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Environmental costing and sustainable accounting: A comprehensive review: Delving into methods of accounting for environmental impacts in financial statements

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Abstract

This study provides a comprehensive review of the integration of environmental costs into financial reporting within the framework of sustainable accounting. The main objectives were to explore the historical evolution, current practices, challenges, and future trends in environmental accounting, and to assess its impact on businesses, the economy, and stakeholders. Employing a systematic literature review and content analysis methodology, the study analyzed peer-reviewed journal articles, industry reports, and policy documents from 2013 to 2023. Key findings reveal a significant evolution in environmental accounting, transitioning from a marginalized practice to a mainstream component in financial reporting. Current practices are characterized by innovative approaches and technological advancements, reflecting a shift towards holistic and sustainable business operations. The study identified challenges such as the complexity of integrating environmental costs, the need for standardized reporting frameworks, and the requirement for skilled expertise. Opportunities include enhanced corporate transparency, improved stakeholder engagement, and alignment with global sustainability goals. The study concludes with strategic recommendations for business leaders and policymakers, emphasizing the adoption of environmental accounting as a strategic business approach and the development of comprehensive environmental accounting standards. Future research directions include exploring the impact of environmental accounting across different industries, the role of emerging technologies, and the long-term effects on business performance and sustainability. This study contributes to the understanding of environmental costing within sustainable accounting, highlighting its growing importance in the corporate world.

Keywords: Environmental Accounting; Sustainable Financial Reporting; Environmental Cost; Corporate Sustainability.

1. Introduction

1.1. The Emergence and Importance of Environmental Costing in Modern Business Practices.

In the contemporary business landscape, the emergence and importance of environmental costing within sustainable accounting practices have become increasingly prominent. This shift reflects a growing recognition of the critical role that environmental considerations play in the long-term viability and ethical responsibility of businesses. The

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integration of environmental costs into financial statements is not just a trend but a fundamental change in how companies view their operations and impact on the world.

Selvaraj (2023) highlights the significance of green business practices, particularly in micro and small enterprises. The study emphasizes the criticality of environmental parameters in business operations, underscoring the need for companies to balance financial progress with environmental protection and social responsibility. This balance is not merely a compliance issue but a strategic approach that can lead to competitive advantages. The research by Selvaraj (2023) reveals that incorporating green practices into business operations is not only beneficial for the environment but also enhances the company's reputation and stakeholder relations, ultimately contributing to long-term profitability and sustainability.

Similarly, Afiat et al. (2023) delve into the interplay between environmental and financial management in the energy industry. Their case study in the West Java energy sector demonstrates how sustainable business models that integrate environmental and financial objectives can lead to competitive profitability, risk mitigation, and improved access to capital. This study is particularly relevant as it showcases the practical application of environmental costing in a sector that is both economically significant and environmentally sensitive. The findings from Afiat et al. (2023) suggest that companies that commit to sustainable practices, including the adoption of clean technologies and emissions reduction, can achieve financial prosperity while also fulfilling their environmental responsibilities.

Furthermore, the work of Sianipar, Lindrianasari, and Syaipudin (2023) explores the impact of environmental accounting on company value. Their literature review indicates that viewing environmental costs as strategic investments can enhance a company's reputation and long-term value. This perspective is crucial in understanding the importance of environmental costing in modern business practices. By recognizing environmental costs as investments rather than mere expenses, companies can align their business strategies with sustainable development goals, thereby creating value for both the company and society.

In summary, the emergence of environmental costing in modern business practices is a response to the growing awareness of environmental issues and their impact on business sustainability. The integration of environmental considerations into financial reporting, as evidenced by the studies of Selvaraj (2023), Afiat et al. (2023), and Sianipar, Lindrianasari, and Syaipudin (2023), demonstrates a shift towards a more holistic approach to business management. This approach not only addresses the immediate financial concerns of a company but also considers the long-term environmental and social implications of business operations. As such, environmental costing is an essential component of sustainable accounting, enabling businesses to navigate the complex interplay of economic, environmental, and social factors in the pursuit of sustainable growth and development.

1.2. Environmental Costing within the Framework of Sustainable Accounting.

Defining the scope of environmental costing within the framework of sustainable accounting is a complex endeavor that requires a nuanced understanding of the interplay between environmental stewardship and financial accountability. This integration is pivotal in shaping how businesses approach their environmental impact and report it in their financial statements.

Khoruzhy et al. (2023) provide a compelling insight into this integration within the agricultural sector. Their research focuses on the development of an adaptive system of management accounting that emphasizes environmental costs. This approach is particularly relevant in the context of agricultural enterprises, where environmental sustainability is a critical factor. The study underscores the importance of adapting product ranges and production activities to meet the growing demand for organic food and green investments. This adaptation is not just a response to market demands but also a strategic move towards sustainable development. The research by Khoruzhy et al. (2023) illustrates how environmental costing can be effectively incorporated into the management accounting systems of organizations, particularly those in sectors with significant environmental impacts.

Sapozhnikova and Tkacheva (2021) delve into the environmental category of sustainable development reporting in corporations. Their work highlights the need for systematization and disclosure of information on environmental aspects within corporate reporting standards. The typology of environmental protection costs presented in their study forms the basis for indicators that assess the effectiveness of environmental initiatives. This approach to environmental costing is crucial for generating reliable information that enables stakeholders to make informed economic decisions. The insights from Sapozhnikova and Tkacheva (2021) are instrumental in understanding how environmental costs can be systematically reported and used to evaluate corporate sustainability efforts.

Chouhan and Goswami (2022) propose a Sustainable Accounting Framework (SAF) for the Indian cement industry, emphasizing the need for performance metrics that reflect a company's sustainability efforts. Their study reveals a lack of a comprehensive framework for environmental and social reporting in the industry, highlighting the need for a stakeholder perspective on such measures. The SAF developed by Chouhan and Goswami (2022) aims to improve transparency and performance by providing a structured approach to measuring and reporting environmental and social initiatives. This framework is a significant step towards integrating environmental costing into the broader context of sustainable accounting, ensuring that investors and other stakeholders have access to a complete set of information for decision-making.

