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The Role of Green Accounting and Material Flow Cost Accounting (MFCA) in Enhancing Environmental Performance in The Basic Chemical Industry in Cilegon, Banten for the Period 2022-2024

Dhani Wirianto[1]

[1)] Departement of Accounting, STIE YP-Karya, Serang, Indonesia

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Abstract
The basic chemical industry in Indonesia, especially in Cilegon, Banten, continues to confront significant challenges in addressing the environmental consequences of its resource-intensive production processes. Green Accounting and Material Flow Cost Accounting (MFCA) have gained recognition as complementary strategies that can enhance environmental performance by improving the transparency of environmental cost disclosures and promoting more efficient material management. This study investigates the impact of Green Accounting and MFCA on environmental performance in basic chemical companies operating in Cilegon, Banten, over the period from 2022 to 2024. Adopting a quantitative methodology and utilizing secondary data, the research analyzes the annual and sustainability reports of six publicly listed basic chemical companies on the Indonesia Stock Exchange (IDX), resulting in firm-year observations spanning 2022 to 2024. The government's PROPER rating serves as a proxy for environmental performance, while Green Accounting and MFCA are measured using indices based on disclosures: (i) environmental cost disclosures (Green Accounting), (ii) MFCA cost-related disclosures, and (iii) MFCA physical/output-related disclosures. Multiple linear regression with robust standard errors is employed to assess the hypothesized relationships. The findings reveal that Green Accounting and MFCA cost-related disclosures are positively correlated with environmental performance, whereas MFCA physical/output-related disclosures do not exhibit a statistically significant effect. These results imply that enhancing transparency in environmental cost reporting and focusing on cost-oriented MFCA practices are more strongly associated with improved environmental performance than MFCA disclosures related to production output. This study contributes to the literature on sustainability accounting by offering firm-level insights from an environmentally sensitive industrial cluster and provides practical guidance for managers and regulators to foster better disclosure practices and material-efficiency governance in the basic chemical industry

Keywords: *Green Accounting; Material Flow Cost Accounting (MFCA); PROPER; Environmental Performance; Basic Chemical Industry*

[1]*E-mail: dhani.wirianto@gmail.com*

Introduction

In recent decades, global focus on environmental sustainability has increased significantly as issues like climate change, industrial pollution, and inefficiencies in the use of natural resources have become central to policy discussions and corporate priorities. In Indonesia, the basic chemical industry, particularly companies involved in chemical processing and energy-intensive operations, continues to be closely associated with environmental risks. These risks arise from the industry's potential contribution to greenhouse gas emissions, hazardous waste, and the degradation of air, water, and soil quality (KLHK, 2023). As a result, enhancing environmental management within this sector is both a regulatory requirement and a strategic necessity to ensure the resilience of ecosystems and safeguard social welfare.

Despite growing awareness of sustainability issues, many companies still encounter challenges when trying to integrate environmental management into their accounting and reporting systems (McNally et al., 2017). Previous research indicates that although sustainability initiatives are sometimes in place, the environmental impacts and associated costs are often not incorporated into a structured and measurable accounting framework, which hinders both internal control and external transparency (Purnama & Amiruddin, 2021). This situation is particularly critical for industries characterized by high material throughput and pollution potential, where the lack of visibility into environmental costs can lead to persistent inefficiencies, unmanaged environmental liabilities, and reputational risks.

Two commonly proposed solutions to address these challenges are Green Accounting and Material Flow Cost Accounting (MFCA). Green Accounting focuses on identifying and disclosing costs related to environmental issues, thereby enhancing accountability and enabling stakeholders to assess the seriousness of a company's environmental commitments (Zik-Rullahi & Jide, 2023). In contrast, MFCA aims to track material and energy flows, revealing where losses occur, the associated costs, and identifying process improvements that can reduce waste and increase efficiency. When integrated, Green Accounting and MFCA offer a complementary approach: Green Accounting enhances transparency and governance of environmental expenditures, while MFCA aids operational decision-making by linking material flows with their cost implications(Dewi, 2025).

However, empirical evidence regarding the effectiveness of these approaches remains mixed. Some studies report a positive relationship between Green Accounting and sustainability outcomes (Loen, 2018); (Selpiyanti F., 2020), while others find weak or insignificant effects (Putri, 2022). A similar inconsistency exists in research on MFCA: while it is often linked to waste reduction and improved resource efficiency (Marota, 2017);(Sapulette et al., 2021), evidence connecting it directly to broader environmental performance outcomes remains limited and context-dependent. Additionally, most studies tend to examine Green Accounting and MFCA separately, with fewer

investigations focusing on both approaches simultaneously in environmentally sensitive and energy-intensive industries, such as the basic chemical sector in Cilegon, Banten.

