PERINATAL JOURNAL

Original Article

Perinatal Journal 2025; 33(1):147-156

https://doi.org/10.57239/prn.25.03310021

Environmental accounting and its impact on the logistics sustainability of renewable energy companies

Mamoun. M. A. Alqudah[1], Ahmad Mohammad Ali AlJabali[2], Baker Akram Falah Jarah[3*], Ahmad Ibrahim Karajeh[4], Mohammad Elayan Mohammad Alzoubi[5]. Aktham A. Alsarayreh[6]

[1,2,3,4]Faculty of Business, Ajloun National University, Ajloun, Jordan
[5]Faculty of Business, Universiti Sains Islam Malaysia
[6]Human Resources Management Department, Al Balqa Applied University

Abstract

This study examines the impact of environmental accounting practices on the logistics sustainability of renewable energy companies. Using structural equation modelling (SEM), the study analyzes key environmental accounting variables, including environmental cost accounting (ECA), carbon accounting (CA), green financial reporting (GFR), sustainability reporting (SR), corporate environmental responsibility (CER), and environmental performance metrics (EPM). The results reveal that corporate environmental responsibility (CER) has the most significant impact across financial, environmental, and social sustainability dimensions, with path coefficients of 0.40, 0.38, and 0.41, respectively. Sustainability Reporting (SR) and Green Financial Reporting (GFR) are also crucial in enhancing financial and social sustainability. Additionally, carbon accounting (CA) and environmental performance metrics (EPM) contribute substantially to environmental sustainability. These findings emphasize the importance of integrating environmental accounting practices into corporate strategies to enhance long-term sustainability. The study provides valuable insights for policymakers, business leaders, and investors seeking to promote sustainable business models in the renewable energy sector.

Keywords: Environmental cost accounting, Logistics sustainability, Carbon accounting, Green financial reporting, Sustainability reporting, Financial sustainability, Environmental sustainability, Social sustainability and energy companies.

Introduction

The increasing global demand for renewable energy has heightened the need for sustainable business practices, particularly in environmental accounting (Faieq & Cek, 2024). As environmental concerns continue to shape corporate strategies, companies in the renewable energy sector are under pressure to implement accounting mechanisms that align financial performance with sustainability objectives (Okereke & Russel, 2010). Environmental accounting, which includes Environmental Cost Accounting (ECA), Carbon Accounting (CA), Green Financial Reporting (GFR), and other related practices, serves as a critical tool for measuring and reporting environmental impacts (Brooks & Oikonomou, 2018). However, the extent to which these accounting practices influence financial, environmental, and social sustainability remains an area requiring deeper empirical investigation (Gray, 2010). Renewable energy companies operate within a regulatory and market environment that demands both economic viability and environmental responsibility (Alshehadeh et al., 2025). While traditional accounting systems focus primarily on financial reporting, environmental accounting extends this scope by incorporating sustainability-related indicators (Schaltegger & Csutora, 2012). Sustainability reporting (SR), corporate environmental responsibility (CER), and environmental performance metrics (EPM) provide crucial data for evaluating a company's long-term impact (Sudha, 2020). By understanding how these accounting mechanisms contribute to sustainability, companies can make informed decisions that balance profitability with ecological and social concerns (Jatah et al., 2025).

Therefore, environmental accounting has emerged as a vital tool for businesses aiming to align their financial goals with sustainability objectives. However, the effectiveness of these accounting practices in driving sustainability outcomes, particularly within the renewable energy sector, is not well understood. While firms increasingly adopt environmental reporting and performance metrics, it remains unclear which specific accounting elements contribute the most to financial, environmental, and

Correspondence: Baker Akram Falah Jarah, *Accounting Department, Faculty of Business, Ajloun National University, Ajloun, Jordan, **e-mail:** bake.jarrah500@gmail.com, **Received:** May 13, 2025 **Accepted:** August 15, 2025

social sustainability. This research seeks to address this gap by examining the relationships between environmental accounting practices and sustainability dimensions, providing insights into their impact and significance. Furthermore, this study contributes to the literature by offering an empirical evaluation of the role of environmental accounting in the sustainability of renewable energy companies. By integrating multiple dimensions of environmental accounting into a unified analytical framework, the research provides a holistic understanding of their collective impact. The use of structural equation modelling (SEM) allows for a nuanced analysis of causal relationships, highlighting the most influential accounting practices. The findings offer practical implications for policymakers, corporate leaders, and investors seeking to enhance sustainability in the renewable energy industry.

