African Journal of Accounting and Financial Research
ISSN: 2682-6690
Volume 8, Issue 5, 2025 (pp. 62-97)
www.abjournals.org

PANEL GRANGER CAUSALITY OF GREEN ACCOUNTING AND FINANCIAL PERFORMANCE OF LISTED COMPANIES IN SUB-SAHARAN AFRICAN COUNTRIES

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Cite this article:

Adeusi, A. S., Gbadamosi, M. R., Olofintuyi, T. A. (2025), Panel Granger Causality of Green Accounting and Financial Performance of Listed Companies in Sub-Saharan African Countries. African Journal of Accounting and Financial Research 8(5), 62-97. DOI: 10.52589/AJAFR-LH2TZF8L

Manuscript History

Received: 20 Aug 2025

Accepted: 23 Sep 2025

Published: 31 Dec 2025

ABSTRACT: *Amid growing global emphasis on environmental sustainability, responsible corporate firms target whether environmental accounting initiatives could result in resource conservation and emissions disclosure, be ecological friendly in applying compliance tools, and act as strategic drivers of financial outcomes. Hence, this study investigates Green accounting, measuring and reporting the environmental impacts of Green House Gas (GHG) emissions, energy usage, waste, and water management on financial performance of listed companies in sub-Saharan African countries. The study employs panel data regression and the Dumitrescu-Hurlin panel Granger causality to test the bidirectional and unidirectional causal relationships between proxies of green accounting and financial performance. The results reveal that GHG emissions, energy usage, and waste management have a negative and statistically insignificant impact on financial performance, while water management has a negative and statistically significant influence on returns on equity (ROE). On the other side, the result of Dumitrescu-Hurlin panel Granger causality to test the bidirectional and unidirectional causal across sectors fails due to evidence of absence of balanced panel data. These findings provide empirical support for integrating environmental performance into financial strategies and offer crucial insights for policymakers, investors, and corporate managers in advancing sustainable business practices in the region.*

KEYWORDS: Dynamic Relationship, Dumitrescu-Hurlin Panel Granger Causality, Ecological Friendly, Green Accounting.

JEL: Classification Code - Q56 · M41 · G30 · C33 · O55

Article DOI: 10.52589/AJAFR-LH2TZF8L
DOI URL: https://doi.org/10.52589/AJAFR-LH2TZF8L

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INTRODUCTION

The growing global concern over environmental degradation and climate change has intensified the call for sustainable corporate practices. Within this context, Green Accounting, which is the integration of environmental costs, benefits, and impacts into traditional financial accounting frameworks, has emerged as a critical factor as a tool for organizations seeking to align economic performance with environmental responsibility. By quantifying environmental activities in monetary terms, Green Accounting enables firms to better assess the true cost of operations, manage resources more efficiently, and report transparently to stakeholders. Its adoption reflects a shift from purely profit-driven decision-making toward a more holistic model of corporate accountability that incorporates ecological sustainability (Ahmad et al., 2025; Zik-Rullahi & Jide, 2023).

In sub-Saharan African (SSA) countries, the adoption of green accounting practices is particularly significant. The region faces acute environmental challenges, including deforestation, biodiversity loss, pollution, and the impacts of climate change on agriculture, energy, and infrastructure (Adams et al., 2025). Corporate companies are often at the forefront of industrial and commercial activities that have externality key actors in both contributing to and mitigating environmental impacts. Companies' disclosure and management of environmental information can influence investor confidence, stakeholder relations, and long-term profitability. However, the extent to which Green Accounting contributes to financial performance in SSA remains an underexplored empirical question, especially considering the diverse regulatory environments, resource constraints, and varying levels of corporate governance across the region.

How well a company does in monetary terms—which can be juxtaposed by financial performance, commonly measured through indicators such as Return on Assets (ROA), Return on Equity (ROE), Earnings per Share (EPS), and stock market valuation—remains a central concern for managers and shareholders (Lusiana, 2020). The theoretical relationship between green accounting and financial performance can be viewed through multiple lenses. On the one hand, implementing green accounting practices may increase operational costs due to environmental monitoring, reporting, and compliance requirements, potentially reducing short-term profitability. On the other hand, it can enhance efficiency, foster innovation, and improve a firm's reputation, thereby attracting investment and boosting long-term returns.

Granger causality analysis offers a valuable econometric approach to investigating the directional relationship between green accounting and financial performance. While correlation can suggest association, Granger causality helps to determine whether past values of one variable contain predictive information about another. When applied in a panel data framework which combines cross-sectional and time-series dimensions, this method allows researchers to capture both firm-level heterogeneity and temporal dynamics. This is particularly relevant for SSA listed companies, where variations in firm size, sector, governance quality, and environmental exposure can influence the relationship between sustainability practices and profitability.

Examining panel Granger causality in this context addresses two critical research gaps. First, it moves beyond static association studies to explore causation, whether green accounting practices actually drive improvements in financial performance, whether financial success enables greater investment in green accounting, or whether the relationship is bidirectional.

Article DOI: 10.52589/AJAFR-LH2TZF8L
DOI URL: https://doi.org/10.52589/AJAFR-LH2TZF8L

Second, it situates the analysis within the socio-economic realities of sub-Saharan Africa, where institutional capacity, investor awareness, and market maturity differ substantially from developed economies.

This study is not only academically significant but also practically relevant. For policymakers, it offers insights into whether environmental disclosure requirements can promote both sustainability and economic competitiveness. For corporate managers, it provides empirical evidence on the potential strategic benefits of green accounting. The study will also interest investors as it highlights the informational value of environmental reporting in evaluating firm prospects. Ultimately, understanding the causal link between green accounting and financial performance in SSA's listed companies can inform sustainable business strategies that align profitability with environmental stewardship.

Statement of the Problem

The escalating threat of climate change has placed environmental sustainability at the forefront of global policy, business strategy, and academic research. In sub-Saharan African countries, rapid economic growth, urbanization, and industrial expansion have contributed to rising environmental pressures, including greenhouse gas emissions, resource depletion, and waste generation. Green Accounting, which integrates environmental costs and benefits into traditional financial reporting, has been promoted as a tool to enhance corporate transparency, sustainability, and long-term value creation (Omisore, 2018; Zik-Rullahi & Jide, 2023). However, its adoption in sub-Saharan Africa remains uneven, with significant variation in regulatory enforcement, institutional capacity, and corporate commitment.

While proponents argue that Green Accounting can improve corporate image, attract socially responsible investors, and foster operational efficiency, skeptics suggest that the associated costs and reporting burdens may detract from short-term profitability. Financial performance, often measured by Return on Equity (ROE) remains a critical concern for shareholders and management. The causal relationship between Green Accounting practices and financial performance, however, is not well understood in the sub-Saharan African context (Omisore, 2018).

Most existing studies on the nexus between green accounting and financial performance focus on developed economies, where robust regulatory frameworks, active capital markets, and high investor awareness shape corporate behavior (Maama & Appiah, 2019). There is limited empirical evidence on whether green accounting in sub-Saharan Africa drives financial performance or whether financially strong firms are simply better positioned to implement such practices. Furthermore, the dynamic and potentially bidirectional nature of the relationship has received little attention (Endiana et al., 2025; Kiranmai & Swetha, 2018; Maama & Appiah, 2019).

The absence of rigorous, region-specific analyses using techniques such as Panel Granger causality limits policymakers' and corporate leaders' ability to design effective sustainability strategies. Without clear evidence on causality, firms risk misallocating resources or missing opportunities to align environmental stewardship with financial success.

This study examines the Panel Granger Causality relationship between green accounting practices and the financial performance of listed companies in sub-Saharan African (SSA) countries. The panel approach enables analysis over time and across countries, accounting for

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heterogeneity in economic structures, regulatory environments, and environmental policies. Financial performance is measured as Return on Equity (ROE). The time dimension will allow for assessing whether changes in Green Accounting practices lead (or lag) improvements in financial performance, while the causality test will determine the direction of influence whether environmental initiatives drive financial success or whether profitable firms are more able to invest in sustainability.

The study is relevant to policy formulators as many SSA countries are in the process of developing or strengthening environmental regulations. Understanding the causal link between Green Accounting and firm performance provides evidence for designing effective environmental policies without undermining business competitiveness. This research offers investors in SSA markets evidence on whether green accounting is merely a compliance exercise or a driver of financial returns. Corporate managers are strategists; hence, listed firms can use the findings to align sustainability reporting with profit-maximizing strategies, improving both stakeholder trust and long-term viability.