In summary, defining the scope of environmental costing within sustainable accounting involves developing systems and frameworks that allow for the effective integration of environmental considerations into financial reporting. The research by these authors collectively demonstrate the various ways in which this integration can be achieved. Whether it is through adapting management accounting systems in the agricultural sector, systematizing environmental reporting in corporations, or developing comprehensive frameworks in specific industries like cement, these studies provide valuable insights into how environmental costing can be effectively incorporated within the sustainable accounting paradigm. This integration is essential for businesses to accurately reflect their environmental impact and for stakeholders to assess the sustainability of business practices.

1.3. Historical Evolution of Environmental Accounting

The historical evolution of environmental accounting from a marginalized practice to a mainstream component in financial reporting reflects a significant shift in the corporate world's approach to environmental responsibility. This transition has been shaped by various factors, including regulatory changes, increased stakeholder awareness, and the growing recognition of environmental sustainability as a key component of corporate strategy.

Guzzo and Rotolo (2019) explore the theoretical and historical evolution of firm accounting, emphasizing the increasing importance of non-financial information, particularly social and environmental responsibility, in the accounting debate. Their study traces the developments in Italian and French accounting research, highlighting how the theme of social and environmental responsibility gained prominence throughout the twentieth century. This evolution signifies a broader shift in the accounting field, where non-financial reporting, including environmental accounting, has evolved from being an extension of financial reporting to a critical component in its own right. The research underscores the need for a generalized reporting framework that encompasses both financial and non-financial aspects of corporate performance, reflecting the integrated nature of modern business operations.

Kameel and Festus (2023) provide an analysis of environmental accounting and reporting practices in the Nigerian banking sector, illustrating the global acceptance of environmental accounting as a means to enhance organizational financial performance. Their study reveals that despite the voluntary nature of environmental reporting in Nigeria, there is a growing trend towards adherence to global reporting standards, such as the Global Reporting Initiative (GRI). This trend is indicative of the broader movement in the corporate world towards more transparent and comprehensive environmental disclosure, driven by both internal and external pressures. The research highlights the challenges faced by companies in complying with environmental regulations, including legal frameworks and monitoring issues, underscoring the need for more robust and coordinated efforts in implementing environmental accounting practices.

Barbu, Ionescu-Feleagă, and Ferrat (2022) examine the evolution of environmental reporting in Europe, focusing on the impact of financial and non-financial regulations on corporate environmental disclosure. Their study is motivated by the implementation of the International Accounting Standards (IASs)/International Financial Reporting Standards (IFRSs) and the 2014/95/EU Non-Financial Reporting Directive in the European Union. The research demonstrates how these regulations have significantly improved the level of environmental disclosure among European companies, reflecting a shift towards greater transparency and accountability in environmental reporting. The study provides valuable insights into the role of regulatory frameworks in shaping environmental accounting practices and highlights the importance of such regulations in driving the evolution of environmental reporting.

In summary, the historical evolution of environmental accounting from a peripheral practice to a mainstream element in financial reporting is a testament to the growing recognition of environmental sustainability as a crucial aspect of corporate governance. The research collectively illustrates the dynamic nature of environmental accounting, shaped by regulatory changes, stakeholder demands, and the increasing integration of environmental considerations into business strategies. As environmental accounting continues to evolve, it plays an increasingly vital role in enabling businesses to address their environmental impacts effectively and align their operations with sustainable development goals.

1.4. Aim and Objectives of the Study

The aim of this study is to comprehensively analyze and evaluate the integration of environmental costs into financial reporting within the framework of sustainable accounting. This involves exploring the evolution, current practices, challenges, and future trends in environmental accounting, with a focus on how these practices impact businesses, the economy, and stakeholders in both financial and non-financial sectors.

The objectives of the study are;

- To understand the historical evolution of environmental accounting.
- To examine current best practices and innovations in environmental costing.
- To identify challenges and limitations in current environmental accounting practices.

2. Methodology

2.1. Data Sources

For this study, data sources primarily comprised peer-reviewed academic journals, industry reports, and policy documents. These sources were accessed through various academic databases such as JSTOR, ScienceDirect, Google Scholar, and specific environmental accounting journals. Additionally, reports from environmental agencies, accounting bodies, and sustainability organizations were reviewed to provide a comprehensive understanding of the field.

2.2. Search Strategy

The search strategy involved a systematic approach to identify literature relevant to environmental costing and sustainable accounting. Keywords such as "Environmental Accounting," "Sustainable Accounting," "Environmental Costing," and "Financial Reporting" were used in various combinations. Boolean operators (AND, OR) were employed to refine the search. The search was limited to documents published in English from 2013 to 2023 to ensure the relevance and currency of the data.

2.3. Inclusion and Exclusion Criteria for Relevant Literature

The inclusion and exclusion criteria for relevant literature in this study were meticulously defined to ensure a focused and comprehensive review. For inclusion, the study primarily targeted peer-reviewed journal articles that explicitly focused on environmental accounting and sustainable practices. This encompassed studies providing insights into the evolution, current practices, challenges, and future trends in environmental accounting. Additionally, reports and policy documents from recognized environmental and accounting bodies were included to enrich the analysis with practical and regulatory perspectives. On the exclusion front, the study omitted non-peer-reviewed articles and opinion pieces to maintain academic rigor. Literature that was not directly related to environmental costing or sustainable accounting, despite being in the broader domain of environmental studies or accounting, was also excluded. Furthermore, to ensure the relevance and timeliness of the information, studies published before 2013 or in languages other than English were not considered. This approach aimed to strike a balance between the depth and breadth of the literature, ensuring a focused yet comprehensive understanding of the subject matter.

2.4. Selection Criteria

The selection of literature was based on the relevance to the study's aim and objectives. Abstracts and summaries were initially reviewed to assess relevance. Full texts were then scrutinized for detailed analysis. Priority was given to studies that offered empirical data, comprehensive reviews, or significant theoretical contributions to the field of environmental accounting.

2.5. Data Analysis

Data analysis involved a systematic literature review and content analysis. The literature review synthesized findings from various sources to identify common themes, trends, and gaps in the field. Content analysis was employed to interpret and categorize data, focusing on identifying patterns related to the evolution, challenges, and advancements in environmental accounting. Quantitative data, where available, were analyzed to assess the impact of environmental accounting practices on business performance and stakeholder engagement. Qualitative data were used to understand the complexities and nuances of implementing sustainable accounting practices in different contexts.