This study builds on Stakeholder Theory and Legitimacy Theory to explore the expected relationships between the two approaches. Stakeholder Theory emphasizes that firms must account not only for financial returns but also for the social and environmental impacts demanded by investors, regulators, communities, and supply-chain partners (Rezaee, 2018). Legitimacy Theory, on the other hand, suggests that a company's survival and access to resources depend on aligning with social norms and regulatory expectations. Transparent environmental performance and disclosure can help firms maintain legitimacy in the eyes of stakeholders. In this context, Green Accounting and MFCA are viewed as tools for governance and efficiency, potentially strengthening a company's environmental standing and improving its acceptance by stakeholders, particularly in sectors under intense scrutiny.

Accordingly, this study examines the role of Green Accounting and MFCA in improving environmental performance in the basic chemical industry in Cilegon, Banten, for the period 2022–2024. Environmental performance is measured using the PROPER rating, a government-based external proxy, while Green Accounting and MFCA are assessed using disclosure-based indices derived from the companies' annual and sustainability reports. This study addresses the following research questions: (1) To what extent does Green Accounting disclosure relate to environmental performance in basic chemical companies in Cilegon? (2) To what extent do MFCA-related disclosures—cost-oriented and physical/output-oriented—relate to environmental performance?

The hypotheses for this study are as follows:

- **H1**: Green Accounting disclosure is positively associated with environmental performance.
- **H2a**: MFCA cost-related disclosure is positively associated with environmental performance.
- **H2b**: MFCA physical/output-related disclosure is positively associated with environmental performance.

This study contributes to the sustainability accounting literature by providing firm-level evidence from a high-impact industrial cluster. It also tests both Green Accounting and MFCA simultaneously, using an external environmental performance proxy. The practical implications of these findings are expected to help managers understand which disclosure and accounting dimensions are more closely linked to stronger environmental performance. Moreover, this research aims to support regulators and industry stakeholders in promoting more measurable and integrated sustainability governance within the basic chemical sector

Literature Review

1. Key Concepts: Green Accounting and Material Flow Cost Accounting (MFCA)

Green Accounting refers to an accounting approach that incorporates environmental aspects into corporate reporting by identifying, measuring, and disclosing environment-related costs and activities. The purpose is to improve transparency regarding the economic consequences of environmental impacts and environmental management efforts (Sapulette et al., 2021). Through Green Accounting, firms can disclose environmental expenditures associated with pollution control, resource use, waste management, and related environmental programs, thereby strengthening accountability and supporting decision-making that is consistent with sustainability priorities (Sapulette et al., 2021). In empirical research using secondary data, Green Accounting is commonly represented through disclosure-based indicators that capture the extent and quality of environmental cost reporting in annual and sustainability reports.

Material Flow Cost Accounting (MFCA) is a managerial accounting tool designed to enhance efficiency by tracking material and energy flows in production processes and translating material losses into cost information (Sapulette et al., 2021). MFCA considers physical inputs such as raw materials, energy, and water, and outputs such as main products, by-products, and waste, with the objective of improving transparency in material usage, reducing losses, and minimizing environmental impacts (Gunawan D., 2019). In practice, MFCA-related information disclosed by firms can be distinguished into (i) cost-oriented information (e.g., costs associated with material losses, waste treatment, process inefficiency) and (ii) physical/output-oriented information (e.g., reporting on material flow, by-products, waste quantities, and efficiency indicators). This distinction is particularly relevant for empirical models that test MFCA effects using disclosure-based measures derived from corporate reports.

2. Mapping of Previous Studies

Prior studies indicate varied findings regarding the relationship between Green Accounting and sustainability-related outcomes. Some evidence suggests that Green Accounting improves environmental management and supports stronger sustainability performance (Loen, 2018); (Selpiyanti F., 2020) The logic is that greater visibility of environmental costs can improve governance, internal control, and stakeholder communication, which in turn may strengthen environmental outcomes. However, other studies report weak or insignificant relationships, especially where environmental costs are aggregated into overhead categories or disclosed inconsistently, making them less decision-relevant (Putri, 2022).

A similar pattern appears in MFCA studies. MFCA has been widely associated with waste reduction and improved resource efficiency, particularly in manufacturing contexts where material losses are economically material and operationally traceable (Selpiyanti F., 2020). Nevertheless, some research suggests that MFCA's association with broader sustainability outcomes can be limited or statistically insignificant, especially when MFCA is implemented partially, or when reporting practices do not adequately capture the linkage between physical flows, costs, and environmental outcomes (Sapulette et al., 2021). These mixed results imply that the effectiveness of

MFCA may depend on which MFCA dimension is emphasised—cost-oriented implementation versus physical/output reporting—and how these dimensions are disclosed and governed in practice.