Academic Contribution: While studies on environmental accounting exist globally, there is limited empirical evidence using panel Granger causality in SSA contexts. This research addresses that gap, contributing to the literature on sustainable finance in emerging economies. By bridging environmental responsibility and financial outcomes, the study offers a nuanced understanding of how sustainability can be integrated into corporate and investment decision-making in sub-Saharan Africa.

LITERATURE REVIEW

Concept of Financial Performance

Financial performance refers to the extent to which a firm utilizes its resources to generate revenues, profits, and value for shareholders over a given period (Erasmus, 2008; Knight & Bertoneche, 2000). It serves as a key indicator of organizational health, efficiency, and competitiveness, and is often the focal point for investors, managers, and regulators. In the context of listed companies, financial performance is typically assessed through quantitative measures, such as Return on Assets (ROA), Return on Equity (ROE), Earnings per Share (EPS), and net profit margins. These metrics provide insights into profitability, operational efficiency, and the company's ability to create shareholder value.

In sub-Saharan African (SSA) markets, financial performance is influenced by unique macroeconomic and institutional factors, such as fluctuating commodity prices, exchange rate volatility, infrastructural limitations, and evolving regulatory frameworks. These factors can amplify the risks and opportunities associated with corporate strategies, including those linked to environmental responsibility and Green Accounting practices. For publicly listed companies, sustained financial performance is not only a measure of past success but also a determinant of future growth potential and access to capital. Investors increasingly consider Environmental, Social, and Governance (ESG) disclosures, including Green Accounting information, when making investment decisions. This is due to growing recognition that environmental management can affect risk profiles, operational costs, and long-term value creation.

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In a panel Granger causality context, financial performance acts as a dependent or independent variable to explore whether the adoption of green accounting practices predicts improvements in profitability, or conversely, whether stronger financial results enable firms to invest in more robust environmental strategies. Understanding this interplay is particularly relevant in SSA, where companies operate in resource-sensitive environments and where sustainable financial performance is critical for long-term economic development.

Return on Equity (ROE) as a Measure of Financial Performance

Return on Equity (ROE) is one of the most widely used indicators of a company's financial performance, capturing the efficiency with which management utilizes shareholders' equity to generate net profits. It is calculated as net income divided by total shareholders' equity, usually expressed as a percentage. A higher ROE indicates greater profitability relative to the equity invested, suggesting that the company is delivering better returns to its owners (Venanzi, 2010).

In the context of listed companies in sub-Saharan African countries, ROE provides a robust measure for comparing financial performance across firms and sectors, especially given differences in firm size and capital structures. It reflects not only operational efficiency but also strategic decisions regarding leverage, cost management, and market positioning. ROE is particularly relevant in emerging markets where capital is often scarce, and investors demand evidence that their funds are being used effectively to create value.

From the perspective of green accounting, ROE serves as a key link between environmental responsibility and shareholder wealth maximization (Ahmad et al., 2025; Lusiana, H., 2020). Firms adopting Green Accounting practices, such as integrating environmental costs, measuring carbon footprints, and disclosing sustainability initiatives, may influence ROE through both cost and revenue channels. While environmental investments can initially increase expenses, they can also lead to long-term benefits such as operational efficiency, reduced regulatory risk, enhanced brand value, and access to Green financing. These effects may, over time, strengthen ROE.

Panel Granger causality analysis allows researchers to test whether changes in Green Accounting practices precede changes in ROE, or vice versa, across multiple firms and countries. This approach is valuable for sub-Saharan African markets, where the interplay between sustainability and financial performance is shaped by diverse regulatory regimes, environmental challenges, and investor expectations.

Concept of Green Accounting

Green Accounting, also known as environmental accounting, is an emerging field that integrates environmental factors into conventional financial accounting systems. It expands the traditional scope of accounting by incorporating environmental costs and the use of natural resources into the financial statements of businesses, government bodies, and nations. The primary objective of green accounting is to provide a more comprehensive and realistic assessment of economic performance by reflecting the true costs associated with environmental degradation and resource consumption (El Serafy, 1997; Ibrahim et al., 2025; Luo, Zhang & Wei, 2025; Rounaghi, 2019).

Traditional accounting systems primarily focus on financial transactions and do not account for the environmental consequences of business activities, or the externality activities, such as

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air and water pollution, carbon emissions, deforestation, and the depletion of natural resources. Green Accounting seeks to bridge this gap by assigning monetary values to these environmental impacts, thereby offering a clearer picture of sustainability and long-term economic viability. For instance, a company that pollutes a river may incur clean-up costs, regulatory fines, and reputational damage, all of which should ideally be included in its financial reports. Green accounting ensures such costs are recognized, encouraging more responsible and informed decision-making.

Green Accounting operates at both the micro and macroeconomic levels. At the firm level, it helps organizations track environmental costs, assess eco-efficiency, and improve resource management (Abdelhalim, Ibrahim & Alomair, 2023). This includes expenses related to waste disposal, environmental audits, regulatory compliance, energy consumption, and investment in cleaner technologies. At the national level, governments use green accounting (often through systems like the United Nations' System of Environmental-Economic Accounting, SEEA) to measure the impact of economic activities on natural capital and adjust national income accounts accordingly. For example, Gross Domestic Product (GDP) can be adjusted to reflect environmental depletion, resulting in a more sustainable measure known as Green GDP (Aguilar-Rivera, 2021; Hamilton, 1994; Stjepanović, 2019; Stjepanović, Tomić & Škare, 2017; Stjepanović, Tomić, D. & Škare, M., 2025).

Green Accounting is rooted in sustainability principles and is supported by several accounting and economic theories (Ibrahim et al., 2025; Hernádi, 2012; Maama & Appiah, 2019). From the standpoint of stakeholder theory, organizations have responsibilities beyond shareholders, including to the environment and the broader community. Green Accounting reflects this wider accountability by incorporating environmental performance into corporate reporting. Additionally, the triple bottom line framework encompassing profit, people, and planet highlights the need to balance financial performance with social and environmental considerations, which balanced Green Accounting facilitates (Ahad, 2023; Alsayed, 2025; Arowoshegbe, Emmanuel & Gina, 2016).

One of the critical tools in green accounting is Environmental Management Accounting (EMA), which involves collecting and analyzing environmental cost data to support internal decision-making. This includes both physical data (like material and energy use) and monetary data (such as environmental-related costs and savings). EMA helps organizations improve operational efficiency, reduce waste, and enhance environmental performance while simultaneously improving financial outcomes.

Despite its growing importance, Green Accounting faces challenges such as the absence of universally accepted measurement standards, difficulty in valuing non-market environmental assets, and limited expertise among accountants (Atkinson, 2010). Nonetheless, global momentum toward sustainability and responsible business practices is driving the adoption of green accounting frameworks.

In conclusion, Green Accounting represents a vital evolution in accounting thought and practice. By internalizing environmental costs and providing data on ecological impacts, it empowers decision-makers to pursue economic growth without compromising environmental integrity. As sustainability becomes a central business imperative, green accounting is poised to play a pivotal role in shaping responsible economic development. To this extent, there are several green accounting proxies in extant literature, but this study considered environmental

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expenditure, carbon disclosure level, environmental fine or penalties, and renewable energy usages. These are discussed in turns.

Greenhouse Gas (GHG) Emissions

Greenhouse gas (GHG) emissions refer to the release of gases, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), into the atmosphere, which trap heat and contribute to global warming. In the context of corporate operations, GHG emissions are a critical environmental metric, often measured in carbon dioxide equivalents (CO_2e) to allow for comparability across gases with varying global warming potentials. These emissions arise from both direct sources (e.g., fuel combustion in company-owned facilities and vehicles) and indirect sources (e.g., electricity consumption, supply chain activities) (Wang, Li & Gao, 2014).

For listed companies in sub-Saharan Africa, GHG emissions are increasingly relevant due to growing regulatory requirements, investor expectations, and alignment with international reporting frameworks, such as the Greenhouse Gas Protocol and the Task Force on Climate-related Financial Disclosures (TCFD). Many African economies are heavily dependent on resource-intensive sectors such as mining, oil and gas, and manufacturing, which are significant contributors to GHG emissions. Consequently, measuring and disclosing these emissions forms a critical component of green accounting practices (Le & Nguyen-Phung, 2024).

From a financial performance perspective, GHG emissions can influence profitability, cost structures, and access to capital. High emissions may expose firms to regulatory penalties, carbon taxes, and reputational risks, potentially deterring environmentally conscious investors. Conversely, proactive emission management can enhance operational efficiency, reduce long-term energy costs, and improve stakeholder trust, thereby supporting better financial outcomes.

In the context of panel Granger causality analysis, GHG emissions serve as a key variable for examining whether environmental performance indicators predict changes in financial performance or vice versa. For sub-Saharan African listed firms, understanding this causal relationship can guide strategic decisions, balancing sustainability imperatives with shareholder value creation in an evolving global economy.

