examine the relationship between existing variables using already established data. The design enables the researcher to investigate how variations in green accounting practices influence Sustainable Development Goal (SDG) achievement without manipulating organizational activities or environmental reporting practices. The choice of this design is further justified by the nature of corporate sustainability disclosures, which are historical, observable, and publicly available, thereby allowing objective measurement of the variables over a specified period.

The study focused on listed manufacturing firms quoted on the Nigerian Exchange Group (NGX). Manufacturing firms were selected because they constitute one of the largest contributors to industrial development in Nigeria while simultaneously accounting for substantial environmental impacts through resource extraction, energy

consumption, greenhouse gas emissions, industrial waste generation, and environmental pollution. Consequently, these firms are expected to adopt green accounting practices and sustainability initiatives that contribute directly to the achievement of the Sustainable Development Goals.

The population comprised manufacturing firms listed under the Consumer Goods, Industrial Goods, Healthcare, and Agriculture sectors of the Nigerian Exchange Group as of 31 December 2025. However, not all listed firms met the criteria required for inclusion in the study. To ensure consistency and availability of data, firms were included only if they satisfied the following conditions: continuous listing throughout the study period, availability of complete audited annual reports and sustainability disclosures, and consistency in financial reporting during the period under investigation. Firms with incomplete financial statements, recent listings, mergers, acquisitions, prolonged trading suspension, or missing sustainability disclosures were excluded.

Based on these criteria, fifteen (15) listed manufacturing firms constituted the final study population. These firms have consistently published annual reports containing financial statements and varying levels of environmental and sustainability disclosures, making them suitable for evaluating the relationship between green accounting practices and Sustainable Development Goal achievement.

Table 1. Selected Listed Manufacturing Firms Used for the Study

S/N	Company	Sector
1	Dangote Cement Plc	Industrial Goods
2	BUA Cement Plc	Industrial Goods
3	Lafarge Africa Plc	Industrial Goods
4	Dangote Sugar Refinery Plc	Consumer Goods
5	Nigerian Breweries Plc	Consumer Goods
6	Guinness Nigeria Plc	Consumer Goods
7	Nestlé Nigeria Plc	Consumer Goods
8	Unilever Nigeria Plc	Consumer Goods
9	Cadbury Nigeria Plc	Consumer Goods
10	Flour Mills of Nigeria Plc	Consumer Goods
11	Honeywell Flour Mills Plc	Consumer Goods
12	PZ Cussons Nigeria Plc	Consumer Goods
13	Presco Plc	Agriculture
14	Okomu Oil Palm Plc	Agriculture
15	May & Baker Nigeria Plc	Healthcare

Source: Nigerian Exchange Group (2025); Compiled by the Researcher (2026).

The study employed a census sampling technique because all firms that satisfied the selection criteria were included in the analysis. The census approach eliminates sampling bias and enhances the representativeness of the findings by ensuring that every eligible manufacturing firm forms part of the investigation. Given the relatively manageable number of firms with complete environmental disclosure information, there was no statistical advantage in selecting only a subset of the population. Furthermore, the use of a census approach increases the robustness of panel data estimation by maximizing the number of firm-year observations available for empirical analysis.

Secondary data constituted the primary source of information for the study. The data were extracted from audited annual reports, sustainability reports, integrated reports, environmental reports, corporate governance reports, and financial statements published by the selected firms between 2020 and 2025. Additional information relating to Sustainable Development Goal disclosures was obtained from the official websites of the respective companies where sustainability reports were separately published. The study also consulted publications of the Nigerian Exchange Group, the Financial Reporting

Council of Nigeria, and other relevant regulatory agencies to validate disclosure practices and ensure consistency in data collection.

Data collection followed a systematic content analysis procedure. Annual reports for each firm covering the six-year period from 2020 to 2025 were downloaded directly from the official corporate websites to ensure authenticity and completeness. Each report was carefully reviewed to identify environmental accounting disclosures, environmental expenditure, waste management initiatives, pollution prevention activities, carbon emission reduction programmes, energy conservation initiatives, environmental restoration activities, recycling programmes, renewable energy investments, and sustainability initiatives aligned with the United Nations Sustainable Development Goals.

A structured data extraction template was developed to ensure uniformity throughout the coding process. The template captured financial information, environmental accounting indicators, sustainability disclosures, and control variables for each company-year observation. Environmental disclosure items were coded using predefined measurement criteria derived from internationally recognized sustainability reporting frameworks, including the Global Reporting Initiative (GRI Standards), the International Sustainability Standards Board (ISSB), and the United Nations Sustainable Development Goals disclosure recommendations. Financial variables were cross-checked with audited financial statements to minimize transcription errors, while sustainability disclosures were independently verified across multiple sections of each annual report before final coding.

To improve data reliability, each annual report was reviewed more than once during the coding process. Where disclosure information appeared under different report sections, such as the sustainability report, directors' report, corporate social responsibility report, environmental report, or notes to the financial statements, all relevant information was reconciled before assigning the final disclosure score. This multiple-review procedure minimized measurement errors and improved consistency in the construction of the study variables.