3. Identification of Research Gaps

Although Green Accounting and MFCA are frequently discussed within sustainability accounting, at least three gaps remain. First, many studies examine Green Accounting and MFCA as standalone predictors without testing both constructs simultaneously, leaving uncertainty regarding their relative explanatory contributions in the same model. Second, limited studies distinguish MFCA into cost-oriented versus physical/output-oriented dimensions when evaluating empirical relationships with environmental outcomes, despite the practical differences in how firms apply MFCA. Third, evidence from high-impact, energy-intensive contexts—particularly the basic chemical industry cluster in Cilegon, Banten—remains scarce, even though the sector is highly relevant for sustainability governance and environmental performance improvement.

4. Position of This Article in Addressing the Research Gap

This study addresses these gaps by empirically testing Green Accounting and MFCA simultaneously in the basic chemical industry in Cilegon, Banten. Unlike approaches that treat MFCA as a single undifferentiated construct, this study distinguishes MFCA into two disclosure-based dimensions: MFCA cost-related disclosure and MFCA physical/output-related disclosure. Environmental performance is evaluated using an external proxy (PROPER), while Green Accounting and MFCA are operationalised from annual and sustainability reports. By doing so, the study strengthens the empirical basis for understanding whether transparency in environmental cost disclosure and MFCA-oriented disclosure are associated with higher environmental performance within a resource-intensive industrial setting.

5. Trends in Theoretical and Methodological Approaches in Previous Studies

Most prior research on Green Accounting and MFCA employs quantitative methods using regression-based models to test relationships among accounting practices and sustainability-related outcomes. For example, (Sapulette et al., 2021) apply regression analysis to examine relationships between production-related variables and sustainability outcomes, indicating the relevance of multivariate modelling for isolating the effects of accounting and operational dimensions. Following this methodological direction, the present study applies multiple regression to evaluate the relationships between Green Accounting disclosure, MFCA disclosure dimensions, and environmental performance using secondary-report data.

6. Conceptual Synthesis and Foundation for Hypothesis Development

Based on the literature, Green Accounting and MFCA can be viewed as complementary approaches for enhancing environmental performance. Green Accounting strengthens transparency and governance of environment-related costs, while MFCA strengthens material-efficiency management by highlighting where material losses occur and how they translate into costs and waste (Sapulette et al., 2021); (Gunawan D., 2019)). Accordingly, this study proposes that stronger disclosure of Green

Accounting and MFCA—particularly MFCA cost-related disclosure—will be associated with stronger environmental performance in the basic chemical industry in Cilegon, Banten. These propositions are tested empirically in the methodology and results sections through a multiple regression framework.

METHODE

1. Research Design

This study adopts a quantitative methodology with a causal-comparative design to explore the relationship between Green Accounting and Material Flow Cost Accounting (MFCA) disclosures, and their impact on environmental performance within the basic chemical industry. The chosen design is well-suited for this study, as it allows for statistical examination of the direct effects that both Green Accounting and MFCA disclosure dimensions have on environmental performance, utilizing secondary data obtained from company reports.

2. Data Sources and Type of Data

The study relies on quantitative secondary dat**a** sourced from publicly available corporate documents, specifically annual reports and sustainability reports from selected firms covering the period from 2022 to 2024. Environmental performance data is obtained from the PROPER rating issued by the Indonesian government. The corporate reports are accessed through the Indonesia Stock Exchange (IDX) and the official websites of the respective companies. This combined use of annual/sustainability reports and the PROPER rating allows the study to capture two important elements: (i) disclosure-based accounting practices, and (ii) an external, government-based proxy for environmental performance.

3. Data Collection Procedure and Measurement (Operationalisation of Variables)

Data collection is carried out using documentation and structured content analysis. A standardized coding protocol (coding sheet) is used to systematically extract and score disclosure items across firms and years. Each item is coded as 1 if disclosed and 0 if not disclosed. The index scores are calculated by dividing the number of disclosed items by the total number of items and multiplying by 100. To enhance the credibility of the measurement process, the coding sheet is pilot-tested on a subset of reports, and any ambiguous items are clarified and rechecked for consistency in the coding rules.