Energy Use & Efficiency (ENG)

Energy use and efficiency represent critical components of Green Accounting, especially in the context of sub-Saharan African (SSA) countries where energy systems face challenges of limited supply, high costs, and growing demand. In corporate sustainability discourse, energy efficiency refers to the ability of firms to produce goods and services with minimal energy input, while maintaining output quality. This is a vital consideration for listed companies as it influences both operational costs and environmental impact (Stjepanović, Tomić & Škare, 2025).

From a Green Accounting perspective, energy use is not merely an operational metric but also an environmental performance indicator, as it directly correlates with greenhouse gas emissions and resource depletion. Firms in SSA, particularly in manufacturing, mining, and energy-intensive sectors, often rely on fossil fuels due to inadequate renewable infrastructure. Consequently, inefficient energy use can increase production costs, heighten carbon footprints, and expose companies to regulatory and reputational risks.

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Improving energy efficiency through modern technologies, process optimization, and renewable integration can reduce operational expenditures, enhance competitiveness, and improve long-term profitability. This aligns with financial performance measures, such Returns on Equity (ROE), where reduced costs and enhanced productivity can yield better returns (Endiana et al., 2020; Zik-Rullahi & Jide, 2023).

In the context of panel Granger causality analysis, energy use and efficiency may exhibit bidirectional relationships with financial performance. Higher profitability could enable firms to invest in energy-efficient technologies, while improved efficiency can in turn lower costs and increase profitability. For SSA's listed firms, this dynamic is shaped by capital availability, government incentives, and stakeholder pressure for sustainability. Therefore, incorporating energy use and efficiency into Green Accounting provides a quantifiable link between environmental stewardship and financial outcomes, enabling empirical tests of whether sustainability initiatives causally influence firm profitability over time.

Water Management (WATE)

Water management (WATE) refers to the planning, control, and optimization of water resources to ensure sustainable availability, quality, and usage across corporate operations (Silva, 2023). For listed companies in sub-Saharan African countries, effective water management is a critical component of Green Accounting, given the region's vulnerability to water scarcity, climate variability, and infrastructure constraints. In a corporate sustainability context, WATE encompasses activities such as water conservation, recycling, wastewater treatment, efficient irrigation (for agribusiness), and responsible discharge into the environment (Jain & Singh, 2023; Moreno, 2024).

Within green accounting frameworks, water management is quantified and disclosed as part of environmental performance indicators. Companies may measure total water withdrawal, intensity per unit of output, and improvements in water use efficiency (Wang, Li & Gao, 2014). These disclosures not only respond to growing investor and regulatory demands for transparency but also signal environmental stewardship, which can influence market perception and, consequently, financial performance.

From a financial perspective, WATE initiatives can create both costs and benefits. Short-term costs include investment in water-saving technologies, treatment facilities, and staff training. However, long-term benefits may arise through reduced operational risks, lowered water purchase costs, avoidance of regulatory penalties, and enhanced brand reputation. In water-intensive industries, such as mining, beverage production, and agriculture, strategic water management can directly affect productivity, supply chain stability, and ultimately, profitability.

Panel Granger causality analysis in this context can help determine whether improvements in water management predict changes in financial performance or vice versa. For example, a causal relationship from WATE to profitability would suggest that proactive water stewardship drives better financial outcomes (Fu & Jacobs, 2022). Conversely, if financial performance predicts WATE investment, it would imply that profitable firms have more capacity to allocate resources toward water sustainability (Ji, Y.; Ji, M.; Yang & Dong, 2023). Understanding this causal direction is vital for designing policies and corporate strategies in sub-Saharan Africa's environmentally and economically sensitive markets.

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Waste Management (WAST)

Waste management refers to the systematic handling of solid, liquid, and hazardous waste materials generated by business operations, with the aim of minimizing environmental impact and optimizing resource efficiency (Rahman et al., 2025). In the context of Green Accounting, waste management is not merely an operational necessity but also a measurable indicator of environmental performance. Effective waste management strategies such as waste segregation, recycling, energy recovery, and safe disposal can be captured through environmental accounting systems, providing quantifiable data for assessing corporate sustainability (Zakariah et al., 2023).

For listed companies in sub-Saharan African countries, waste management plays a dual role: environmental stewardship and financial prudence (Almasyhari et al., 2024). Poor waste management can lead to environmental degradation, regulatory penalties, and reputational damage, which may undermine investor confidence and financial performance. Conversely, efficient waste handling can reduce production costs, recover value from recyclables, and foster positive stakeholder relations, potentially enhancing profitability and Return or Return on Equity (ROE).

From a Panel Granger causality perspective, the link between waste management (WAST) and financial performance can be bidirectional. Improvements in waste management, as recorded through Green Accounting disclosures, may "cause" better financial outcomes by lowering operational inefficiencies and compliance risks. Alternatively, stronger financial performance can "cause" better waste management by providing the capital necessary to invest in advanced waste processing technologies and training (Aiguobarueghian et al., 2025; Aldouri, 2024).

In sub-Saharan Africa, where infrastructure for waste collection and recycling is often underdeveloped, listed companies face unique challenges. The adoption of Green Accounting frameworks enables standardized reporting of waste management performance, allowing for cross-country panel data analysis. Understanding the causal direction between WAST and financial performance can guide policymakers and corporate leaders in aligning sustainability goals with economic growth strategies, fostering both environmental protection and shareholder value creation.

In summary, Green Accounting measures—GHG emissions, energy use, water management, and waste management—significantly influence financial performance in sub-Saharan African listed firms. High GHG emissions expose firms to regulatory fines, carbon taxes, and reputational risks, while proactive reduction improves efficiency and investor trust. Energy efficiency lowers costs and enhances returns, with profitability enabling reinvestment in cleaner technologies. Effective water management mitigates scarcity risks, reduces costs, and supports brand reputation, though requiring upfront investment. Similarly, waste management reduces inefficiencies, avoids penalties, and recovers value, improving profitability. Overall, these measures demonstrate a bidirectional causal link between sustainability practices and firm financial outcomes.

Theoretical Review

Sustainable Development Theory (SDT): This theory serves as a foundational framework for understanding the relationship between environmental responsibility and corporate financial outcomes. Rooted in the principle of meeting present needs without compromising the ability

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DOI URL: https://doi.org/10.52589/AJAFR-LH2TZF8L

of future generations to meet theirs, the theory advocates for a balance between economic growth, environmental stewardship, and social equity. In the context of listed companies in sub-Saharan African countries, this theory provides a lens through which green accounting practices and their influence on financial performance can be examined.

Green Accounting, also referred to as environmental accounting, involves the integration of environmental costs into financial decision-making and reporting. From the perspective of SDT, Green Accounting is not merely an ethical or regulatory obligation but a strategic approach to ensuring long-term corporate sustainability. In resource-rich but environmentally vulnerable regions like sub-Saharan Africa, companies face increasing scrutiny from investors, governments, and civil society to operate in ways that are environmentally responsible. By adopting green accounting, companies demonstrate a commitment to sustainability, potentially enhancing their reputation, stakeholder trust, and long-term financial viability.

The use of panel Granger causality analysis in this study is crucial for determining the directional influence between green accounting and financial performance over time. SDT supports the hypothesis that companies embracing sustainable practices, including environmental disclosures and cost internalization, may realize improved operational efficiency, risk management, and access to capital, which in turn lead to enhanced financial performance. Conversely, it is also possible that companies with strong financial positions are more capable of investing in and implementing green accounting measures, suggesting a bi-directional causal relationship.

In sub-Saharan Africa, where economic development often contends with environmental degradation and weak regulatory enforcement, SDT emphasizes the need for firms to internalize the broader impacts of their operations. By applying this theory, the study not only tests the empirical relationship between green accounting and financial performance but also frames it within a normative goal: promoting sustainable business practices in emerging markets. Ultimately, SDT underlines the rationale for integrating environmental considerations into corporate strategy. It supports the argument that green accounting is not a cost burden but a value-creating activity that aligns with long-term financial success. The panel Granger causality approach complements this theoretical lens by exploring whether this sustainability-driven transformation has a measurable and causal impact on firm performance in the Sub-Saharan African context.

Legitimacy Theory (LT): The theory provides a valuable lens through which to understand the relationship between Green Accounting practices and financial performance in listed companies, especially within the context of sub-Saharan African countries. The theory posits that organizations continually seek to operate within the bounds and norms of their respective societies to ensure continued survival and access to resources. In essence, companies strive to legitimize their operations by aligning their values and actions with societal expectations, which increasingly include environmental stewardship and sustainable development.