The findings from this methodology aim to provide a holistic understanding of environmental costing within the framework of sustainable accounting, offering insights into its implications for businesses, policymakers, and stakeholders.

3. Literature Review

3.1. Fundamental Principles of Environmental Costing in Sustainable Accounting.

The fundamental principles of environmental costing in sustainable accounting are pivotal in guiding corporations towards integrating environmental considerations into their financial reporting and decision-making processes. These principles are essential for businesses to address their environmental impacts effectively and align their operations with sustainable development goals.

Zik-rullahi and Jide (2023) emphasize the significance of green accounting as a fundamental pillar of corporate sustainability reporting. Green accounting, which involves the quantification and communication of the environmental impact of business operations, is crucial for comprehensive sustainability reporting. The study highlights the moderate integration of green accounting across various industries, with reporting frameworks such as the Global Reporting Initiative (GRI) and the Task Force on Climate-related Financial Disclosures (TCFD) being commonly adopted. This adoption indicates a push for standardized reporting and reflects the multifaceted nature of sustainability. The research underscores the importance of stakeholder engagement in ensuring accurate and relevant reporting and recommends emphasizing data integrity, robust stakeholder engagement, and the adoption of technology to enhance the effectiveness of green accounting practices.

Marinho Neto et al. (2018) propose an innovative approach to environmental costing through Activity-Based Costing (ABC) using multicriteria drivers, including economic, emissions, and energy (with an "m") values. This approach, known as ABCsustain, allocates each of the multicriteria drivers into a specific part of the sustainability conceptual model, embracing a holistic perspective for sustainable-based decision-making. The study demonstrates that ABCsustain allows for decisions that support a company's sustainability by managing both the quantity and type of a company's products and activities. This accounting approach effectively integrates environmental issues into companies' strategic planning, moving beyond simple diagnoses to actionable decisions towards a more sustainable world system.

Arif and Abdulazeez (2023) discuss the role of Attributes Based Costing (ABC II) technology in achieving sustainable development goals. Their study examines the effect of cost-based ABC II specifications in supporting decision-making for manufacturing firms in the Kurdistan region of Iraq. The research reveals that ABC II has a significant effect on contributing to sustainable development goals, indicating a strong positive relationship between the application of ABC II and sustainable development. The study concludes that the implementation of advanced managerial accounting techniques, such as ABC II, positively contributes to sustainable development goals achievement, highlighting the importance of new accounting technologies in promoting sustainability.

In summary, the fundamental principles of environmental costing in sustainable accounting involve the integration of environmental considerations into financial reporting and decision-making processes. The research collectively illustrates the diverse approaches and methodologies in environmental costing. These studies underscore the importance of a comprehensive approach to environmental accounting, one that considers the full spectrum of a company's environmental impacts and aligns its financial reporting with sustainable development objectives. As environmental accounting continues to evolve, it plays an increasingly vital role in enabling businesses to address their environmental impacts effectively and align their operations with sustainable development goals.

3.2. Theoretical Frameworks Underpinning Environmental Accounting.

The theoretical frameworks underpinning environmental accounting are crucial for understanding how this practice integrates into the broader context of sustainable accounting. These frameworks provide the foundation for developing and implementing environmental accounting systems that align with sustainable development goals.

Mhmoud, Hamad, and Amen (2023) propose a framework for environmental accounting systems specifically tailored to the construction sector. Their study identifies the objectives of environmental disclosure and the models adopted in accounting disclosure of environmental information by construction companies. The research methodology includes survey lists designed to test hypotheses related to the effectiveness of environmental accounting systems. The study concludes that there is a need to enhance the role of environmental accounting systems within companies, which

contributes to strategic decision-making and overall success in the areas they operate. This framework is significant as it addresses the unique environmental impacts and accounting needs of the construction sector, demonstrating how environmental accounting can be adapted to different industry contexts.

El-Deep, Abu Ajwa, and Abd El-Wahid (2021) focus on the role of environmental taxes in achieving sustainable development. Their proposed accounting framework aims to activate the role of environmental taxes, particularly in the context of brick factories. The study uses introspective and descriptive analytical methods to determine the impact of environmental taxes on sustainable development. The findings include the development of environmental awareness, training for sustainability, and the potential of the tax system to reduce negative environmental impacts. This research highlights the importance of environmental accounting in the context of taxation and its role in promoting sustainable practices in specific industries.

Mondal, Akter, and Polas (2023) conduct a systematic literature review to synthesize a conceptual framework illustrating the link between various factors and environmental accounting disclosure practices. Their study identifies critical motivators of environmental accounting disclosure, such as firm size, profitability, leverage, industry type, and ownership. The research provides insights into the factors influencing environmental accounting practices and underscores the importance of these practices in achieving clean and healthy environments. The proposed conceptual frameworks offer new perspectives for future research and management implications in environmental accounting.

In summary, the theoretical frameworks underpinning environmental accounting play a vital role in guiding the development and implementation of environmental accounting practices. The research by collectively provides a comprehensive understanding of the various aspects and drivers of environmental accounting. These frameworks are essential for businesses to effectively integrate environmental considerations into their accounting practices, thereby aligning their operations with sustainable development goals and contributing to a more sustainable future

3.3. Classification and Types of Environmental Costs in Financial Statements.

The classification and types of environmental costs in financial statements are critical for understanding how businesses account for their environmental impact. This accounting is essential for stakeholders, including investors, regulators, and the public, to assess a company's environmental performance and its commitment to sustainable practices.

Putri, Ariana, and Saputra (2021) analyze the environmental cost accounting treatment at PT Alove Bali and its effect on financial statements and sustainability performance assessment. Their study provides insights into how the company identifies, acknowledges, measures, discloses, and presents environmental costs. The research shows that the company has recognized waste treatment costs, although these are still presented combined with other similar costs as a component of production costs in the income statement. This approach to environmental cost accounting is crucial for the company's environmental management and contributes to its sustainability performance.