The variables employed in this study were operationalized using standardized measures adapted from contemporary environmental accounting and sustainability literature. The dependent variable was Sustainable Development Goal (SDG) achievement, while the independent variable was green accounting practices. To minimize omitted variable bias and improve the robustness of the empirical estimates, firm size, leverage, and firm age were incorporated as control variables because prior studies have shown that organizational characteristics influence the level of sustainability disclosure and environmental performance. The operational definitions and measurement procedures adopted for each variable are presented in Table 2.

Table 2. Operationalization and Measurement of Variables

Variable	Proxy	Measurement	Expected Sign	Source/Adapted From
Sustainable Development Goal Achievement (Dependent Variable)	SDGA	Sustainable Development Goal Achievement Index computed as the ratio of disclosed SDG-related indicators to the total applicable SDG indicators for manufacturing firms	Dependent	Adapted from GRI Standards, ISSB Sustainability Disclosure Framework, and recent sustainability accounting literature

Variable	Proxy	Measurement	Expected Sign	Source/Adapted From
Green Accounting Practices	GAP	Composite Green Accounting Practice Index derived from environmental cost reporting, environmental investment, waste management expenditure, pollution prevention initiatives, recycling activities, carbon emission reduction programmes, energy efficiency disclosures, and environmental restoration activities	Positive (+)	Adapted from recent environmental accounting studies (2020–2026)
Firm Size	FSIZE	Natural logarithm of total assets	Positive (+)	Accounting literature
Leverage	LEV	Total liabilities divided by total assets	±	Accounting literature
Firm Age	FAGE	Number of years since incorporation	Positive (+)	Corporate governance literature

Source: Researcher's Compilation (2026).

The dependent variable, Sustainable Development Goal Achievement (SDGA), was measured using a disclosure index approach. The index was developed through content analysis of annual reports and sustainability reports of the selected firms. The disclosure checklist consisted of SDG indicators considered directly relevant to manufacturing companies, particularly those associated with responsible production, environmental conservation, energy efficiency, climate action, waste management, employee welfare, innovation, and sustainable industrialization. Each disclosure item was assigned a score of one (1) where adequate evidence of implementation or disclosure existed and zero (0) otherwise. The total score obtained by each firm was divided by the maximum obtainable score to generate an SDG Achievement Index ranging from 0 to 1. A higher index value indicated greater corporate commitment toward achieving the Sustainable Development Goals.

Green accounting practices, which constitute the explanatory variable, were equally measured using an index approach because no universally accepted monetary measure adequately captures the multidimensional nature of environmental accounting activities. A Green Accounting Practice Index (GAPI) was therefore constructed through systematic content analysis of environmental disclosures contained in annual reports and sustainability reports. The index incorporated environmental expenditure reporting, pollution prevention initiatives, waste recycling programmes, environmental restoration activities, carbon emission reduction strategies, renewable energy investments, environmental compliance disclosures, resource conservation programmes, environmental training, and ecological risk management practices. Similar to the SDG index, each disclosed practice received a score of one (1), while non-disclosure attracted

zero (0). The aggregate score was divided by the maximum possible score to produce a standardized index between 0 and 1.

The selection of an index-based measurement approach is appropriate because green accounting extends beyond the mere recognition of environmental costs to include broader environmental management initiatives that cannot always be expressed in monetary terms. Consequently, disclosure indices have become one of the most widely accepted approaches for measuring environmental accounting practices within sustainability accounting research.

Firm size was included as a control variable because larger firms generally possess greater financial capacity, stronger corporate governance structures, and increased stakeholder pressure to adopt sustainability initiatives. It was measured as the natural logarithm of total assets reported in each firm's audited financial statements. Logarithmic transformation was adopted to reduce data skewness and improve normality.

Leverage was measured as the ratio of total liabilities to total assets. Highly leveraged firms often experience greater pressure from creditors and investors to maintain transparency and demonstrate sound environmental governance. However, excessive debt obligations may equally reduce management's willingness to invest in environmental initiatives due to financial constraints. Consequently, the expected relationship between leverage and SDG achievement remains indeterminate.

Firm age was measured as the number of years from the firm's incorporation to the end of each financial reporting year. Older firms are generally expected to possess greater organizational experience, stronger institutional legitimacy, and more established sustainability practices than younger organizations.

The study utilized panel data because observations were obtained across multiple firms over several accounting periods. Specifically, annual data covering six financial years were collected for fifteen listed manufacturing firms, resulting in a balanced panel consisting of ninety (90) firm-year observations. Panel data analysis offers several advantages over purely cross-sectional or time-series analyses. It controls for unobservable firm-specific heterogeneity, increases the number of observations available for estimation, improves the efficiency of parameter estimates, reduces multicollinearity among explanatory variables, and enhances the reliability of statistical inference. Furthermore, panel data enable researchers to capture both temporal changes and cross-sectional differences among firms, making them particularly suitable for studies involving corporate sustainability practices.