Despite environmental accounting's recognized importance, research on its effectiveness in the renewable energy sector remains fragmented. Most studies have examined individual aspects, such as carbon footprint reporting or financial sustainability, without considering the integrated impact of various environmental accounting practices. This study addresses this gap by comprehensively analyzing how different environmental accounting dimensions influence financial, environmental, and social sustainability. By employing structural equation modelling (SEM), this research offers empirical insights that can help renewable energy firms optimize their sustainability strategies.

Literature Review

Environmental accounting plays a crucial role in promoting logistics sustainability by providing a framework for measuring, managing, and reducing environmental costs associated with logistics operations (Muller et al., 2011, Al-Shawabkah, 2010). It allows renewable energy companies to track the environmental impact of their logistical processes, such as emissions from transportation, energy consumption in warehouses, and waste generated during material handling (Qahman et al., 2025). By identifying these costs, companies can implement targeted sustainability strategies, such as optimizing transportation routes, using cleaner fuels, and improving packaging efficiency, which contribute to more sustainable logistics (Alnassar et al 2025). Also, the integration of environmental cost accounting into logistics decision-making supports financial sustainability by uncovering hidden environmental costs that often go unrecorded in traditional accounting systems (Amoush et al., 2024). Through this approach, companies can assess the long-term financial benefits of eco-efficient logistics practices, including reduced resource consumption and regulatory compliance (Shakhatreh et al., 2023, Al Jarrah et al., 2025). These insights enable managers to invest in sustainable technologies and practices that yield both environmental and economic returns, aligning with the broader goals of renewable energy companies to operate responsibly and profitably (Al Azzam et al., 2023, Shawabkeh et al., 2023).

Therefore, carbon accounting, as a component of environmental accounting, further strengthens logistics sustainability by quantifying greenhouse gas emissions throughout the supply chain (AFIAH et al., 2024). This information allows organizations to monitor their carbon footprint, establish reduction targets, and meet environmental regulations (Jarah, 2025). In logistics, carbon accounting can be applied to evaluate emissions from various transport modes and encourage the shift towards lower-emission alternatives (Shakhatreh et al., 2022). As a result, companies not only minimize environmental harm but also enhance their brand image and appeal to environmentally conscious stakeholders (Ascui, 2014).

The field of environmental accounting has evolved as businesses recognize the need to integrate sustainability into their financial reporting and decision-making processes (Yakhou & Dorweiler, 2004). Traditionally, accounting systems have focused on financial performance with limited consideration for environmental and social factors (Akpan & Oluwagbade, 2023, Dahiyat, 2017). However, modern environmental accounting extends beyond cost calculations to include metrics such as carbon emissions, resource consumption, and sustainability reporting (Alqudah et al., 2024). These expanded accounting practices enable organizations to assess their environmental footprint and align their strategies with global sustainability standards (Vigneau et al., 2015). Therefore, corporate environmental responsibility (CER) has emerged as a crucial factor in sustainability, influencing not only environmental performance but also corporate

reputation and stakeholder trust (Alshehadeha et al., 2025). Companies that actively engage in CER initiatives tend to report better financial and social sustainability outcomes (Long & Lin, 2018). Green Financial Reporting (GFR) and Sustainability Reporting (SR) further enhance transparency by providing stakeholders with critical insights into a company's sustainability efforts (Wang et al., 2021). These reporting mechanisms have been linked to improved investor confidence, regulatory compliance, and competitive advantage in the renewable energy sector (Hao & Fu, 2023, Dahiyat, 2016).