The study of Fibriani, Taufiq, and Yusnaini (2020) examines the effect of financial performance and environmental costs on the environmental performance of coal-mining companies listed on the Indonesia Stock Exchange from 2015 to 2018. The study uses various financial ratios to measure financial performance and calculates environmental costs using the rehabilitation provision, reclamation, and mining closure divided by earnings after tax (EAT). The research finds that liquidity and leverage ratios in financial performance affect environmental performance, while profitability ratios and environmental costs do not. This study highlights the complex relationship between financial performance, environmental costs, and environmental performance in the coal-mining sector.

From the foregoing, the classification and types of environmental costs in financial statements are diverse and have different impacts on a company's financial and environmental performance. The research collectively provides a comprehensive understanding of how environmental costs are accounted for in different industries and their implications for financial and sustainability reporting. These insights are crucial for companies to effectively integrate environmental considerations into their accounting practices, thereby aligning their operations with sustainable development goals and contributing to a more sustainable future.

3.4. Key Developments and Milestones in Environmental Accounting Practices.

The field of environmental accounting has witnessed significant developments and milestones, reflecting the growing importance of environmental considerations in business and financial reporting. These advancements are crucial for understanding how businesses can integrate environmental concerns into their accounting practices and decision-making processes.

Brooks and Schopohl (2020) explore the advancement of research in green accounting and finance, focusing on environmental disclosure, value impacts, and management control systems. Their paper serves as an editorial for a special issue in the *British Accounting Review*, which aims to provide new insights into the incorporation of environmental factors into accounting and risk management frameworks. The research highlights the relevance of environmental factors as essential determinants of economic development and business decisions. This study is pivotal in understanding how accounting and finance as academic disciplines can develop innovative approaches to integrate environmental considerations into business practices and mobilize capital flows towards environmentally sustainable economies.

Burritt, Schaltegger, and Christ (2021) examine environmental accounting and the management challenges associated with it. Their work focuses on informing decision-makers about combined environmental and economic matters and supporting improvement processes. The study discusses environmental accounts at both the national and regional macro levels, which are mostly focused on the environmental condition and changes over time. In contrast, company environmental accounting at the micro level either focuses on reporting overall impact, providing detailed internal information for managers, or identifying aspects for improvement. This research is crucial in linking company-related micro-level accounts and activities with macro-level environmental objectives, addressing the economic and management challenge of achieving sustainability.

In conclusion, the key developments and milestones in environmental accounting practices reflect a significant shift towards integrating environmental concerns into financial reporting and business decision-making. These studies underscore the importance of legislative frameworks, international standards, and innovative research in shaping the future of environmental accounting. As businesses continue to navigate the challenges of sustainability, these developments in environmental accounting play a vital role in promoting responsible and sustainable business operations.

3.5. Current Best Practices and Innovations in Environmental Costing.

The current best practices and innovations in environmental costing are pivotal in guiding businesses towards sustainable development. These practices involve the integration of environmental considerations into business operations, decision-making, and financial reporting. The adoption of green technologies and sustainable practices is increasingly recognized as essential for achieving environmental and economic sustainability.

Chovancová et al. (2023) explore the role of technological innovation in achieving sustainable development. The study emphasizes that technology can promote sustainability by incorporating green practices into production methods. However, it is crucial to design technology that balances economic, environmental, and social considerations. The paper provides a systematic overview of the challenges of development over time and according to societal interest. It identifies the direction of progress towards a more holistic and sustainable approach to innovation, aligned with the requirements of Smart Industry 4.0 and 5.0. The significance of advanced tools like Cleaner Production (CP), Environmental Accounting (EA), Pollution Prevention (PP), Recycling (R), Life Cycle Analysis (LCA), Eco-labelling (EL), and the Environmental Technologies Action Plan (ETAP) in promoting sustainable development is highlighted. This research underscores the importance of technological advancements in enhancing the effectiveness of environmental costing and sustainable practices.

Sapuan et al. (2022) focus on the construction and building industry, where sustainable development is becoming increasingly important. The study investigates the most relevant practices for green building employment, evaluates the benefits of executing green building, and analyzes the best practices of green building characteristics. The findings show that green buildings developed using energy-efficient systems and implementing sustainable practices can reduce energy consumption and lower the cost of operating and maintaining these buildings in the long term. The government's role is essential in attracting more participants to implement sustainable practices in the construction and building sector, especially through stringent regulations and appealing incentives. This study highlights the best practices in green building as a key aspect of environmental costing in the construction industry.

Lutfi et al. (2023) examine the factors influencing small and medium enterprises (SMEs) to adopt green innovations. The study uses resource-based view (RBV) theory and the technology–organization–environment (TOE) framework to develop and validate a model that encourages firms to adopt green innovation. The integrated constructs of the model—perceived benefits, top management support, coercive pressure, normative pressure, and mimetic pressure—all predicted green management accounting practices. The study finds that green management accounting practices directly and significantly impact green environmental performance. This research provides clear implications for

decision-makers, highlighting the importance of adopting green practices and innovative technologies to enhance environmental performance.

In summary, the current best practices and innovations in environmental costing involve the adoption of green technologies, sustainable practices, and the integration of environmental considerations into business operations and financial reporting. The research by Chovancová et al. (2023), Sapuan et al. (2022), and Lutfi et al. (2023) collectively provides a comprehensive understanding of the advancements in environmental costing. These studies underscore the importance of technological advancements, sustainable building practices, and green management accounting in promoting environmental sustainability and economic viability. As businesses continue to navigate the challenges of sustainability, these best practices and innovations play a vital role in promoting responsible and sustainable business operations.

3.6. Future Trends and Emerging Concepts in Sustainable Accounting.

The future trends and emerging concepts in sustainable accounting are shaping the way businesses approach environmental and social governance (ESG) issues. These trends are crucial for understanding how sustainable accounting practices are evolving to meet the challenges of a rapidly changing global environment.

Xiao et al. (2023) explore contemporary trends in sustainable finance and ESG investment, highlighting the significance of these dynamics in the modern financial landscape. The study delves into the core concepts of sustainable finance and ESG investment, examining their principles and relevance. It discusses current trends, including the importance of impact investing and the role of green finance in climate resilience. The paper emphasizes ESG integration in investment strategies, covering screening, exclusion criteria, and ESG factors in decision-making. This research is pivotal in understanding how sustainable finance and ESG investment are evolving and their impact on the financial industry and society.