To examine the relationship between green accounting practices and Sustainable Development Goal achievement, the study specified the following econometric model:

$$SDGA_{it} = \beta_0 + \beta_1 GAP_{it} + \beta_2 FSIZE_{it} + \beta_3 LEV_{it} + \beta_4 FAGE_{it} + \mu_i + \epsilon_{it}$$

Where:

- a. $SDGA_{it}$ = Sustainable Development Goal Achievement Index of firm i in year t
- b. GAP_{it} = Green Accounting Practice Index
- c. $FSIZE_{it}$ = Firm Size
- d. LEV_{it} = Leverage
- e. $FAGE_{it}$ = Firm Age
- f. β_0 = Constant term
- g. $\beta_1 - \beta_4$ = Regression coefficients
- h. μ_i = Unobserved firm-specific effect
- i. ϵ_{it} = Error term
- j. $i = 1, 2, \dots, 15$
- k. $t = 2020, \dots, 2025$

The model assumes that Sustainable Development Goal achievement is a function of green accounting practices while controlling for firm-specific characteristics. A positive and statistically significant coefficient for green accounting practices would indicate that

improvements in environmental accounting and disclosure contribute meaningfully to enhanced SDG achievement among listed manufacturing firms in Nigeria.

Recognizing that panel data can be estimated using different techniques, the study estimated the pooled Ordinary Least Squares (OLS), Fixed Effects (FE), and Random Effects (RE) models. The pooled OLS model served as the baseline estimation, while the Fixed Effects model controlled for time-invariant firm-specific characteristics that could influence sustainability performance. The Random Effects model assumed that individual firm effects were randomly distributed and uncorrelated with the explanatory variables. The most appropriate estimation technique was selected based on the outcome of the Hausman Specification Test, which compares the consistency and efficiency of the Fixed Effects and Random Effects estimators. Where the Hausman test yielded a statistically significant result ($p < 0.05$), the Fixed Effects model was preferred; otherwise, the Random Effects estimator was considered appropriate. This estimation strategy enhances the robustness and validity of the empirical findings.

The data obtained from the selected firms were subjected to rigorous statistical analysis to ensure that the estimated relationship between green accounting practices and Sustainable Development Goal achievement was valid, reliable, and free from violations of the assumptions underlying panel regression analysis. The analytical procedure commenced with descriptive statistics, followed by correlation analysis, diagnostic tests, panel regression estimation, and post-estimation tests. This sequential approach enabled a comprehensive examination of the characteristics of the variables and ensured that the selected econometric model produced efficient and unbiased estimates.

Descriptive statistics were first employed to summarize the distributional characteristics of the study variables. Measures including the mean, median, maximum value, minimum value, standard deviation, skewness, and kurtosis were computed for all variables. The mean provided information regarding the average level of each variable across the study period, while the standard deviation measured the degree of variability among firms. The minimum and maximum values indicated the range of observations, whereas skewness and kurtosis were used to evaluate the normality of the data distribution. These statistics also assisted in identifying potential outliers and understanding the overall characteristics of the panel dataset before inferential analysis.

Following the descriptive analysis, Pearson Product Moment Correlation analysis was conducted to examine the direction and strength of the linear association among the variables. The correlation matrix provided preliminary evidence of the relationship between green accounting practices and Sustainable Development Goal achievement while also indicating the extent of association among the explanatory variables. Although correlation analysis does not establish causality, it serves as an important diagnostic tool for identifying possible multicollinearity problems before regression estimation.

To ensure the reliability of the regression results, several diagnostic tests were performed. Multicollinearity among the explanatory variables was examined using the Variance Inflation Factor (VIF). Multicollinearity exists when independent variables exhibit high linear relationships, resulting in unstable coefficient estimates and inflated standard errors. A VIF value below 10 and a tolerance value greater than 0.10 were considered evidence that multicollinearity was not a significant concern in the study. These benchmark values are widely accepted in accounting and econometric literature for assessing the independence of explanatory variables.

The presence of heteroskedasticity was examined using the Modified Wald Test for Groupwise Heteroskedasticity following the estimation of the Fixed Effects model. Heteroskedasticity occurs when the variance of the error terms differs across observations, thereby violating one of the classical assumptions of regression analysis and potentially producing inefficient estimates. Where heteroskedasticity was detected, robust standard errors were employed to correct the problem and ensure that the estimated coefficients remained statistically reliable.

Autocorrelation was assessed using the Wooldridge Test for Serial Correlation in panel data. Serial correlation arises when error terms are correlated across time for the same cross-sectional unit, leading to biased standard errors and misleading hypothesis tests. A non-significant Wooldridge test statistic indicated the absence of first-order autocorrelation, while a significant result necessitated the application of robust estimation procedures capable of correcting serial dependence.

Considering that the dataset consisted of multiple firms operating within the same economic environment, the study further tested for cross-sectional dependence using Pesaran's Cross-sectional Dependence (CD) Test. Cross-sectional dependence may occur because firms respond similarly to macroeconomic conditions, regulatory changes, inflationary pressures, exchange rate fluctuations, or environmental policy reforms. Ignoring cross-sectional dependence can produce inconsistent parameter estimates and misleading statistical inference. Where evidence of cross-sectional dependence existed, robust covariance estimators were employed to improve the efficiency of the regression estimates.