In recent years, public concern over environmental degradation, climate change, and the social responsibilities of corporations has grown significantly in Africa and globally. As a result, stakeholders including governments, investors, communities, and civil society organizations have placed greater pressure on firms to demonstrate environmental accountability. In response, firms have adopted green accounting practices, such as environmental disclosures, sustainability reporting, and internal eco-efficiency measures. Through such practices,

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companies signal their commitment to responsible environmental behavior, thereby securing legitimacy in the eyes of key stakeholders.

Within the context of this study, LT suggests that companies engaging in green accounting may be doing so to enhance their legitimacy, which in turn could influence their financial performance. For example, firms that transparently report their environmental impacts and mitigation strategies may experience improved reputational capital, increased investor confidence, or even favorable regulatory treatment, all of which could contribute to better financial outcomes. Conversely, firms that fail to align with environmental expectations may face reputational risks, regulatory sanctions, or loss of market share, negatively affecting financial performance.

By employing panel Granger causality analysis, this study aims to empirically investigate whether changes in Green Accounting practices Granger-cause changes in financial performance or vice versa. LT supports the hypothesis that Green Accounting could drive financial outcomes by reinforcing the firm's legitimacy among stakeholders. However, the causality could also be bidirectional or driven by external factors such as regulatory changes or industry-specific norms. In sub-Saharan Africa, where regulatory environments and stakeholder expectations are evolving, LT helps explain why companies may adopt Green Accounting practices even in the absence of stringent enforcement. Thus, the theory provides a robust conceptual foundation for interpreting the empirical results of causality between Green Accounting and financial performance within the region.

Signaling Theory (ST): This offers a compelling lens through which to examine the causal relationship between Green Accounting and financial performance, particularly in the context of listed companies in sub-Saharan Africa. Originating from the field of information economics, ST posits that firms convey information to external stakeholders to reduce information asymmetry. In capital markets, where investors and other stakeholders often lack full visibility into a firm's operations, companies use various signals such as financial disclosures, certifications, or sustainability reports to project their quality, reliability, and long-term viability.

In the case of Green Accounting, environmental disclosures act as strategic signals of corporate responsibility, governance standards, and long-term risk management. By voluntarily or mandatorily reporting environmental costs, liabilities, and sustainability initiatives, firms aim to convey a message of environmental stewardship and forward-looking management. This signaling is particularly important in sub-Saharan African countries, where corporate governance and regulatory enforcement may vary, and transparency remains a critical concern for investors and international stakeholders.

From the signaling perspective, companies adopting Green Accounting may experience improved financial performance due to increased investor confidence, better access to green financing, or enhanced reputation. Investors often interpret environmental disclosures as a commitment to sustainability, operational efficiency, and long-term value creation. Thus, Green Accounting serves not only as a compliance mechanism but also as a differentiator in competitive capital markets. Panel Granger causality analysis is relevant here because it allows researchers to test the direction of the relationship between Green Accounting (as a signaling variable) and financial performance. If Green Accounting Granger-causes financial performance, it supports the notion that sustainability-related signals precede and potentially

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influence financial outcomes. Conversely, if financial performance Granger-causes green accounting, it may imply that more profitable firms have the resources and incentives to engage in environmental disclosures as part of their signaling strategy.

In summary, Signaling Theory provides a valuable framework for understanding the motivations behind Green Accounting practices in listed sub-Saharan African firms and how these practices might affect or be affected by financial performance. The dynamic interaction captured through panel Granger causality testing can reveal whether Green Accounting acts as a credible and impactful signal in influencing investor perceptions and corporate valuation in the region.

The Resource-Based View (RBV): The theory of Resource-Based View (RBV) of the firm is a strategic management framework that emphasizes the role of internal resources in achieving and sustaining competitive advantage. According to Barney (1991), for a resource to contribute to sustained competitive advantage, it must be valuable, rare, inimitable, and non-substitutable (VRIN). In the context of corporate environmental sustainability, green accounting can be considered a strategic resource, especially when embedded in the firm's operational and reporting frameworks. The RBV is particularly useful for examining whether environmental accounting practices serve as internal capabilities that enhance financial performance over time.

In the sub-Saharan African context, where environmental regulations are often evolving and pressure from international stakeholders is increasing, Green Accounting can represent a firm's proactive adaptation to both environmental and economic demands. Firms that invest in environmental management systems, emission reduction technologies, and sustainability disclosures may create intangible resources such as improved brand reputation, stakeholder trust, and enhanced regulatory compliance. These capabilities are not easily replicable, especially in industries with complex environmental impacts, making them a potential source of long-term financial benefit.

Panel Granger causality analysis becomes a valuable econometric tool in this framework. It allows researchers to determine the directionality of the relationship between Green Accounting practices (as a proxy for internal environmental capabilities) and financial performance. If Green Accounting Granger-causes financial performance, this supports the RBV proposition that firms derive competitive advantage and improved financial outcomes from unique internal resources. Conversely, if financial performance Granger-causes Green Accounting, it might suggest that only financially stable firms can afford to invest in sustainability, positioning Green Accounting as an outcome rather than a driver of strategic capability.

In sub-Saharan African countries, where companies are increasingly exposed to global markets, sustainability practices can differentiate firms from competitors. Those that internalize environmental considerations may not only reduce operational risks and costs but also attract foreign investment, favorable credit ratings, and access to sustainable finance, all of which enhance financial performance. The RBV thus provides a robust theoretical foundation for understanding the causality dynamics between Green Accounting and financial outcomes in the region. In summary, applying RBV to the study of Green Accounting and financial performance allows researchers to interpret sustainability practices as strategic assets, and

Article DOI: 10.52589/AJAFR-LH2TZF8L
DOI URL: https://doi.org/10.52589/AJAFR-LH2TZF8L

panel Granger causality analysis helps test whether these assets indeed contribute to superior financial results in listed companies across sub-Saharan Africa.

Empirical Review

Causality of Green Accounting and Financial Performance

Asubiojo, Oluwagbade, and Igbekoyi (2024) examined the link between sustainability practices and financial performance in listed manufacturing firms across selected sub-Saharan African countries. The study used ex-post facto research designs; data were gathered from 62 manufacturing companies selected through criterion sampling from annual and sustainability reports. These firms, listed before 2011 and still active, were categorized into material products, consumer goods, healthcare, and industrial sectors. Descriptive and regression analyses were employed to assess the influence of social, economic, and environmental disclosures on return on assets (ROA), return on equity (ROE), and economic value added (EVA). Findings revealed that sustainability practices positively and significantly affect financial performance. The study recommends greater integration of sustainability into operations to enhance firm performance in the region.

Onyebuenyi and Ofoegbu (2022) explored how environmental sustainability disclosure impacts the financial performance of listed Oil and Gas firms in Nigeria, Namibia, and Kenya. The study used data from 15 firms over a nine-year period (2011–2019); six hypotheses were tested through content analysis based on the Global Reporting Initiative (GRI) standards. The crucial disclosure variables included emissions, energy, waste, compliance policies, and environmental investments. Financial performance was measured by return on equity, gross profit margin, and earnings per share, with robust least square regression employed for analysis. Results showed mixed effects: emissions and energy disclosures had opposing impacts on different performance metrics, while waste disclosure significantly affected earnings per share. Biodiversity and water disclosures influenced return on equity positively and gross profit negatively. Environmental expenditure showed a significant positive effect on profit margin. The study recommends that governments enforce mandatory environmental disclosure policies and strengthen regulatory frameworks to enhance financial and environmental outcomes in the oil and gas sector.

Emmanuel (2021) investigated how Green Accounting disclosure influences the financial performance of listed manufacturing firms in Nigeria. It specifically assessed its impact on return on assets (ROA), return on equity (ROE), and share price. The study employed an ex-post facto research design; data from 40 out of 66 manufacturing firms listed on the Nigerian Stock Exchange between 2010 and 2019 were analyzed. Descriptive statistics and panel regression were applied, with the Arellano and Bond (1991) GMM estimator used to address potential endogeneity. The results showed that Green Accounting disclosure positively and significantly affected both ROA and ROE, indicating improved profitability. However, a negative relationship was found between Green Accounting disclosure and share price. The study recommends that firms enhance their Green Accounting efforts to aid stakeholder decision-making. It also urges the government to enforce disclosure regulations in line with the Global Reporting Initiative (GRI) standards, especially for publicly listed firms.

Adeusi and Alade (2021) explored the role of sustainability accounting in supporting human survival within the framework of the Sustainable Development Goals (SDGs). The study employed statistical methods such as descriptive analysis, correlation, multivariate, and panel

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data regression. The study analyzed the collected data. Findings indicated that disclosures related to water, biodiversity, emissions, and compliance with environmental/ecological regulations are minimal. These limited disclosures are linked to negative externalities that hinder the Human Development Index, used here as a proxy for sustainable development.