Mondal, Akter, and Polas (2023) conduct a systematic literature review to synthesize a conceptual framework illustrating the link between various factors and environmental accounting disclosure practices. The study identifies critical motivators of environmental accounting disclosure, such as firm size, profitability, leverage, industry type, and ownership. This research provides new insights into future research and management implications in environmental accounting. It underscores the importance of environmental accounting disclosures in helping society achieve clean and healthy environments.

In summary, the future trends and emerging concepts in sustainable accounting involve a deeper integration of ESG factors into financial decision-making, the evolving role of CSR in sustainable development, and the importance of environmental accounting disclosures. The research by collectively provides a comprehensive understanding of the advancements in sustainable accounting. These studies underscore the importance of sustainable finance, CSR, and environmental accounting in promoting responsible business practices and contributing to a more sustainable future. As businesses continue to navigate the challenges of sustainability, these emerging trends and concepts play a vital role in shaping the future of sustainable accounting.

3.6.1. Innovative Approaches in Environmental Costing.

Innovative approaches in environmental costing are increasingly becoming a focal point in sustainable accounting, as businesses seek to align their operations with environmental sustainability goals. These approaches involve the integration of environmental considerations into business operations, decision-making processes, and financial reporting.

Klychova and Gallyamov (2023) analyze approaches to environmental cost accounting in crop production, highlighting the need for systematization and summarization of knowledge about the problems and opportunities of accounting for environmental costs. Their study focuses on the possibilities of accounting for environmental costs in modern automation conditions and formulates a definition of environmental costs that considers the influence of force majeure circumstances on the environmental component in enterprise activities. The research proposes an approach to environmental cost accounting based on the allocation of current and capital expenditure items in financial accounting. This study is significant as it addresses the unique environmental impacts and accounting needs of the agricultural sector, demonstrating how environmental costing can be adapted to different industry contexts.

Scherz et al. (2023) explore the transition of the procurement process to Paris-compatible buildings, considering environmental life cycle costing (eLCC) in the tendering and awarding phase of buildings. Their study validates a theoretical framework through eLCC conducted on a single-family house case study, taking into account external costs

caused by greenhouse gas (GHG) emissions. The research shows that award decisions based on eLCC lead to a reduction in GHG emissions, highlighting the potential of eLCC in influencing award decisions and reducing environmental impacts in the construction industry. This study underscores the importance of incorporating environmental life cycle costs into the procurement process of buildings.

Brooks and Schopohl (2020) advance research in green accounting and finance, focusing on environmental disclosure, value impacts, and management control systems. Their paper provides insights into three key areas of green finance and accounting research: firms' environmental disclosure choices, the value impact of climate change and carbon emissions, and the latest research into environmental management control systems. This research is pivotal in understanding how accounting and finance as academic disciplines can develop innovative approaches to integrate environmental factors into business practices and mobilize capital flows towards environmentally sustainable economies.

In summary, innovative approaches in environmental costing involve the adoption of advanced methodologies, such as environmental life cycle costing, and the integration of environmental considerations into business operations and financial reporting. The research collectively provides a comprehensive understanding of the advancements in environmental costing. These studies underscore the importance of innovative methodologies, sustainable procurement practices, and green accounting in promoting environmental sustainability and economic viability. As businesses continue to navigate the challenges of sustainability, these innovative approaches play a vital role in promoting responsible and sustainable business operations.

3.6.2. *Technological Advancements in Sustainable Accounting Practices*

Technological advancements in sustainable accounting practices are reshaping the way businesses approach environmental sustainability. These advancements are crucial for integrating environmental considerations into business operations, decision-making processes, and financial reporting.

Sudarminto and Harto (2023) discuss green accounting concepts and practices and their impact on environmental sustainability and sustainable business value. The study focuses on the Indonesian context, where green accounting practices include reducing carbon emissions, efficient use of natural resources, and better management of industrial waste. The positive impacts of these practices include improved reputation, operational efficiency, and competitive advantage for companies that adopt them. The article notes that green accounting practices are not a one-size-fits-all approach and must be adapted to each context. With technological developments, increasingly stringent regulations, and public awareness of environmental issues, green accounting practices will remain an integral part of sustainable business strategies in the future.

Chovancová et al. (2023) explore the role of technological innovation in achieving sustainable development. The study provides a systematic overview of the challenges of development over time and according to the scope of societal interest. It identifies the direction of progress towards a more holistic and sustainable approach to innovation, aligned with the requirements of Smart Industry 4.0 and 5.0. The paper delves into the significance of advanced tools like Cleaner Production (CP), Environmental Accounting (EA), Pollution Prevention (PP), Recycling (R), Life Cycle Analysis (LCA), Eco-labelling (EL), and the Environmental Technologies Action Plan (ETAP) in promoting sustainable development. This research underscores the importance of technological advancements in enhancing the effectiveness of environmental costing and sustainable practices.

Nemade et al. (2023) provide a comprehensive analysis of the advancements in agronomic practices that contribute to sustainable crop production. The paper systematically examines the evolution of agronomic practices from traditional methods to contemporary innovations, highlighting the integration of technology, sustainability, and socio-economic factors in modern agriculture. The historical perspective of agronomic practices reveals a transition from rudimentary, labor-intensive methods to technologically driven, precision-based approaches. These tools have revolutionized farming by enabling precise resource management and data-driven decision-making. The study also addresses the vital aspect of environmental sustainability, focusing on strategies for carbon footprint reduction, biodiversity preservation, and ecosystem services enhancement.

In summary, technological advancements in sustainable accounting practices involve the adoption of green accounting concepts, the integration of environmental considerations into business operations, and the use of advanced tools and methodologies. The research collectively provides a comprehensive understanding of the advancements in sustainable accounting practices. These studies underscore the importance of technological advancements, sustainable agronomic practices, and green accounting in promoting environmental sustainability and economic viability. As businesses

continue to navigate the challenges of sustainability, these technological advancements play a vital role in promoting responsible and sustainable business operations.

4. Discussion of Findings

4.1. Evaluating the Impact of Environmental Costing on Business and Economy.

The impact of environmental costing on business and the economy is a multifaceted issue, encompassing various aspects from macro-environmental factors to green supply chain management and green innovation. Understanding this impact is crucial for businesses to align their operations with environmental sustainability goals.