Although the study utilized disclosure indices bounded between zero and one, normality of the residuals was also examined using the Jarque–Bera test alongside graphical assessment of residual distributions. The purpose was not necessarily to satisfy strict normality assumptions but to identify extreme departures that could affect statistical inference. The relatively large number of panel observations further reduced the sensitivity of regression estimates to moderate deviations from normality due to the Central Limit Theorem.

Because panel datasets may exhibit non-stationary characteristics over time, the study conducted panel unit root tests using the Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) procedures where necessary. These tests examined whether the variables possessed constant statistical properties throughout the study period. Variables found to be stationary at level were retained in their original form, while non-stationary variables would ordinarily require transformation before estimation. However, since the variables consisted primarily of disclosure indices and financial ratios measured over a relatively short six-year period, the likelihood of serious non-stationarity was expected to be minimal.

Model selection constituted another important stage of the analysis. Initially, the pooled Ordinary Least Squares regression model was estimated to provide baseline results. Thereafter, the Fixed Effects and Random Effects models were estimated to account for firm-specific heterogeneity. The Breusch–Pagan Lagrange Multiplier Test was first employed to determine whether panel estimation was preferable to pooled Ordinary Least Squares regression. Subsequently, the Hausman Specification Test was conducted to determine whether the Fixed Effects or Random Effects estimator was more appropriate for the study. A statistically significant Hausman test statistic ($p < 0.05$) implied that the Fixed Effects model provided consistent estimates and was therefore selected for hypothesis testing. Conversely, where the Hausman statistic was insignificant, the Random Effects estimator was considered more efficient.

The hypotheses formulated for the study were tested using panel regression analysis at the 5 percent level of significance. Statistical significance was determined based on the probability values associated with the estimated regression coefficients. The decision rule adopted was that the null hypothesis would be rejected whenever the probability value (p -value) was less than or equal to 0.05, indicating a statistically significant relationship between the explanatory variable and Sustainable Development Goal achievement. Conversely, where the probability value exceeded 0.05, the null hypothesis would not be rejected, implying insufficient statistical evidence to establish a significant relationship.

The overall explanatory power of the regression model was evaluated using the coefficient of determination (R^2) and the adjusted coefficient of determination (Adjusted R^2). While the R^2 statistic measured the proportion of variations in Sustainable

Development Goal achievement explained collectively by the explanatory variables, the Adjusted R² accounted for the number of predictors included in the model and therefore provided a more reliable measure of model fitness. The statistical significance of the overall regression model was assessed using the F-statistic for the Fixed Effects model or the Wald Chi-square statistic for the Random Effects model, depending on the estimator selected after the Hausman test.

All statistical analyses were performed using STATA Version 18, which is widely recognized for handling panel data estimation, advanced econometric modelling, and diagnostic testing in accounting, finance, and sustainability research. STATA provides efficient procedures for estimating pooled Ordinary Least Squares, Fixed Effects, Random Effects, robust regression models, diagnostic tests, and post-estimation analyses, thereby ensuring the reliability and reproducibility of empirical findings.

To enhance the validity and reliability of the content analysis procedure, a standardized disclosure checklist was developed based on internationally accepted sustainability reporting frameworks, including the Global Reporting Initiative, the International Sustainability Standards Board (ISSB) Standards (IFRS S1 and IFRS S2), and the United Nations Sustainable Development Goals Reporting Framework. These globally recognized frameworks provided objective criteria for identifying and coding environmental accounting disclosures and SDG-related activities, thereby minimizing researcher subjectivity. Furthermore, the coding process was undertaken systematically using uniform coding guidelines across all sampled firms and reporting years. The extracted data were reviewed repeatedly to verify accuracy, completeness, and consistency before statistical analysis.

The methodological approach adopted in this study provides a rigorous framework for examining the relationship between green accounting practices and Sustainable Development Goal achievement among listed manufacturing firms in Nigeria. By combining systematic content analysis with balanced panel data techniques, robust diagnostic testing, and appropriate econometric estimation procedures, the study ensures that its findings are empirically reliable, reproducible, and capable of contributing meaningful evidence to the growing literature on environmental accounting and corporate sustainability.

3. Results

The empirical results are presented in this section. The analysis begins with descriptive statistics to examine the distributional characteristics of the variables, followed by correlation analysis, multi-collinearity diagnostics, panel diagnostic tests, model selection tests, and panel regression estimates. The results are presented objectively without interpretation beyond what the statistics indicate.

Descriptive Statistics

Table 3. Presents the descriptive statistics of the study variables for the 90 firm-year observations obtained from fifteen listed manufacturing firms over the period 2020–2025.

Table 3. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Minimum	Maximum
SDGA	90	0.621	0.148	0.290	0.910
GAP	90	0.574	0.131	0.240	0.860
FSIZE	90	18.964	1.247	16.302	21.581
LEV	90	0.437	0.168	0.081	0.782
FAGE	90	47.422	18.635	10.000	99.000

Source: Researcher's Computation using STATA 18 (2026).

The descriptive statistics indicate that Sustainable Development Goal Achievement (SDGA) recorded an average value of 0.621, suggesting that the sampled manufacturing firms disclosed approximately 62.1% of the SDG-related indicators assessed during the

study period. The minimum value of 0.290 and maximum value of 0.910 indicate considerable variation in sustainability performance across firms.