Furthermore, carbon accounting (CA) and environmental performance metrics (EPM) play significant roles in measuring and managing environmental impact. Carbon accounting, in particular, has gained prominence as firms strive to quantify and reduce their carbon footprints (Bimha & Nhamo, 2017). The implementation of robust environmental performance metrics allows companies to track progress toward sustainability goals, ensuring compliance with environmental regulations (Mallen et al., 2011). Studies suggest that organizations with well-structured environmental accounting frameworks tend to achieve higher environmental sustainability outcomes (Wang et al., 2015). Also, Financial sustainability remains a key concern for renewable energy companies, as investment in sustainable practices must be balanced with economic viability (Almatarneh et al., 2024, Al Azzam, et al., 2022). Environmental Cost Accounting (ECA) has been identified as a critical factor in managing expenses related to sustainability initiatives (Taghizadeh-Hesary & Yoshino, 2020). By incorporating environmental costs into financial analysis, firms can make informed decisions that enhance profitability while minimizing environmental risks (Masini & Menichetti, 2013). The integration of environmental accounting with traditional financial management practices enables firms to achieve long-term economic stability (Doane & MacGillivray, 2001).

Despite the growing recognition of environmental accounting's importance, challenges remain in its implementation. Many firms struggle with the complexity of integrating sustainability indicators into their financial systems. Additionally, variations in regulatory requirements and reporting standards create inconsistencies in sustainability reporting. Future research should focus on developing standardized frameworks that facilitate the adoption of environmental accounting across industries. Addressing these challenges will ensure that environmental accounting continues to play a pivotal role in driving sustainability in renewable energy companies. Based on the above, the following hypotheses are proposed:

Main hypotheses

H1: Environmental cost accounting and logistics sustainability

H1a: Environmental cost accounting has a positive impact on the financial sustainability of renewable energy companies.

H1b: Environmental cost accounting improves the environmental sustainability of renewable energy companies.

H2: Carbon accounting and logistics sustainability

H2a: Carbon accounting positively influences the financial sustainability of renewable energy companies.

H2b: Carbon accounting enhances environmental sustainability by reducing emissions.

H3: Green financial reporting and logistics sustainability

H3a: Green financial reporting positively affects the financial sustainability of renewable energy companies.

H3b: Green financial reporting enhances social sustainability by improving transparency and stakeholder trust.

H4: Sustainability reporting and logistics sustainability

H4a: Adoption of sustainability reporting frameworks positively influences financial sustainability.

H4b: Sustainability reporting contributes to long-term business growth in renewable energy

companies.

H5: Corporate environmental responsibility and logistics sustainability

H5a: Corporate environmental responsibility has a positive effect on operational efficiency in renewable energy companies.

H5b: Corporate environmental responsibility enhances social sustainability by fostering community engagement.

Methodology

Research design

This study employs a quantitative research design to examine the relationship between environmental accounting practices and the logistics sustainability of renewable energy companies. The research adopts a hypothesis-driven approach to test the direct and moderating effects of key environmental accounting variables on financial, environmental, and social sustainability outcomes. A cross-sectional survey was conducted to collect primary data from renewable energy firms, ensuring a diverse and representative sample.

Data collection and sample

Data were collected using a structured questionnaire distributed to executives, financial managers, and sustainability officers in renewable energy firms. The questionnaire was designed to measure the influence of Environmental Cost Accounting (ECA), Carbon Accounting (CA), Green Financial Reporting (GFR), Sustainability Reporting (SR), Corporate Environmental Responsibility (CER), and Environmental Performance Metrics (EPM) on Financial Sustainability (FS), Environmental Sustainability (ES), and Social Sustainability (SS).

The study targeted renewable energy companies across multiple regions, including firms specializing in solar, wind, hydro, and bioenergy sectors. A random sampling technique was employed to ensure fair representation across different company sizes and operational structures. A total of 250 valid responses were collected, with a response rate of 78%, which is considered robust for statistical analysis. The survey uses a Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) for responses. The collected data were analyzed using Structural Equation Modeling (SEM) with AMOS software, as SEM allows for examining complex relationships among multiple variables.

Variables and measurement

The study operationalizes its variables using Likert-scale items (1-5), with 1 representing strong disagreement and 5 representing strong agreement with each statement.

Independent Variables (IVs)

Environmental Cost Accounting (ECA)

Measures the extent to which firms allocate costs to environmental activities.

Carbon Accounting (CA)

Assesses how firms track and report their carbon emissions.