Gini and Agala (2023) examine the influence of macro-environmental factors on business performance in Nigeria. Their study reveals that macro factors such as high interest and inflation rates, terrorism, culture, religion, volatile exchange rates, and susceptibility of the economy to external shocks escalate the cost of doing business and pose serious threats to firm performance. The research concludes that macro environments significantly impact the success of business activities, emphasizing the need for strategic business planning to consider these environmental factors. This study is significant as it highlights the broader environmental context in which businesses operate and the need for adaptive strategies to mitigate the impact of external environmental factors.

Rupa and Saif (2021) explore the impact of Green Supply Chain Management (GSCM) practices on business performance and environmental sustainability in Bangladesh. Their study finds that GSCM practices have a statistically significant impact on cost, waste disposal, resource consumption, and greenhouse gas emission, but the impact on profit was statistically insignificant. The research identifies barriers to implementing GSCM practices, such as lack of IT implementation, high cost of waste disposal, market uncertainty and competition, resistance to change, and lack of top management support. This study underscores the importance of GSCM practices in enhancing environmental sustainability and highlights the challenges businesses face in adopting these practices.

Arsawan et al. (2021) examine the role of environmental strategy and green innovation in building SMEs' environmental performance in an emerging economy. The study uses a survey method on managers and assistant managers of export SMEs concerned with environmental efforts. The results show that environmental strategy significantly affects green innovation in realizing environmental performance. This research is crucial in understanding how environmental strategy and green innovation can enhance the environmental performance of SMEs, contributing to sustainable development goals.

In conclusion, the impact of environmental costing on business and the economy involves a complex interplay of macro-environmental factors, green supply chain management, and green innovation. The research collectively provides a comprehensive understanding of how environmental costing affects business performance and sustainability. These studies highlight the importance of considering external environmental factors, adopting GSCM practices, and implementing green innovation strategies to enhance environmental performance and align business operations with sustainability goals. As businesses continue to navigate the challenges of sustainability, understanding and addressing the impact of environmental costing becomes increasingly vital.

4.1.1. Economic, Social, and Environmental Dimensions.

The economic, social, and environmental dimensions of environmental costing are interrelated and play a crucial role in sustainable development. Understanding these dimensions is essential for businesses to align their operations with environmental sustainability goals and contribute positively to society and the economy.

Grzelak, Borychowski, and Staniszewski (2022) examine the interactions between the economic, social, and environmental dimensions of farming sustainability. Their study, based on surveys of 120 farms in the Wielkopolska region of Poland, uses structural equation modeling to analyze these relationships. The results show significant and positive relationships between the economic, social, and environmental dimensions, indicating synergies between them. The strongest positive relationships exist between the economic and environmental dimensions, suggesting that economic and environmental development can be stimulated simultaneously. This study highlights the complementarity between environmental and economic governance in agricultural practices, emphasizing the need for region-specific strategies in environmental and social policies in rural areas.

Zhao et al. (2019) develop a theoretical framework within the data envelopment analysis context to examine the efficiency of sustainable development systems, composed of economic and environmental subsystems and a social

subsystem. The study explores the performances of these subsystems and their interactions in a linked parallel setting. A case study of 30 major Chinese cities illustrates the approach, showing significant differences in system performances among the cities. The research finds that in some sustainable development systems, the subsystems behave inharmoniously, resulting in significant inefficiency. This study underscores the importance of harmonious interactions between economic, environmental, and social dimensions in achieving overall sustainability.

Mohamed (2020) investigates how social and environmental progress indicators lead economic indicators of development in Sudan. The study uses dynamic econometric methods utilizing time series data to establish analytical links between these development dimensions. The research finds empirical verification that social and environmental performance indicators cause economic growth rather than the other way around. This study provides recommendations and projections on enhancing social progress indicators toward 2030 Sustainable Development Goal (SDG) targets, highlighting the crucial role of social and environmental indicators in driving economic development.

In conclusion, the economic, social, and environmental dimensions of environmental costing are deeply interconnected and play a vital role in sustainable development. These studies highlight the importance of considering all three dimensions in environmental costing and sustainable practices to enhance environmental performance, social well-being, and economic growth. As businesses continue to navigate the challenges of sustainability, understanding and addressing these dimensions becomes increasingly vital.

4.1.2. Challenges and Limitations in Current Environmental Accounting Practices.

The challenges and limitations in current environmental accounting practices are multifaceted, impacting the effectiveness and reliability of environmental reporting and decision-making. Understanding these challenges is crucial for businesses to align their operations with environmental sustainability goals and contribute positively to society and the economy.

Hossain (2019) examines the challenges of environmental accounting practices in selected manufacturing enterprises in Bangladesh. The study, based on primary data collected through questionnaires and expert opinion, highlights critical challenges in implementing environmental accounting in manufacturing enterprises. These challenges include cost involvement, lack of skilled manpower, lack of set rules about environmental accounting, inadequate environmental accounting standards, low adoption of environmental accounting, and no specific principles of environmental accounting. The average mean score of challenges is 2.47 on a scale of 3, indicating significant difficulties faced by enterprises in adopting environmental accounting practices. The study also provides recommendations to overcome these challenges, emphasizing the key role of accountants in environmental accounting and reporting.

Kameel and Festus (2023) analyze environmental accounting and reporting practices of listed banking companies in Nigeria. The study reviews the adherence of these companies to the Global Reporting Initiative (GRI) requirements and identifies challenges for non-compliance with environmental regulations. The research reveals that Nigerian deposit money banks do not strictly adhere to GRI requirements, as environmental reporting is at a voluntary stage in Nigeria. Challenges identified for non-compliance are categorized into three main groups: legal frameworks, banks-related problems, and staff/individual-related problems. The study concludes that environmental accounting and reporting practices are significant to corporate performance reporting, and their inclusion in non-financial reporting has improved corporate decision-making.

Senn and Giordano-Spring (2020) provide insights into insiders' perspectives on environmental accounting disclosures. The study, based on a multiple-case study focusing on eight French listed firms in sensitive industries, explores how regulation guidance affects and shapes disclosure strategies. The findings show that the disclosure of environmental accounting information (EAI) is still in its infancy, with weak definitions and poor guidance in regulations explaining the limitations in disclosure. The study documents separate logics driving environmental expenditure and environmental liability disclosures, highlighting the interpretative strategies depending on the type of data to be disclosed in annual reports.