Green Accounting Practices (GAP) had a mean value of 0.574, implying a moderate level of environmental accounting adoption among the selected firms. The relatively small standard deviation of 0.131 suggests moderate dispersion in environmental accounting practices.

Firm Size (FSIZE) exhibited an average logarithmic asset value of 18.964, reflecting differences in organizational scale among the sampled firms. Leverage averaged 43.7%, indicating that debt financing constituted a substantial proportion of firms' capital structures. Firm Age averaged approximately 47 years, suggesting that most sampled companies were well-established manufacturing organizations.

Overall, the descriptive statistics demonstrate adequate variability among the variables, thereby supporting further econometric analysis [9].

Correlation Analysis

To examine the degree of association among the variables and identify possible multicollinearity problems, Pearson Product Moment Correlation coefficients were computed.

Table 4. Pearson Correlation Matrix

Variable	SDGA	GAP	FSIZE	LEV	FAGE
SDGA	1.000				
GAP	0.691	1.000			
FSIZE	0.447	0.381	1.000		
LEV	-0.236	-0.182	-0.294	1.000	
FAGE	0.301	0.275	0.492	-0.214	1.000

Source: Researcher's Computation using STATA 18 (2026).

The correlation matrix reveals a strong positive relationship ($r = 0.691$) between Green Accounting Practices and Sustainable Development Goal Achievement. Firm Size and Firm Age also show positive associations with SDGA, whereas Leverage exhibits a weak negative relationship. Importantly, none of the independent variables records a correlation coefficient exceeding 0.80, providing preliminary evidence that severe multicollinearity is unlikely [10].

Multicollinearity Test

Variance Inflation Factor (VIF) analysis was conducted to further assess multicollinearity among the explanatory variables.

Table 5. Variance Inflation Factor (VIF)

Variable	VIF	Tolerance
FSIZE	2.18	0.459
GAP	1.94	0.516
FAGE	1.71	0.585
LEV	1.38	0.724
Mean VIF	1.80	

Source: Researcher's Computation using STATA 18 (2026).

The highest VIF value is 2.18, while the mean VIF equals 1.80, both substantially below the critical threshold of 10. These results confirm that multicollinearity is not a concern in the estimated regression model.

Panel Diagnostic Tests and Model Selection

Before estimating the panel regression model, several diagnostic tests were conducted to determine the suitability of the data for panel estimation and to identify the most appropriate estimation technique. Specifically, the Breusch–Pagan Lagrange Multiplier (LM) Test, Wooldridge Test for Autocorrelation, Modified Wald Test for Groupwise

Heteroskedasticity, Pesaran Cross-sectional Dependence Test, and Hausman Specification Test were performed. The results are presented below [11].

Breusch–Pagan Lagrange Multiplier Test

The Breusch–Pagan Lagrange Multiplier (LM) Test was conducted to determine whether panel estimation was more appropriate than pooled Ordinary Least Squares (OLS) regression.

Table 6. Breusch–Pagan Lagrange Multiplier Test

Test	Chi-square	Probability
Breusch–Pagan LM Test	42.81	0.0000

Source: Researcher's Computation using STATA 18 (2026).

The probability value of 0.0000 is less than the 5 percent level of significance, indicating that the null hypothesis of no panel effects is rejected. This suggests that panel estimation is more appropriate than pooled Ordinary Least Squares regression [12].

Wooldridge Test for Serial Correlation

The Wooldridge Test was employed to determine whether first-order autocorrelation existed in the panel dataset.

Table 7. Wooldridge Test for Autocorrelation

Test Statistic	Value
F-statistic	1.82
Probability	0.1824

Source: Researcher's Computation using STATA 18 (2026).

The probability value of 0.1824 exceeds the 5 percent significance level, indicating that the null hypothesis of no first-order serial correlation cannot be rejected. Therefore, the dataset does not suffer from autocorrelation.

Modified Wald Test for Groupwise Heteroskedasticity

The Modified Wald Test was conducted to examine whether the error variances were constant across firms.

Table 8. Modified Wald Test

Test Statistic	Value
Chi-square	36.57
Probability	0.0012

Source: Researcher's Computation using STATA 18 (2026).

The significant probability value ($p = 0.0012$) indicates the presence of heteroskedasticity across firms. Consequently, robust standard errors were employed in the regression estimation to produce efficient and unbiased statistical inferences [13].

Pesaran Cross-sectional Dependence Test

Since the sampled firms operate within the same macroeconomic environment, the Pesaran Cross-sectional Dependence Test was performed.

Table 9. Pesaran Cross-sectional Dependence Test

Test Statistic	Value
CD Statistic	1.26
Probability	0.2070

Source: Researcher's Computation using STATA 18 (2026).

The probability value of 0.2070 indicates that cross-sectional dependence is not statistically significant. Therefore, the assumption of cross-sectional independence is satisfied.

Hausman Specification Test

The Hausman Specification Test was conducted to determine whether the Fixed Effects or Random Effects estimator was more appropriate for the study [14].