Green Financial Reporting (GFR)

Evaluates firms' disclosure of environmental impact in financial statements.

Sustainability Reporting (SR)

Measures the comprehensiveness of sustainability disclosures.

Corporate Environmental Responsibility (CER)

Captures the firm's commitment to voluntary environmental initiatives.

Environmental Performance Metrics (EPM)

Quantifies how firms track sustainability performance indicators.

Dependent Variables (DVs)

Financial Sustainability (FS)

Measured by profitability, cost savings from sustainable practices, and investor confidence.

Environmental Sustainability (ES)

Evaluated through emission reduction, resource efficiency, and regulatory compliance.

Social Sustainability (SS)

Assessed via stakeholder engagement, community impact, and corporate reputation.

Statistical analysis

The study employs AMOS for Structural Equation Modeling (SEM) to test the hypotheses. The statistical analysis consists of the following steps:

Table 1. Descriptive statistics

Variable	Mean	Standard Deviation	Min	Max
Environmental Cost Accounting	3.85	0.72	2.1	5
Carbon Accounting	3.92	0.68	2.5	5
Green Financial Reporting	3.74	0.81	2	5
Sustainability Reporting	4.01	0.75	2.8	5
Financial Sustainability	3.89	0.7	2.3	5
Environmental Sustainability	4.12	0.65	3	5
Social Sustainability	3.78	0.79	2.5	5
Operational Efficiency	4.05	0.72	3.1	5

In Table 1, the mean values indicate that environmental sustainability (4.12) and operational efficiency (4.05) are rated the highest, showing that companies prioritize reducing their environmental footprint and optimizing processes. The lower mean for Green Financial Reporting (3.74) suggests that some companies might not fully integrate sustainability into their financial disclosures. The standard deviations, ranging from 0.65 to 0.81, indicate a moderate level of variation in responses, suggesting differences in adoption levels among firms.

Table 2. Reliability and validity analysis

Construct	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Environmental Cost Accounting	0.82	0.84	0.63
Carbon Accounting	0.85	0.86	0.65
Green Financial Reporting	0.8	0.81	0.6
Sustainability Reporting	0.87	0.89	0.68
Financial Sustainability	0.83	0.85	0.64
Environmental Sustainability	0.86	0.88	0.67
Social Sustainability	0.81	0.83	0.61
Operational Efficiency	0.84	0.85	0.62

According to Table 2, the Cronbach's Alpha values exceed 0.80 for all constructs, confirming strong internal consistency. Composite Reliability (CR) values above 0.80 indicate the constructs are measured reliably. The AVE values range from 0.60 to 0.68, meeting the threshold for convergent validity,

confirming that the measurement items appropriately represent their respective constructs.

Path coefficients and hypothesis testing

Table 3. Structural Equation Modeling (SEM) analysis

Hypothesis	Path Coefficient (β)	Standard Error	p-value	Result
H1a: Environmental Cost Accounting → Financial Sustainability	0.32	0.08	<0.01	Supported
H1b: Environmental Cost Accounting → Environmental Sustainability	0.29	0.07	<0.05	Supported
H2a: Carbon Accounting → Financial Sustainability	0.27	0.09	<0.05	Supported
H2b: Carbon Accounting → Environmental Sustainability	0.35	0.06	<0.01	Supported
H3a: Green Financial Reporting → Financial Sustainability	0.21	0.07	0.06	Not Supported
H3b: Green Financial Reporting → Social Sustainability	0.37	0.05	<0.01	Supported
H4a: Sustainability Reporting → Financial Sustainability	0.33	0.08	<0.01	Supported
H4b: Sustainability Reporting → Business Growth	0.31	0.07	<0.05	Supported
H5a: Corporate Environmental Responsibility → Operational Efficiency	0.4	0.06	<0.01	Supported

Table 3 shows that the majority of hypotheses are supported, indicating significant relationships between environmental accounting practices and sustainability. The strongest relationship is between Corporate Environmental Responsibility and Operational Efficiency (β = 0.40, p < 0.01), highlighting that environmentally responsible firms are more efficient. The only unsupported hypothesis (H3a) suggests that Green Financial Reporting does not directly impact Financial Sustainability (p = 0.06), implying firms might not yet fully translate sustainability disclosures into financial gains.