In conclusion, the challenges and limitations in current environmental accounting practices involve issues related to cost, lack of skilled manpower, inadequate standards, and interpretative strategies in disclosure. These studies highlight the importance of addressing these challenges to enhance the effectiveness and reliability of environmental accounting and reporting. As businesses continue to navigate the challenges of sustainability, understanding and addressing these limitations becomes increasingly vital.

4.1.3. Evolution and Progression in Environmental Costing Methods.

The evolution and progression in environmental costing methods have been significant over the years, with new methodologies and approaches being developed to better assess and manage environmental impacts. These advancements are crucial for businesses and policymakers to make informed decisions that align with environmental sustainability goals.

Sala et al. (2021) explore the evolution of life cycle assessment (LCA) in European policies over three decades. Their study reviews European Union (EU) legal acts and communications explicitly mentioning life cycle thinking (LCT), LCA, life cycle costing (LCC), and environmental footprint (PEF/OEF) from 1990 to 2020. The research shows that LCT and life cycle approaches have been increasingly mentioned in policy, from the Ecolabel Regulation of 1992 to the Green Deal in 2019. The study analyzed a total of 159 policies and 167 communications, finding that life cycle concepts and approaches have been adopted with higher levels of prescriptiveness in some sectors, such as products, vehicles, and waste, while implementation in other sectors, like food and agriculture, is only at a preliminary stage. This study highlights the growing importance of life cycle considerations in EU policies and the need for sector-specific strategies in environmental and social policies.

Wang et al. (2022) evaluate the ecological vulnerability of the Danjiang River Basin (Henan section) using the fuzzy comprehensive evaluation/catastrophe progression method. The study quantitatively analyzes the spatiotemporal evolution patterns of ecological vulnerability in the area and identifies the main evolutionary drivers using GeoDetector. The results show that the ecological vulnerability of the basin was mainly moderate and mild, with an overall vulnerability distribution characteristic of "low in the north and high in the south." The study provides a reference for ecological environmental protection in water source areas, demonstrating the application of advanced methodologies in environmental assessment.

Wu, Wu, Warner, Li, and Liu (2021) address the need to evaluate environmental flow outcomes and inform future management through an interdisciplinary modeling approach in the case of the Lower Yongding River in Beijing. The study simulates the landscape evolution under five flow scenarios and assesses their ecological effects using the CAESAR-Lisflood model and habitat suitability index method. The research finds that higher-flow scenarios generally created larger and more evenly distributed habitat areas but showed a low payback given the higher flow volumes needed. The study emphasizes the importance of targeted channel-floodplain geomorphological restoration for flows to generate desired ecological outcomes, offering a promising modeling framework for future rehabilitation actions in heavily modified urban streams.

The evolution and progression in environmental costing methods involve the adoption of advanced methodologies, such as life cycle assessment, fuzzy comprehensive evaluation, and landscape evolution modeling. These studies highlight the importance of adopting innovative approaches and methodologies to enhance environmental assessment and management. As businesses and policymakers continue to navigate the challenges of sustainability, these advancements in environmental costing methods play a vital role in promoting responsible and sustainable decision-making.

4.1.4. Prospective Developments in Environmental Accounting.

The prospective developments in environmental accounting are shaping the future of how businesses and organizations approach sustainability. These developments are crucial for integrating environmental considerations into business operations, decision-making processes, and financial reporting.

Burritt, Schaltegger, and Christ (2023) discuss the developments in environmental management accounting over the last 20 years from a framework perspective. Their study takes stock of environmental management accounting research and practice, providing a conceptual discussion based on extant literature and the authors' extensive experience. The paper reflects on the developments from the perspective of the framework and looks towards how environmental management accounting could be further developed in the future. It considers the current and future potential of environmental management accounting and managers to contribute towards sustainable development through new areas of application, thematic scopes targeting aspirational sustainability goals, extending spatial scope beyond the organization, development of new social and environmental measures of performance, and implementing new drivers for environmental and sustainability management accounting such as AI and chatbots.

Mhmoud, Hamad, and Amen (2023) propose a framework for environmental accounting systems to achieve sustainable development in the construction sector. The study aims to identify the concept of environmental accounting and accounting classifications related to environmental accounting from the perspective of the contracting sector. It also examines the development of environmental accounting measurement methods and analyzes whether the disclosure of

environmental accounting information improves or negatively affects the performance of the entity. The research methodology depends on the use of survey lists, and the study concludes the need to increase the effective role of environmental accounting systems within companies, contributing to making important strategic decisions.

Bebbington, Laine, Larrinaga, and Michelon (2023) reflect upon how the European Accounting Review has conceived of environmental accounting over its 30-year history. The paper discusses ways in which environmental accounting research can further develop, both within and beyond this journal. After outlining the broader social and ecological context from which environmental accounting has emerged, the authors identify three themes critical for the direction of future research: the financial materiality of ecological issues and their impact on risk, how environmental accounting practices are constructed, and how a new relationship between nature and society may affect accounting practices. The paper envisions a future of environmental accounting research that dovetails with the sustainability ambitions drawn from the detailed targets underpinning the Sustainable Development Goals.

In conclusion, the prospective developments in environmental accounting involve new areas of application, thematic scopes, extending spatial scope, development of new performance measures, and the implementation of innovative technologies. The research by Burritt et al. (2023), Mhmoud et al. (2023), and Bebbington et al. (2023) collectively provides a comprehensive understanding of the future directions in environmental accounting. These studies highlight the importance of evolving environmental accounting practices to enhance sustainability and contribute to a more sustainable future. As businesses and policymakers continue to navigate the challenges of sustainability, these prospective developments play a vital role in shaping the future of environmental accounting.

4.2. The Role of Standards and Regulatory Frameworks in Shaping Environmental Accounting.

The role of standards and regulatory frameworks in shaping environmental accounting is pivotal in guiding businesses and organizations towards sustainable practices. These standards and frameworks provide the necessary structure and guidelines for environmental accounting, ensuring that it is consistent, reliable, and meaningful.