Table 10. Hausman Specification Test

Test Statistic	Value
Chi-square	14.73
Probability	0.0053

Source: Researcher's Computation using STATA 18 (2026).

The Hausman test produced a Chi-square value of 14.73 with a probability value of 0.0053, which is statistically significant at the 5 percent level. Accordingly, the null hypothesis that the Random Effects estimator is appropriate is rejected. This indicates that the Fixed Effects model provides more consistent and efficient parameter estimates and was therefore adopted for hypothesis testing.

Comparison of Alternative Panel Regression Models

To further demonstrate the appropriateness of the selected estimator, the pooled OLS, Random Effects, and Fixed Effects models were estimated and compared.

Table 11. Comparison of Alternative Estimation Models

Model	R ²	F/Wald Statistic	Probability
Pooled OLS	0.482	18.44	0.0000
Random Effects	0.638	39.61	0.0000
Fixed Effects	0.721	47.82	0.0000

Source: Researcher's Computation using STATA 18 (2026).

The Fixed Effects model explains approximately 72.1% of the variation in Sustainable Development Goal Achievement, compared with 63.8% for the Random Effects model and 48.2% for the pooled OLS model. Coupled with the statistically significant Hausman test result, these findings justify the adoption of the Fixed Effects estimator for the main regression analysis [15].

Summary of Diagnostic Tests

Table 12. Summary of Diagnostic Tests

Diagnostic Test	Decision Criterion	Result	Conclusion
Correlation Matrix	$r < 0.80$	Highest = 0.691	No serious correlation problem
VIF Test	$VIF < 10$	Mean = 1.80	No multicollinearity
Breusch–Pagan LM	$p < 0.05$	0.0000	Panel estimation preferred
Wooldridge Test	$p > 0.05$	0.1824	No autocorrelation
Modified Wald Test	$p < 0.05$	0.0012	Heteroskedasticity detected
Pesaran CD Test	$p > 0.05$	0.2070	No cross-sectional dependence
Hausman Test	$p < 0.05$	0.0053	Fixed Effects selected

Source: Researcher's Computation using STATA 18 (2026).

The diagnostic tests confirm that the explanatory variables are free from multicollinearity and that panel estimation is appropriate. Although heteroskedasticity is present, its effect is mitigated through the use of robust standard errors in the Fixed Effects regression model. Consequently, the Fixed Effects estimator provides reliable and consistent estimates for examining the relationship between green accounting practices

and Sustainable Development Goal achievement among listed manufacturing firms in Nigeria [16].

Regression Analysis and Hypotheses Testing

Following the diagnostic tests and the outcome of the Hausman Specification Test, the Fixed Effects regression model with robust standard errors was adopted to examine the relationship between green accounting practices and Sustainable Development Goal achievement among listed manufacturing firms in Nigeria. The regression estimates are presented in Table 13.

Table 13. Fixed Effects Regression Results (Robust Standard Errors)
Dependent Variable: Sustainable Development Goal Achievement (SDGA)

Variable	Coefficient	Robust Std. Error	t-value	Probability
Constant	0.184	0.092	2.00	0.049
Green Accounting Practices (GAP)	0.612	0.086	7.12	0.000
Firm Size (FSIZE)	0.041	0.017	2.41	0.018
Leverage (LEV)	-0.097	0.048	-2.02	0.046
Firm Age (FAGE)	0.002	0.001	2.27	0.026

Model Summary

Statistic	Value
Number of Observations	90
Number of Firms	15
Number of Years	6
R-squared (Within)	0.721
Adjusted R-squared	0.703
F-statistic	47.82
Prob > F	0.0000

Source: Researcher's Computation using STATA 18 (2026).

Interpretation of Regression Results

The regression results indicate that Green Accounting Practices (GAP) exert a positive and statistically significant influence on Sustainable Development Goal Achievement among listed manufacturing firms in Nigeria. The estimated coefficient of 0.612 implies that a one-unit increase in the Green Accounting Practice Index is associated with an average increase of approximately 61.2% in the Sustainable Development Goal Achievement Index, holding other variables constant [17]. The corresponding t-statistic of 7.12 and probability value of 0.000 indicate that the relationship is statistically significant at the 1 percent level. This finding suggests that manufacturing firms that strengthen environmental accounting practices—including environmental cost recognition, pollution control reporting, waste management initiatives, carbon reduction programmes, environmental investments, and sustainability disclosures—are more likely to improve their contribution toward the achievement of the Sustainable Development Goals.

Firm Size (FSIZE) records a positive coefficient of 0.041, which is statistically significant at the 5 percent level ($p = 0.018$). This result indicates that larger manufacturing firms tend to demonstrate higher levels of SDG achievement than smaller firms. The finding may be attributed to the greater financial resources, stronger governance structures, and increased stakeholder expectations associated with larger organizations, enabling them to invest more substantially in environmental sustainability initiatives and sustainability reporting.

Leverage (LEV) exhibits a negative coefficient of -0.097 , which is statistically significant ($p = 0.046$). This suggests that firms with higher debt obligations may experience constraints in allocating financial resources toward environmental initiatives

and sustainability programmes. Consequently, increased leverage may reduce a firm's ability to contribute effectively to Sustainable Development Goal achievement [18].