Adams, Tackie, and Idun (2025) explored the link between green reporting and firm performance, examining how CEOs' cultural backgrounds influence this relationship. Covering the period from 2015 to 2021, it analyzed 158 listed manufacturing firms across 14 Anglophone sub-Saharan African countries. The study used the instrumental variable-generalized method of moments (IV-GMM) to address endogeneity; the findings show that green reporting positively impacts firm performance, measured by return on assets (ROA) and return on equity (ROE), supporting legitimacy, stakeholder, and signaling theories. The positive effect is stronger when CEOs come from cultures with high power distance, uncertainty avoidance, and masculinity. Additionally, firms led by CEOs from cultures with low individualism, long-term orientation, and indulgence see enhanced green reporting benefits. The study suggests that policymakers should encourage green reporting, cultural diversity, and sustainability to improve both financial and environmental outcomes. Notably, this is among the first studies to assess how CEOs' cultural origins shape the green reporting–performance relationship.

Saeed et al. (2025) examined how corporate environmental reporting affects the financial performance of 20 publicly listed manufacturing firms in Ghana over a 10-year period (2012–2021). Using panel regression and content analysis of annual reports. The research found that environmental sustainability disclosures significantly enhance return on equity (ROE) and net profit margin. Additionally, disclosures related to health, safety, and community development show a strong positive influence on ROE. The study recommends the development of clear environmental reporting guidelines to support firms and encourages accountants to collaborate with environmental experts. These findings offer useful insights for policymakers and set the stage for further research on environmental reporting and firm performance in sub-Saharan Africa.

Obadire et al. (2025) examined how sustainable business practices (SBPs) influence firm performance among selected listed companies in Botswana during 2022 and 2023. Using legitimacy and agency theories, the research applied quantitative content analysis and pooled OLS regression on annual integrated reports. Results show that social SBPs were the most frequently disclosed, making up 52% of disclosures in 2023 and 51% in 2022, indicating rising focus on sustainability. Governance practices represented 30%, while environmental disclosures were the least at 18%. A positive link was found between ESG (environmental, social, and governance) practices and return on equity (ROE), suggesting that strong ESG efforts boost firm performance. Notably, social SBPs had the greatest impact on ROE, highlighting the value of employee and community engagement in enhancing reputation and goodwill. The study fills a knowledge gap on ESG impacts in Botswana and encourages wider SBP adoption to support transparency, firm profitability, and sustainable national economic growth.

Le and Nguyen-Phung (2024) examined how greenhouse gas (GHG) emission intensity affects corporate financial performance (CFP). Results reveal a significant negative relationship between GHG intensity and CFP, measured by return on assets (ROA) and return on equity (ROE), robust across various measures and tests. Post-Paris Agreement, reductions in GHG

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intensity are linked to improved ROA and ROE. Industry and regional differences are crucial, with the negative impact most evident in high-emission industries and firms in Southern Africa. To address endogeneity, the study applies a two-stage least-squares (2SLS) regression, using industry-level GHG intensity, lagged GHG intensity, Lewbel's (2012) heteroskedasticity-based instrument, and the kinky least squares method by Kiviet (2020). These confirm the primary findings. Overall, the results have important implications for corporate strategy and environmental policy in Africa.

Ganda (2021) investigated how growth factors influence carbon emissions across 44 sub-Saharan African countries from 1990 to 2014, using Dumitrescu and Hurlin's Granger causality and pooled mean group models. It found a two-way causal link between carbon emissions and economic growth, renewable energy use, industrial activity, and financial development. Additionally, there is a one-way causal relationship from agricultural development and human capital to emissions. Economic growth is positively associated with emissions in both the short and long term, while renewable energy reduces emissions across both periods. Financial development negatively affects emissions in the short term but has a positive long-term impact. Industrial activity raises emissions short-term but lowers them in the long term. Agricultural development has an insignificant short-term but significant long-term positive impact on emissions. Similarly, human capital shows a weak short-term link but significantly reduces emissions in the long run. Overall, growth factors continue to drive rising emissions in SSA.

Le and Nguyen-Phung (2024) applied multiple analytical approaches to explore the link between rising military expenditure and external debt in fragile African states from 2000 to 2023. Using dynamic panel techniques, such as System-GMM, to address endogeneity, Prais-Winsten regression to correct serial correlation, and panel Granger causality tests, the research offers a comprehensive view of the fiscal-security relationship. The results highlight a nonlinear pattern: while moderate military spending is fiscally neutral, exceeding a certain threshold significantly drives up debt. Increased defense spending alone is insufficient to reduce conflict, with effective governance, regulatory strength, and sustained economic growth proving more impactful for peace building. The study also uncovers a reinforcing cycle, a "fiscal–security trap," where rising debt and military expenditures feed into each other over time. This dynamic modeling enhances the understanding of fiscal risks in fragile settings and supports efforts to achieve sustainable debt management and lasting peace across the region.

Ilelaboye and Alade (2022) investigated how environmental accounting impacts the performance of family-owned firms in Nigeria, using restoration, community development, and health and safety costs as proxies. An ex-post facto design was adopted, with data from six purposively selected firms listed on the Nigerian Stock Exchange from 2012 to 2020. Analysis using descriptive statistics, correlation, and OLS revealed that restoration and community development costs negatively affect performance, the latter significantly, while health and safety costs have a positive but insignificant effect. The study concludes that only health and safety costs may enhance performance and recommends maintaining such spending and establishing accountable community development trust funds.

Benson et al. (2021) explored the impact of Green Accounting on the financial performance of Nigerian oil and gas companies from 2010 to 2020, focusing on environmental cost accounting and green management accounting. Using a quantitative approach and ex-post facto design, data were sourced from company annual reports and analyzed with regression via E-Views 9.0. Findings revealed that both environmental cost accounting and green management accounting

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significantly influence financial performance. The study recommends that companies prioritize environmental cost accounting and urges the government to enforce mandatory environmental reporting and develop adaptable environmental accounting standards for improved compliance and strategic integration.

Dura and Suharsono (2022) examined the influence of Green Accounting on sustainable development and financial performance, as well as how financial performance, in turn, impacts sustainable development. Additionally, it explored whether Green Accounting indirectly affects sustainable development through its influence on financial performance. The research focused on manufacturing companies engaged in environmentally conscious practices and listed on the Indonesia Stock Exchange during the period from 2017 to 2020. A total of 52 companies were selected using purposive sampling. To analyze the relationships among the variables, the study employed path analysis using STATA software. The findings reveal that Green Accounting significantly influences both sustainable development and financial performance. However, financial performance alone does not have a significant effect on sustainable development. Interestingly, the study also finds that Green Accounting indirectly contributes to sustainable development through its positive impact on financial performance. These results highlight the role of Green Accounting not only in enhancing a company's financial outcomes but also in promoting long-term sustainability. Both Green Accounting practices and financial performance are shown to be key indicators of a company's ongoing viability and commitment to sustainable growth in the manufacturing sector.

Doobee, Ironkwe and Nwaiwu (2024) assessed how Green Accounting impacts the financial performance of listed oil and gas firms in Nigeria from 2012 to 2022, using secondary data from annual reports. Employing Panel cointegration analysis, the results indicate that green investments have a negative, insignificant relationship with profit after tax, suggesting that pollution control spending does not significantly affect net income. However, green investments show a positive, significant relationship with return on assets, implying improved efficiency in profit generation from assets. On the other hand, green activity management has both a negative, insignificant effect on profit after tax and a negative, significant impact on return on assets, highlighting that community development expenses can hinder asset-based profitability. The study recommends that oil and gas firms establish a robust sustainability strategy aligned with their overall business goals. This strategy should span all business functions such as supply chains, operations, and product development to uncover cost-saving opportunities that enhance financial performance.

Gaps in the literature based on the reviewed studies:

1. Sectoral Coverage Bias: Most studies focus on manufacturing and Oil & Gas sectors (Asubiojo et al., 2024; Emmanuel, 2021; Benson et al., 2021; Doobee et al., 2024), with limited evidence from banking, telecommunications, agriculture, and service industries in sub-Saharan Africa.

2. Geographic Limitations: Research is concentrated in Nigeria, Ghana, Kenya, Namibia, and Botswana, while many SSA countries remain underexplored, limiting the generalizability of findings (Onyebuenyi & Ofoegbu, 2022; Saeed et al., 2025).

3. Mixed and Inconclusive Results: Some studies show positive impacts of green accounting on financial performance (Emmanuel, 2021; Saeed et al., 2025), while others

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find insignificant or negative effects (Doobee et al., 2024; Ilelaboye & Alade, 2022). This inconsistency signals a lack of consensus.