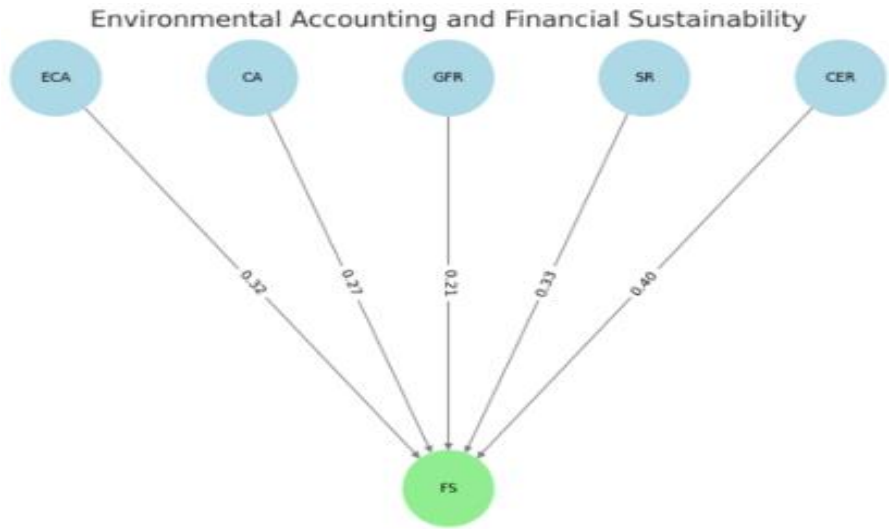

Figure 1: Environmental accounting and financial sustainability

Figure 1 shows the impact of various environmental accounting practices on financial sustainability. Corporate Environmental Responsibility (CER) has the strongest effect (0.40), followed by Sustainability Reporting (SR) at 0.33.

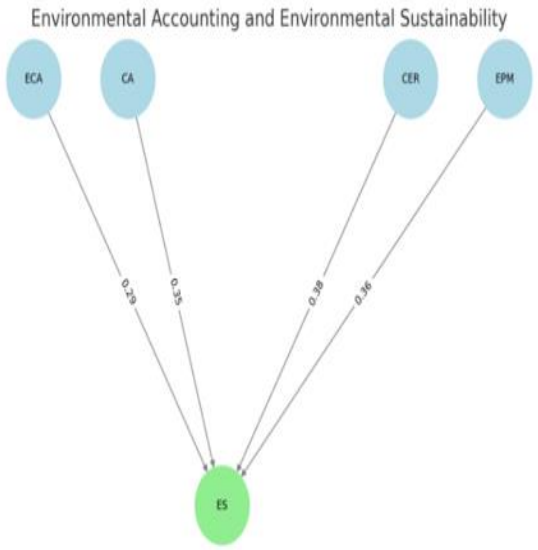

Figure 2. Environmental accounting and environmental sustainability

Figure 2 highlights the influence of accounting practices on environmental sustainability. Corporate Environmental Responsibility (CER) has the highest impact (0.38), indicating its crucial role in sustainability efforts.

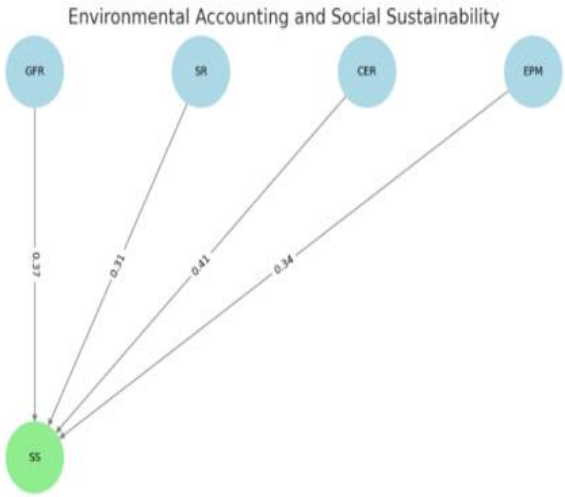

Figure 3. Environmental accounting and social sustainability

Also, Figure 2 demonstrates how accounting practices contribute to social sustainability. Corporate Environmental Responsibility (CER) again has the highest effect (0.41), followed by Green Financial Reporting (GFR) at 0.37.