Firm Age (FAGE) also demonstrates a positive and statistically significant relationship with Sustainable Development Goal Achievement. The estimated coefficient of 0.002 indicates that older firms tend to achieve higher sustainability performance than relatively younger organizations. This finding may reflect accumulated organizational experience, stronger institutional legitimacy, greater familiarity with environmental regulations, and more established sustainability management systems.

The coefficient of determination (Within R^2) of 0.721 indicates that approximately 72.1% of the variation in Sustainable Development Goal Achievement is jointly explained by Green Accounting Practices, Firm Size, Leverage, and Firm Age. The remaining 27.9% is attributable to other factors not included in the regression model. Furthermore, the F-statistic of 47.82, with a corresponding probability value of 0.0000, confirms that the overall regression model is statistically significant and possesses strong explanatory power.

The study tested the null hypothesis at the 5 percent level of significance using the Fixed Effects regression estimates.

Table 14. Summary of Hypothesis Testing

Hypothesis	Decision Rule	Decision
H ₀ : Green accounting practices have no significant relationship with Sustainable Development Goal achievement of listed manufacturing firms in Nigeria.	Reject H ₀ if p-value $\leq$ 0.05	Rejected

Source: Researcher's Computation (2026).

The probability value associated with Green Accounting Practices is 0.000, which is less than the 0.05 significance level. Accordingly, the null hypothesis is rejected, and the alternative hypothesis is accepted. The study therefore concludes that green accounting practices have a positive and statistically significant relationship with Sustainable Development Goal achievement among listed manufacturing firms in Nigeria [19].

Summary of Regression Findings

The regression analysis demonstrates that Green Accounting Practices are a significant predictor of Sustainable Development Goal Achievement among listed manufacturing firms in Nigeria. The positive and highly significant coefficient indicates that firms that invest in environmental accounting systems, recognize environmental costs, strengthen environmental disclosure practices, and implement sustainability-oriented operational strategies are better positioned to contribute to national and global Sustainable Development Goals.

Among the control variables, Firm Size and Firm Age positively influence Sustainable Development Goal Achievement, while Leverage exerts a negative effect. Overall, the model explains more than seventy percent of the variation in Sustainable Development Goal Achievement, indicating that Green Accounting Practices constitute an important determinant of corporate sustainability performance within the Nigerian manufacturing sector.

4. Discussion

The findings of this study provide empirical evidence that green accounting practices are a significant determinant of Sustainable Development Goal (SDG) achievement among listed manufacturing firms in Nigeria. The Fixed Effects regression results reveal that green accounting practices have a positive and statistically significant relationship with SDG achievement, suggesting that firms that integrate environmental accounting into their operational and reporting systems are more likely to contribute meaningfully to sustainable development. This finding underscores the increasing importance of environmental accountability in promoting responsible industrial production, efficient resource utilization, environmental protection, and long-term corporate sustainability.

The positive relationship between green accounting practices and Sustainable Development Goal achievement implies that manufacturing firms adopting comprehensive environmental accounting systems are better positioned to align their operations with global sustainability objectives. Through the recognition and reporting of environmental costs, investments in pollution control technologies, waste management programmes, energy conservation initiatives, carbon emission reduction strategies, and environmental restoration activities, firms demonstrate stronger commitment to sustainable business practices. Such commitment enhances compliance with environmental regulations while simultaneously supporting the realization of Sustainable Development Goals such as Responsible Consumption and Production (SDG 12), Climate Action (SDG 13), Affordable and Clean Energy (SDG 7), Industry, Innovation and Infrastructure (SDG 9), and Clean Water and Sanitation (SDG 6). The result suggests that environmental accounting is no longer merely a reporting mechanism but has evolved into a strategic management tool that facilitates sustainable corporate decision-making [20].

The finding is consistent with the stakeholder theory, which argues that organizations are accountable not only to shareholders but also to employees, customers, governments, local communities, environmental advocacy groups, and future generations. Green accounting practices improve transparency regarding environmental performance and enable organizations to communicate their sustainability commitments to diverse stakeholder groups. Consequently, firms that maintain comprehensive environmental accounting systems are likely to enjoy greater stakeholder confidence, improved corporate legitimacy, stronger investor trust, and enhanced social acceptance, all of which contribute to improved Sustainable Development Goal achievement.

The empirical result also supports the legitimacy theory, which posits that organizations continually seek to ensure that their operations conform to societal expectations and prevailing environmental norms. Manufacturing firms operating in environmentally sensitive industries often experience increased public scrutiny due to the environmental consequences of their production activities. By adopting green accounting practices and disclosing environmental information transparently, firms strengthen their legitimacy and demonstrate that their operations are consistent with societal expectations regarding environmental responsibility and sustainable development. This reinforces the argument that environmental accounting has become an important mechanism through which organizations maintain their social licence to operate.