4. Limited Scope of Environmental Disclosures: Most studies emphasize emissions, waste, energy, and water, but biodiversity, circular economy, renewable energy use, and carbon pricing mechanisms are under-researched (Adeusi & Alade, 2021; Ganda, 2021).

5. Short Time Horizons: Several studies analyze relatively short periods (e.g., 5–10 years), which may not capture long-term sustainability impacts on profitability (Obadire et al., 2025; Dura & Suharsono, 2022).

6. Methodological Constraints: Many rely on content analysis and basic regression models, with fewer studies employing advanced econometric methods like dynamic panel models, causality tests, or structural equation modeling (Le & Nguyen-Phung, 2024; Adams et al., 2025).

7. Cultural and Governance Dimensions: Adams et al. (2025) highlighted CEO cultural background, but broader corporate governance, ownership structure, and stakeholder pressures remain underexplored in shaping green reporting performance links.

8. Financial Market Reactions: While Emmanuel (2021) linked green disclosure to share price (with negative results), capital market perspectives (e.g., stock volatility, investor confidence, cost of capital) are largely absent.

9. Indirect Effects: Few studies (e.g., Dura & Suharsono, 2022) examine mediating or moderating effects, such as whether financial performance mediates the link between green accounting and sustainability.

10. Comparative and Cross-Country Analysis: Limited cross-country comparative research exists within SSA, and studies rarely assess regional differences in regulations, enforcement, and institutional quality (Le & Nguyen-Phung, 2024).

In summary, gaps exist in sectoral and geographic coverage, methodological rigor, the scope of disclosures considered, and the examination of indirect, long-term, and capital market effects. Future research should adopt broader industry coverage, longer time horizons, stronger econometric techniques, and comparative regional analyses to better understand how Green Accounting influences financial performance in sub-Saharan Africa.

RESEARCH METHODOLOGY

Research Design

This study adopts quantitative and ex-post facto research design and panel data analysis to examine the causal relationship between Green Accounting practices and financial performance among listed companies in sub-Saharan Africa. A causal-comparative design supports the goal of identifying whether changes in Green Accounting metrics precede changes in financial performance. The source of data is secondary data, collected from the annual reports of listed companies that have sustainability/ESG reports in financial statements. The population comprises 554 all listed companies in selected sub-Saharan African stock exchanges

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as at 31st Dec., 2023. The sampling technique method deployed is purposive sampling, focusing on companies that are listed on national exchanges for at least 12 consecutive years (2012–2023) and reporting environmental or Green Accounting metrics (e.g., carbon emissions, environmental expenditures). The companies operate in sectors significantly impacting the environment (e.g., energy, manufacturing, and mining). The sample size is made up of listed companies as at December 2023: South Africa has 231 companies, Nigeria has 90, Kenya has 54 and Ghana has 26—a total of 404 companies and four countries.

Variables

Independent Variable (X): Green Accounting metrics.

i. Greenhouse Gas (GHGT) Emissions

ii. Energy Use & Efficiency (ENG)

iii. Water Management (WATE)

iv. Waste Management (WAST)

Dependent Variable (Y): Financial Performance metrics.

i. Return on Equity (ROE)

Model Specification

The study employs Panel Granger Causality tests within a panel vector autoregressive (PVAR) framework. The general model:

$$Y_{it} = \alpha_i + \sum_{k=1}^{p} \beta_k Y_{i,t-k} + \sum_{k=1}^{p} \gamma_k X_{i,t-k} + \epsilon_{it} \quad \text{(i)}$$

where:

- $Y_{it\_}$: Financial performance of firm *i* at time *t*
- X_{it}: Green Accounting indicators of firm *i* at time *t*
- α_i: Firm fixed effects
- ϵ_{it}: Error term
- p: Optimal lag length

$$ROE_{it} = \Omega_{it} + \sum \beta_k ROE_{it\,t-k} + \sum (GHG)_{it} (ENG)_{it} (WATE)_{it} (WAST)_{it\,t-k} + \epsilon_{it} \quad \text{(ii)}$$

where:

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Independent variables

GHG = Greenhouse gas

ENG = Energy usage

WATE = Water management and

WAST = Waste management

€ = Stochastic term

units i = 1

T with common lag order K

Dependent variable

ROE = Returns on Equity

ESTIMATION TECHNIQUES

Panel Regression: Panel regression of tool was used to estimate Fixed Effects and Random Effects regression. The Fixed Effects model controls for time-invariant heterogeneity across firms, isolating the within-company variation to assess the impact of green accounting practices on financial outcomes. Conversely, the Random Effects model accounts for both within- and between-entity variations, assuming uncorrelated individual effects. The Hausman test was conducted to determine the preferred model. These panel data techniques provide robust insights into the direction and strength of causality between green accounting and firm performance over time.

Granger Causality Test: To assess the causal relationship between Green Accounting and financial performance among listed companies in sub-Saharan African countries, the Dumitrescu and Hurlin (2012) panel causality test is conducted. This method is particularly suited for heterogeneous panel data, allowing for individual cross-sectional differences in causal dynamics. It evaluates Granger causality in a panel context by averaging individual Wald statistics across units, making it robust even when coefficients differ across firms. The test is applied to determine whether past values of Green Accounting indicators can predict financial performance, and vice versa, thereby offering insights into the direction and significance of the causal link.

Panel Unit Root Test: It is essential to first assess the stationarity of the panel data series. Commonly used tests such as Levin, Lin & Chu (LLC); Im, Pesaran and Shin (IPS); and Fisher-type tests (ADF and PP) are applied to determine whether the variables contain unit roots. Stationarity ensures valid inference in subsequent panel data analyses, such as Granger causality. Testing at level and first difference under both individual and common unit root assumptions provides robustness to the findings.

Lag Selection: This involves applied statistical criteria such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and Hannan-Quinn Criterion (HQIC).

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These criteria help identify the optimal lag length that minimizes information loss while capturing the dynamic relationship between variables. The selection process involves estimating Vector Autoregressive (VAR) models with varying lags and comparing their performance. The chosen lag ensures model adequacy, stability, and reliable inference, which are crucial for robust Granger causality testing across the panel dataset.

The Dumitrescu and Hurlin (2012) test is a statistical method used in panel data analysis to examine Granger causality in heterogeneous panel settings.

Dumitrescu and Hurlin (2012)'s panel causality test, suitable for heterogeneous panels:

Hypothesis testing:

H_0: No Granger causality from X to Y

H_1: X Granger causes Y

Table 1: Measurement of Variables

Variables	Measure	Standard Indicators	Proxy	Reference
Independent variables				
GHGT	Greenhouse Gas (GHG) Emissions	Scope 1 emissions (direct), Scope 2 emissions (indirect from purchased energy), Scope 3 emissions (supply chain) – metric tons CO_2e	Emission scope (O_{2e}/ (revenue/ Country_Exchange_Rate))<10 & (Emission scope (O_{2e}/ (revenue/ Country_Exchange_Rate))	Lamtink, (2024).
ENG	Energy Use & Efficiency (ENG)	Total energy consumption (MWh), % from renewable sources, energy intensity (MWh per revenue or per output)	Energy_useage/ ((revenue/ Country_Exchange_Rate))<10 & (Energy_useage/ ((revenue/ Country_Exchange_Rate))	Lamtink, (2024).
WATE	Water Management (WATE)	Total water withdrawal (m^3), % recycled water, water intensity	Water_useage/((revenue/ Country_Exchange_Rate))<10 &(Water_useage/((revenue/ Country_Exchange_Rate))	Lamtink, (2024).
WAST	Waste Management (WAST)	Total waste generated (tons), % recycled, hazardous waste generated	Waste_tonne/ /((revenue/ Country_Exchange_Rate))<10 & (Waste_tonne/ /((revenue/ Country_Exchange_Rate)	Edworthy, (1989).
Dependent variable				
ROE	Returns on Equity	Profitability ratio that measures how effectively a company uses its shareholders' equity to generate profit.	ROE = (Net Income)/ (average shareholders, equity)100%	Heikal, Khaddafi, & Ummah (2014).