Senn and Giordano-Spring (2020) explore the limitations of environmental accounting disclosure, focusing on the enforcement of regulations, standards, and interpretative strategies. Their study, based on a multiple-case study of eight French listed firms in sensitive industries, reveals that the disclosure of environmental accounting information is still in its infancy. Weak definitions and poor guidance in regulations explain the limitations in disclosure and induce interpretative strategies depending on the type of data to be disclosed. This research is significant as it highlights the challenges faced by companies in complying with environmental accounting standards and the need for clearer and more robust regulatory guidance.

Elamin (2018) discusses environmental accounting and auditing, focusing on the concept of Eco mark, a certification mark issued to products conforming to a set of standards aimed at minimizing the impact on the ecosystem. The paper reviews the environmental drawbacks associated with hydropower projects and emphasizes that regulatory actions alone cannot restore the environment to its pristine state. The study suggests that proactive and promotional roles should be harmonized with the overall environmental protection strategy, highlighting the importance of consumers in prompting manufacturers to adopt clean and eco-friendly technologies.

In conclusion, the role of standards and regulatory frameworks in shaping environmental accounting involves balancing private innovation with public accountability, addressing the challenges in compliance and disclosure, and emphasizing the importance of holistic environmental strategies. The research collectively provides a comprehensive understanding of the impact of standards and regulatory frameworks on environmental accounting. These studies underscore the importance of robust and clear regulations, the need for private-public collaboration, and the role of consumers in promoting sustainable practices. As businesses and policymakers continue to navigate the challenges of sustainability, understanding and shaping these standards and frameworks becomes increasingly vital.

4.3. Implications for Stakeholders in the Business and Financial Sectors

The implications of environmental accounting for stakeholders in the business and financial sectors are significant, as these practices influence decision-making, investment strategies, and corporate transparency. Understanding these implications is crucial for stakeholders to navigate the complexities of environmental sustainability in business operations.

Martínez and Mesa (2021) delve into the status of environmental financial accounting in Mexico from the perspective of stakeholder theory. Their study analyzes the sustainability reports of 29 sustainable companies from the Mexican Stock Exchange, examining the application of social and environmental accounting theories in the Mexican economy.

The findings indicate that while theoretical concepts of environmental accounting have been applied, there are gaps that continue to make environmental financial accounting a challenge in emerging economies due to the lack of public policies. The study identifies the need for environmental accounting concepts to be applied across micro, small, and medium-sized businesses and for a deeper analysis of stakeholder relationships in environmental reports. This research underscores the importance of stakeholder theory in shaping environmental accounting practices and highlights the need for policy support in emerging economies.

Pasko et al. (2023) explore the relationship between accounting conservatism, valued by financial stakeholders, and corporate social performance (CSP), esteemed by non-financial stakeholders. The study assesses the impact of financial reporting practices, specifically accounting conservatism, on a firm's CSP activities. The empirical findings indicate a negative correlation between accounting conservatism and CSP, suggesting that firms with higher levels of social performance adopt less conservative financial reporting policies. This study establishes a connection between firms' unconventional activities, such as CSP, and conservative financial reporting, offering valuable insights for investors, analysts, and regulators on the preferences of financial and non-financial stakeholders in corporate disclosures.

Korchagina (2023) discusses the disclosure of non-financial information in corporate accounting reports, emphasizing its importance for a diverse range of stakeholders, including employees, suppliers, management, shareholders, financial analysts, creditors, and the government. The study analyzes various aspects related to the disclosure of non-financial information, highlighting the need for regulatory principles that would form the basis for such disclosure. The research points out that non-financial disclosure is critical for users of financial reports to make informed decisions, underlining the significance of publishing reliable and timely information in annual reports.

In summary, the implications of environmental accounting for stakeholders in the business and financial sectors involve balancing the interests of financial and non-financial stakeholders, addressing the challenges in emerging economies, and enhancing corporate transparency through non-financial disclosure. These studies highlight the importance of stakeholder theory, the relationship between accounting practices and CSP, and the need for robust non-financial disclosure in corporate accounting. As businesses and policymakers continue to navigate the challenges of sustainability, understanding and addressing these implications becomes increasingly vital for stakeholders in the business and financial sectors.

5. Conclusion

The study has systematically explored the integration of environmental costs into financial reporting within the framework of sustainable accounting. Key insights reveal a significant evolution from marginalization to mainstream acceptance of environmental accounting. Current practices demonstrate a growing emphasis on innovative approaches and technological advancements, reflecting a shift towards holistic and sustainable business operations. The analysis underscores the importance of considering environmental impacts in financial statements, not only as a compliance measure but as a strategic business approach towards sustainability.

Environmental accounting faces both challenges and opportunities. The primary challenges include the complexity of integrating environmental costs into traditional accounting systems, the need for standardized reporting frameworks, and the ongoing requirement for skilled expertise in this evolving field. However, these challenges are accompanied by opportunities, such as the potential for enhanced corporate transparency, improved stakeholder engagement, and the alignment of business practices with global sustainability goals. The increasing focus on environmental sustainability in the corporate world presents a significant opportunity for businesses to innovate and lead in this area.

For business leaders, it is recommended to embrace environmental accounting as a core component of their business strategy, going beyond compliance to leveraging it for competitive advantage. This involves investing in training and development, adopting best practices in environmental costing, and actively engaging with stakeholders on sustainability issues. For policymakers, the emphasis should be on developing and enforcing clear, consistent, and comprehensive environmental accounting standards. Additionally, policies that incentivize sustainable practices and support businesses in their transition towards greener operations can play a crucial role.

This study contributes to the understanding of environmental costing within sustainable accounting, yet there remains ample scope for further research. Future research could explore the impact of environmental accounting on different industry sectors, the role of emerging technologies in enhancing environmental accounting practices, and the long-term effects of environmental accounting on business performance and sustainability. Additionally, comparative studies

across different geographical regions could provide insights into the global applicability and adaptation of environmental accounting practices.

Lastly, environmental costing and sustainable accounting are dynamic and evolving fields with significant implications for businesses, policymakers, and society. As the world increasingly focuses on sustainability, the role of environmental accounting in shaping business practices and contributing to sustainable development becomes ever more critical.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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