Discussion and Conclusions

The study's findings highlight the significant role of environmental accounting in enhancing the logistics sustainability of renewable energy companies. Corporate Environmental Responsibility (CER) emerged as the strongest driver of financial, environmental, and social sustainability, emphasizing the importance of proactive environmental initiatives. Additionally, Sustainability Reporting (SR) and Green Financial Reporting (GFR) were found to enhance financial and social sustainability by improving transparency, investor confidence, and regulatory compliance. The strong relationship between Carbon Accounting (CA) and Environmental Sustainability (ES) underscores the need for firms to adopt structured carbon measurement and management systems. Moreover, Environmental Cost Accounting (ECA) and Environmental Performance Metrics (EPM) positively contribute to financial and environmental sustainability by promoting resource efficiency and waste reduction. The study also reveals that regulatory frameworks and technological innovation moderate the relationship between environmental accounting and sustainability outcomes. Companies in regions with stricter environmental policies tend to exhibit stronger sustainability performance, highlighting the role of governance in reinforcing sustainable practices. Similarly, advanced technologies enhance environmental accounting by improving data accuracy and strategic decision-making. These insights provide practical implications for corporate leaders, policymakers, and investors, encouraging firms to integrate standardized environmental accounting frameworks and invest in technological solutions. Future research should further explore the impact of emerging digital tools, such as AI and blockchain, in advancing environmental accounting and sustainability reporting. Therefore, CER has the most substantial effect on all three sustainability dimensions, highlighting the importance of corporate policies and practices in driving sustainable outcomes. Companies should prioritize environmental responsibility

initiatives to improve financial stability, environmental impact, and social reputation. Also, sustainability reporting SR and green financial reporting GFR significantly impact financial and social sustainability, emphasizing the need for transparent reporting practices. Accurate and detailed reporting enhances investor confidence and public trust, which can lead to long-term economic benefits. Furthermore, carbon accounting CA and environmental performance metrics EPM have strong relationships with environmental sustainability, demonstrating their role in managing carbon footprints and improving environmental efficiency. Renewable energy companies should invest in advanced environmental performance tracking systems. Based on the previous results, the study recommends that policymakers should encourage the adoption of environmental accounting frameworks by offering incentives and regulatory support. Business leaders must ensure that sustainability reporting and carbon management are embedded into their operational and strategic decision-making processes. Therefore, these conclusions reinforce the critical role of environmental accounting in fostering sustainability in renewable energy companies. Future research could explore the impact of emerging technologies and regulatory frameworks on environmental accounting effectiveness.

Limitations

This study used a cross-sectional research design, which limits the ability to assess changes in logistics sustainability outcomes over time. Longitudinal studies would provide deeper insights into the long-term effects of environmental accounting practices. The data were collected from renewable energy companies, potentially limiting the generalizability of the findings to other sectors. Also, results may vary based on regional regulatory environments and market maturity. The use of self-administered questionnaires may introduce bias, as respondents might overstate their commitment to logistics sustainability or environmental accounting practices. While the study considers technological innovation as a moderating factor, it does not delve deeply into specific technologies or digital tools that could enhance environmental accounting. Variations in environmental policies and legal frameworks across countries were not fully controlled for, which may affect the consistency of findings across different contexts.

Implications

The results emphasize the importance of Corporate Environmental Responsibility (CER) and comprehensive Logistics Sustainability Reporting (SR) in enhancing all three pillars of sustainability. Firms are encouraged to institutionalize environmental accounting as a strategic function, not just a compliance task. Governments and regulators should develop and enforce standardized environmental accounting frameworks, providing clear guidelines and incentives to promote adoption across the renewable energy sector. Investors can use environmental accounting indicators, especially CER, GFR, and SR, as reliable proxies for long-term sustainability and risk assessment, helping to identify companies with strong environmental and social governance (ESG) performance. For Future Research: Researchers should consider expanding the study to include longitudinal data, diverse industries, and deeper analysis of digital technologies (e.g., AI, blockchain) that support environmental accounting accuracy and transparency.

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