The positive influence of green accounting practices observed in this study is consistent with the findings of Adeosun et al. , who reported that environmental accounting disclosures significantly improved corporate sustainability performance by enhancing environmental transparency and supporting responsible resource management. Similarly, Odewumi et al. found that firms implementing comprehensive environmental accounting practices recorded superior sustainability outcomes due to increased investments in environmental protection and stronger environmental governance. The present study also aligns with Samuel and Akinyosoye , who concluded that environmental accounting encourages responsible production practices and strengthens corporate contributions toward national sustainable development objectives. Collectively, these studies reinforce the argument that environmental accounting serves as a catalyst for sustainable corporate performance within emerging economies.

Furthermore, the findings corroborate those of Yinus and Alagbe , who observed that manufacturing firms with well-developed environmental accounting systems demonstrated greater commitment to sustainability reporting and improved environmental performance. The authors argued that green accounting facilitates informed managerial decision-making by providing accurate information regarding environmental costs, environmental liabilities, and ecological investments. Such information enables management to identify inefficiencies, minimize environmental risks, improve operational efficiency, and support strategic sustainability planning. The consistency between the present findings and previous empirical evidence strengthens

confidence in the robustness of the observed relationship between green accounting practices and Sustainable Development Goal achievement.

The study further reveals that firm size exerts a positive and statistically significant influence on Sustainable Development Goal achievement. This finding suggests that larger manufacturing firms contribute more substantially to sustainable development than smaller firms. Large organizations generally possess greater financial resources, stronger corporate governance structures, more advanced environmental management systems, and increased access to sustainability-related technologies. In addition, larger firms often experience greater pressure from regulators, institutional investors, consumers, and international business partners to demonstrate responsible environmental behaviour. Consequently, they are more likely to adopt sophisticated environmental accounting systems and sustainability reporting practices that support Sustainable Development Goal achievement. This finding is consistent with recent studies indicating that organizational size positively influences environmental disclosure and sustainability performance.

Leverage was found to have a negative and statistically significant relationship with Sustainable Development Goal achievement. This result suggests that firms with higher debt obligations may allocate a greater proportion of financial resources toward servicing liabilities, thereby reducing their capacity to invest in environmental protection programmes, green technologies, and sustainability initiatives. Highly leveraged firms may also prioritize short-term financial performance over long-term environmental investments due to pressure from creditors and financial markets. This finding supports previous empirical evidence that financial constraints often discourage corporate investment in environmental sustainability programmes, particularly within developing economies where access to affordable green financing remains limited.

Firm age also exhibited a positive and statistically significant relationship with Sustainable Development Goal achievement. Older manufacturing firms generally possess more established governance systems, greater institutional experience, stronger stakeholder relationships, and accumulated knowledge regarding environmental compliance and sustainability management. Their long-standing operational experience may facilitate the integration of environmental accounting into corporate planning and reporting systems, thereby improving sustainability performance. Older firms are also more likely to have developed structured sustainability policies and internal control mechanisms that support continuous environmental improvement and long-term Sustainable Development Goal achievement.

Overall, the findings demonstrate that green accounting practices constitute an important strategic mechanism through which listed manufacturing firms in Nigeria can strengthen their contribution to sustainable development. The results indicate that environmental accounting extends beyond compliance with environmental regulations by providing organizations with valuable information for strategic planning, resource allocation, environmental risk management, and sustainability reporting. Consequently, firms that integrate green accounting into their management processes are more likely to improve environmental stewardship, enhance stakeholder confidence, strengthen corporate reputation, and contribute effectively to the achievement of the Sustainable Development Goals.

The findings also address an important gap in the existing literature. While many previous Nigerian studies have focused primarily on the relationship between environmental accounting and financial performance indicators such as return on assets, profitability, firm value, or market performance, the present study extends the literature by examining Sustainable Development Goal achievement as the principal outcome variable. This broader perspective reflects the evolving global emphasis on measuring corporate success not only through financial outcomes but also through environmental and social contributions. Accordingly, the study contributes to the growing body of environmental accounting and sustainability literature by providing evidence that green accounting practices are instrumental in advancing Sustainable Development Goal achievement within Nigeria's manufacturing sector.

5. Conclusion

This study examined the relationship between green accounting practices and Sustainable Development Goal (SDG) achievement among fifteen listed manufacturing firms in Nigeria using panel data for 2020–2025. The findings show that green accounting practices have a positive and statistically significant relationship with SDG achievement, while firm size and firm age also contribute positively, whereas leverage has a significant negative effect. These results suggest that integrating environmental costs, pollution prevention, waste management, sustainable production, and environmental disclosures into corporate accounting systems can strengthen environmental accountability and support sustainable industrial development. The study therefore highlights the need for manufacturing firms to institutionalize comprehensive sustainability reporting, invest in cleaner technologies and environmental management systems, and strengthen internal capacity for environmental accounting, while regulators and government should promote consistent disclosure requirements and incentives for green investment. However, the study is limited by its focus on fifteen listed manufacturing firms and the 2020–2025 observation period, which may restrict the generalizability of the findings to other sectors, firms, or longer periods. Future research should therefore extend the sample and study period, examine other sectors and African economies, and investigate how factors such as corporate governance, environmental regulation, innovation capability, and institutional quality may moderate or mediate the relationship between green accounting practices and SDG achievement.

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