Source: Author's Compilation (2025)

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African Journal of Accounting and Financial Research
ISSN: 2682-6690
Volume 8, Issue 5, 2025 (pp. 62-97)

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DATA ANALYSIS AND INTERPRETATION OF RESULTS

Table 2: Summary Statistics

	N	Mean	SD	Max	Min	Skewness	Kurtosis	CV
roe	4669	34.656	1271.220	84019.094	-2160.135	62.219	4086.051	36.681
ghg	4812	.005	0.046	1.255	0	14.868	268.081	8.695
eng	761	374.718	9262.453	254592.41	0	27.238	747.65	24.718
wate	727	14.091	126.661	2847.32	0	16.914	353.652	8.988
wast	506	.312	3.406	56.633	0	14.533	224.012	10.916

Source: Author's Computation (2025)

The ROE measures the profitability relative to shareholders' equity, indicating how effectively a company is generating returns from its equity base. The total observation is 4667 while the mean value of 34.656 suggests, on average, positive returns across the sample. However, the extremely large standard deviation and extraordinary maximum highlight substantial variability SD 1271.220 and max value 84019.094 respectively, suggesting the presence of extreme values. The negative minimum -2160.135 indicates that some companies experienced significant losses during the period. The skewness and kurtosis values are extremely high, indicating a highly non-normal distribution skewness 62.219 and kurtosis 4086.051. Positive skewness of this magnitude means that a small number of firms have exceptionally high ROEs, pulling the mean upward. The kurtosis confirms that the distribution is heavily leptokurtic, meaning it has fat tails and sharp peaks, often due to extreme observations.

The average GHG emission value of 0.005 suggests that emissions, when normalized to the chosen scale, are generally low across companies. The maximum value of 1.255 indicates that some companies have much higher emissions compared to others in the sample. The high positive skewness indicates that most companies have low emissions, but a few extreme values have disproportionately large emissions. The kurtosis of 268.081 is extreme, pointing to a heavy-tailed distribution with significant extreme value effects. Such distributional characteristics are common in environmental datasets, where most firms adhere to average standards, and a few deviate substantially.

Energy consumption displays a high mean compared to environmental indicators like GHG and waste. The variability is immense SD which is over 24 times the mean which shows that energy usage is highly inconsistent across companies. This may be due to industry type, production scale, and operational technology. The skewness and kurtosis values indicate a highly non-normal distribution, again influenced by a small number of very large energy-consuming entities, perhaps heavy manufacturing or mining companies. These extreme values significantly affect the distribution shape and could influence regression or panel analysis results if not handled carefully.

Water usage is another critical sustainability metric. The mean is relatively low at 14.091, suggesting that many companies report modest usage. However, the standard deviation and maximum value are 126.661 and 2847.32 respectively, which indicate significant disparities; some companies consume water at levels far beyond the average, potentially reflecting water-intensive industries, such as beverage production, textiles, or agriculture. The high skewness

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and kurtosis confirm a right-skewed distribution with heavy tails, similar to other environmental variables in the dataset.

Waste management efficiency or quantity (depending on the measure used) has a relatively small mean of 0.312, suggesting low reported waste relative to the measurement scale. However, the large standard deviation is 3.406, along with extreme skewness (14.533) and kurtosis (224.012), which indicate that a minority of firms produce or report waste levels that are vastly higher than the majority. These extreme values may be critical in sustainability-focused studies since they can disproportionately influence statistical models and policy interpretations.

Table 3: Matrix of Correlations

Variables	(1)	(2)	(3)	(4)	(5)
(1) roe	1.000				
(2) ghg	-0.022	1.000			
(3) eng	-0.002	-0.005	1.000		
(4) wate	-0.310	0.031	-0.007	1.000	
(5) wast	-0.003	0.079	-0.000	-0.004	1.000

Source: Author's Computation (2025)

A correlation matrix provides an overview of the pairwise relationships between variables in a dataset. It is a powerful diagnostic tool in preliminary data analysis, allowing researchers to assess the strength, direction, and potential redundancy of variables before applying more sophisticated statistical techniques. The correlation between (ROE/GHG -0.022) emissions is slightly negative but extremely weak. This indicates that, in this dataset, higher GHG emissions are very marginally associated with lower ROE. However, the strength is too small to suggest any meaningful linear relationship. This finding may imply that profitability, as measured by ROE, is not directly determined by GHG emissions levels, at least in the short run.

The almost zero correlation shows no linear relationship between (ROE/ENG -0.002). This suggests that variations in energy usage do not appear to systematically influence financial performance. In real-world terms, it could mean that some high-energy-consuming firms are profitable while others are not, making energy use a poor predictor of ROE.

This is the strongest relationship in the entire matrix (ROE/WATE -0.310), with a moderate negative correlation. It suggests that firms with higher water usage tend to have lower ROE. Possible reasons include: Higher operational costs associated with water-intensive processes; industry types with high water demands (e.g., agriculture, mining) potentially facing lower margins; and regulatory or reputational penalties for excessive water usage. This correlation merits deeper investigation, as it may indicate a tangible link between environmental resource management and financial outcomes. The correlation is negligible (ROE/WAST -0.003), indicating no meaningful association between waste management levels and ROE. It is possible that waste metrics in this dataset are not scaled in a way that directly impacts profitability, or that waste management is a relatively minor cost factor for these firms.

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African Journal of Accounting and Financial Research
ISSN: 2682-6690
Volume 8, Issue 5, 2025 (pp. 62-97)

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Table 4: Regression Result

	(Fixed Effect)	(Random Effect)	(Fixed Effect)	(Random Effect)
VARIABLES	ROE	ROE	ROE	ROE
ghg	1.606	-7.970	89.77	-8.484
	(48.68)	(26.83)	(141.0)	(34.09)
eng	3.78e-05	-6.07e-05	0.00860	-0.00440
	(0.000261)	(0.000246)	(0.0615)	(0.0486)
wate			-0.236***	-0.238***
			(0.0726)	(0.0377)
wast			-0.579	-0.0511
			(1.498)	(0.835)
Constant	10.06***	10.91***	7.098	10.04***
	(2.561)	(3.038)	(5.725)	(3.474)
Observations	760	760	383	383
R-squared	0.000		0.034	
Number of id	136	136	81	81
Hausman test			0.83	
P value			(0.9346)	

Source: Author's Computation (2025) Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results of the random-effects GLS regression reveal important insights into the relationship between selected Green Accounting indicators and firm profitability, as measured by Return on Equity (ROE). The model incorporates four environmental variables—greenhouse gas (GHG) emissions, energy consumption, water usage, and waste generation—using data from 383 firm-year observations across 81 distinct firms. The statistical framework assumes that unobserved firm-level effects are uncorrelated with the explanatory variables, allowing for the inclusion of both between-firm and within-firm variation.

The model's R^2 values tell an important story about the structure of the data from within R^2 = 0.0324: Only about 3.2% of the variation in ROE within individual firms over time is explained by changes in Green Accounting measures. This low value suggests that year-to-year shifts in Green Accounting do not strongly track with changes in profitability, while between R^2 = 0.2283, around 22.8% of the variation between different firms' average ROE levels is explained by differences in their Green Accounting averages. This indicates that cross-sectional differences such as structural industry characteristics or long-term environmental strategies are more relevant than short-term fluctuations. And the overall R^2 = 0.0962; the model explains about 9.6% of total variation in ROE. While modest, this is common for models focusing on non-financial predictors of financial performance.

The joint significance of the predictors is confirmed by the Wald χ^2 statistic ($\chi^2(4) = 40.23$, $p < 0.0001$), indicating that, taken together, the environmental variables provide meaningful explanatory power for ROE. However, individual variable significance and the explanatory strength of the model vary notably across measures.

By contrast, GHG emissions (ghg) show a large negative point estimate (-8.4840) but with a substantial standard error (34.092) and a p-value of 0.803. This lack of statistical significance

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suggests that, in this sample, variation in reported GHG emissions does not reliably predict profitability. The wide confidence interval (-75.302 to 58.334) points to high variability and possibly measurement issues, differences in reporting standards, or weak short-term linkages between emissions intensity and financial returns.

Similarly, energy consumption (eng) has an almost zero coefficient (-0.0044) and no statistical significance ($p = 0.928$). This result suggests that differences in reported energy use, as measured in this dataset, do not systematically affect ROE. This may be because energy costs are a relatively small share of total costs for many firms in the sample, or because energy efficiency improvements are offset by other factors in the short run.

Water usage (WATE) emerges as the only statistically significant predictor of ROE in this specification. The coefficient of -0.2384 ($p < 0.001$) indicates that an increase of one unit in the water usage measure is associated with a reduction of approximately 0.238 percentage points in ROE, holding other variables constant. The magnitude of this effect suggests that water-intensive operations may be inherently less profitable, potentially due to higher operational costs, efficiency losses, or exposure to resource scarcity. This finding aligns with prior literature indicating that excessive water use can signal operational inefficiency, environmental risk exposure, or concentration in low-margin, water-dependent industries.

Finally, waste generation (WAST) has a coefficient of -0.0511 with a large standard error (0.8352) and is not statistically significant ($p = 0.951$). This suggests no clear link between waste output and profitability in the present dataset, possibly due to heterogeneity in waste composition, disposal costs, and industry waste management practices. The finding that between-firm variation explains more than within-firm variation suggests that environmental characteristics may be more stable, structural attributes of firms, rather than variables that fluctuate enough to impact profitability from year to year.

In summary, this analysis finds that among four environmental performance measures, only water usage exhibits a statistically significant association with firm profitability, and the relationship is strongly negative. This suggests that water efficiency is not only an environmental imperative but may also be financially beneficial. For practitioners, policymakers, and investors, the results underscore the importance of integrating water risk management into both operational strategy and ESG evaluation frameworks. However, the absence of significant relationships for other environmental indicators highlights the complexity of ESG-financial linkages and the need for nuanced, context-specific analysis.

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

Summary of Findings

The central objective of this study was to investigate the effect of selected Green Accounting indicators, namely, greenhouse gas (GHG) emissions, energy consumption (ENG), water usage (WATE), and waste generation (WAST) on the financial performance of firms in sub-Saharan Africa, as proxied by Return on Equity (ROE). Panel regression models (fixed effects and random effects) were employed to analyze the data. The major findings are summarized below.

Article DOI: 10.52589/AJAFR-LH2TZF8L
DOI URL: https://doi.org/10.52589/AJAFR-LH2TZF8L

First, the explanatory power of the model was modest. The random-effects GLS regression produced an overall R^2 of approximately 9.6%, suggesting that the selected Green Accounting measures collectively explained less than one-tenth of the variation in profitability. While this value is relatively low, it is not unusual for studies focusing on non-financial predictors of firm performance. Importantly, between-firm variation accounted for 22.8% of the differences in profitability, while within-firm variation explained only 3.2%. This indicates that structural characteristics, such as industry type, firm strategy, and long-term environmental practices, are more influential than year-to-year changes in environmental performance.

Second, GHG emissions demonstrated a negative relationship with profitability (-8.484), although this effect was not statistically significant ($p = 0.803$). The wide confidence interval suggested considerable variability across firms, likely attributable to differences in reporting practices, measurement inconsistencies, or the relatively weak regulatory frameworks prevalent in many sub-Saharan African economies (Ganda & Milondzo, 2018; Le & Nguyen-Phung, 2024). The findings imply that emissions may exert financial consequences only over longer time horizons.

Third, energy consumption was found to have an almost negligible effect on profitability, with a coefficient close to zero (-0.0044) and no statistical significance ($p = 0.928$). This result suggests that energy usage, in isolation, is not a reliable predictor of firm performance. A plausible explanation lies in sectoral heterogeneity: in some industries, high energy use reflects large-scale production and efficiency, while in others, it signals cost inefficiency. The aggregate neutrality of the results thus reflects these offsetting dynamics.

Fourth, water usage emerged as the only statistically significant predictor of profitability. The coefficient (-0.238, $p < 0.001$) revealed a strong negative association between water dependency and firm performance. This finding implies that firms with greater reliance on water resources tend to record lower profitability, possibly due to high operational costs, inefficiencies in resource utilization, exposure to scarcity risks, or concentration in industries with inherently lower margins such as agriculture, textiles, or resource extraction (Ganda & Milondzo, 2018; Le & Nguyen-Phung, 2024).

Finally, waste generation demonstrated a negative but insignificant coefficient (-0.0511, $p = 0.951$). This suggests that waste generation, at least as measured in this dataset, does not exert a consistent financial effect across firms. Heterogeneity in waste types, disposal methods, and recycling practices may obscure a direct relationship.

In summary, the findings suggest that among the four Green Accounting indicators examined, only water usage exerts a statistically significant impact on profitability, and this effect is negative. The results underscore the uneven and context-specific nature of sustainability profitability linkages.

CONCLUSION

The study concludes that Green Accounting indicators influence financial performance in complex and heterogeneous ways. The evidence demonstrates that water usage is a critical determinant of profitability, with excessive reliance on water resources negatively affecting firm outcomes. This finding highlights the strategic importance of water efficiency not only as an ecological necessity but also as a financial imperative.

Article DOI: 10.52589/AJAFR-LH2TZF8L
DOI URL: https://doi.org/10.52589/AJAFR-LH2TZF8L

By contrast, the lack of significant associations for GHG emissions, energy consumption, and waste generation indicates that these factors may not yet be financially material in the short term within the sub-Saharan African context. This may be explained by weak enforcement of environmental policies, inconsistencies in disclosure practices, or the inherently long-term nature of their financial consequences (Galama & Scholtens, 2021; Ganda & Milondzo, 2018).

Taken together, the findings affirm that while sustainability is a pressing concern, its implications for firm performance are uneven across different environmental dimensions. For sub-Saharan African firms, water efficiency represents both a sustainability priority and a financial necessity.

RECOMMENDATIONS

Therefore, the study profiles the following recommendations:

Companies should enhance Water Management Practices in the area, particularly those in water-intensive sectors, and should invest in conservation technologies, recycling systems, and efficient discharge mechanisms. Improving water efficiency not only reduces operational costs but also enhances resilience to resource scarcity.

Companies should adopt standardized environmental reporting that is aligned with globally recognized frameworks, such as the Global Reporting Initiative (GRI) and the Task Force on Climate-related Financial Disclosures (TCFD). Standardization will improve transparency, comparability, and the credibility of environmental disclosures.

Corporate entities should integrate sustainability into Core Strategy and be embedded into corporate strategy rather than treated as a compliance obligation. Green investments in renewable energy, clean technologies, and eco-efficient production systems can enhance both environmental performance and competitiveness.

Corporations should endeavor to strengthen Stakeholder Engagement communication into sustainability strategies and performance more effectively. Transparent engagement with investors, regulators, and communities can improve corporate reputation and attract ESG-focused capital.

Policymakers should strengthen regulatory enforcement into their mandate and stricter disclosure standards and enforce penalties or incentives to ensure that firms internalize environmental costs.

They should prioritize Water Resource Governance in order for Governments to invest in water infrastructure, support conservation technologies, and establish clear allocation policies. Public-private partnerships could also play a role in addressing water scarcity.

The government should encourage green investments in fiscal incentives, such as tax breaks, subsidies, and grants, to encourage firms to adopt environmentally friendly technologies and practices.

Shareholders should incorporate water risk into investment decisions due to the association of significant negative association between water use and profitability. Investors should consider

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DOI URL: https://doi.org/10.52589/AJAFR-LH2TZF8L

water dependency as a material financial risk. Investors should demand standardized environmental disclosures and reward firms that demonstrate commitment to sustainability. Capital should be directed toward firms with strong sustainability practices, as they are better positioned to generate long-term value and mitigate environmental risks.

FUTURE RESEARCH

While this study has provided valuable insights, several areas warrant further investigation:

Long-Term Impacts: Future research should adopt longer time horizons to capture delayed financial effects of GHG emissions, energy use, and waste management.

Sector-Specific Analysis: Disaggregating firms by industry could reveal sectoral differences in sustainability–profitability relationships.

Cross-Regional Comparisons: Studies that compare sub-Saharan Africa with other regions may determine whether the findings are context-specific or globally applicable.

Broader ESG Dimensions: Future research should integrate social and governance indicators, offering a more comprehensive view of ESG impacts on financial performance.

Causal Inference: Advanced econometric methods, such as the Dumitrescu and Hurlin (2012) panel causality test, could be employed to clarify the direction of causality between environmental performance and profitability.

Refined Environmental Metrics: Intensity-based measures (e.g., emissions per unit of output) should be explored for greater accuracy.

Policy Moderation Effects: Further studies could examine how differences in regulatory strength and institutional quality moderate the sustainability–profitability nexus.

Thus, there are key empirical findings, conclusions, recommendations, and suggested areas for future research. The results revealed that among the Green Accounting measures, only water usage significantly affected profitability, and its effect was negative. This finding emphasizes the dual environmental and financial importance of water efficiency. By contrast, GHG emissions, energy use, and waste generation were not statistically significant predictors of profitability in this study. This underscores the complexity of sustainability–profitability relationships and the need for context-sensitive interpretations. Recommendations were provided for firms, policymakers, and investors to strengthen environmental management practices and enhance financial outcomes. Finally, several avenues for future research were identified, particularly regarding long-term impacts, sectoral variations, and cross-regional comparisons. This synthesis concludes the analytical sections of the study and sets the foundation for broader reflections on the theoretical and practical implications of Green Accounting in emerging economies.

Article DOI: 10.52589/AJAFR-LH2TZF8L
DOI URL: https://doi.org/10.52589/AJAFR-LH2TZF8L

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