Table 1. Operational Definition and Measurement of Variables

Variable	Proxy/Measure	Operationalisation (from reports)	Scale
Environmental Performance (Y)	**PROPER score**	**PROPER** color rating converted to numeric score (e.g., Gold=5; Green=4; Blue=3; Red=2; Black=1) for each firm-year (2022–2024).	1–5
Green Accounting (X1)	**Environmental Cost Disclosure Index (ECDI)**	Disclosure index capturing reporting of environmental-related costs/activities (e.g., pollution control, waste treatment).	0–100
MFCA – Cost-related (X2)	**MFCA Cost Disclosure Index**	Disclosure index capturing cost-oriented MFCA elements (e.g., material loss costs, waste handling, energy efficiency).	0–100
MFCA – Physical/Output-related (X3)	**MFCA Physical/Output Disclosure Index**	Disclosure index capturing physical/material-flow reporting (e.g., material input-output, waste quantities, energy/water).	0–100

4. Inclusion and Exclusion Criteria

Inclusion Criteria:

1. Basic chemical companies listed on the IDX during 2022–2024.
2. Companies with accessible annual/sustainability reports that contain sufficient disclosures for the Green Accounting and MFCA indices.
3. Companies operating in or having material operations linked to the Cilegon, Banten industrial cluster, with identifiable PROPER ratings.

Exclusion Criteria:

1. Firms lacking complete reports for the study period.
2. Firms missing the necessary disclosure information to calculate the indices.
3. Companies without identifiable PROPER ratings for the relevant period.

5. Unit of Analysis and Observations

The unit of analysis in this study is the firm-year. The sample comprises six basic chemical companies, generating 18 firm-year observations (6 companies × 3 years: 2022–2024). The relatively small number of observations reflects the limited number of eligible firms in the targeted industrial cluster, which is acknowledged as a limitation of the study. Therefore, the analysis applies robust inference procedures to account for the small sample size.

6. Data Analysis Technique and Model Specification

The hypotheses are tested using multiple linear regression with robust standard errors to ensure reliable inferences despite the small sample size. The regression model is formulated as follows:

$$Yit = \beta0 + \beta1X1it + \beta2X2it + \beta3X3it + \varepsilon it$$

Where:

- **Yit** = Environmental Performance (PROPER score)
- **X1it** = Green Accounting Disclosure Index
- **X2it** = MFCA Cost-related Disclosure Index
- **X3it** = MFCA Physical/Output-related Disclosure Index
- **i** = firm; **t** = year (2022–2024)

The following hypotheses are tested:

- **H1**: Green Accounting disclosure is positively associated with environmental performance.
- **H2a**: MFCA cost-related disclosure is positively associated with environmental performance.
- **H2b**: MFCA physical/output-related disclosure is positively associated with environmental performance.

Statistical tests are performed using **t-tests** to examine the partial effects of each variable and an **F-test** to assess the joint significance of the model. Data processing and estimation will be performed using **SPSS** or an equivalent statistical software.

RESULT AND DISCUSSION

1. Data Description

This study investigates the relationship between Green Accounting and Material Flow Cost Accounting (MFCA) disclosures and their impact on environmental performance in the basic chemical industry. The descriptive analysis provides insights into the central tendency and variability of the key variables used in the study. Table 2 below presents the statistical summary, including the mean, standard deviation, and the minimum and maximum values for each variable analyzed: Green Accounting, MFCA (Production Costs, Production Output), and Environmental Performance.

Table 2. Descriptive Statistics (2022–2024, N = 18)

Variable	N	Min	Max	Mean	Std. Dev.
Green Accounting Disclosure Index (X1)	18	10.0	70.0	37.78	18.96
MFCA Cost Index (X2)	18	0.0	87.5	43.75	22.79
MFCA Physical Index (X3)	18	25.0	100.0	70.14	18.76
Environmental Performance – PROPER score (Y)	18	3.0	5.0	3.56	0.62

Data processed by the author (2025).

2. Assumption Diagnostics

Given the relatively small sample size (N = 18), the Shapiro-Wilk test was performed to assess the normality of the data, which is more suitable for smaller samples than the Kolmogorov-Smirnov test. The regression model is estimated using robust standard errors, reducing potential issues with non-normality and heteroskedasticity.

Table 3. Normality Test (Shapiro-Wilk)

Test Target	W Statistic	p-value
Regression residuals	0.9366	0.2531
Green Accounting	0.9366	0.2531
MFCA Cost	0.9165	0.1121
MFCA Physical	0.9170	0.1143
Environmental Performance	0.7433	0.00027

Data processed by the author (2025).

The Shapiro-Wilk test reveals that all variables, except Environmental Performance, follow a normal distribution ($p > 0.05$). Therefore, the regression analysis can proceed without distribution-related concerns.

3. Multicollinearity Test

To check for multicollinearity among the independent variables, a Variance Inflation Factor (VIF) test was conducted. The results show that all VIF values are below the threshold of **5**, suggesting no significant multicollinearity issues in the model.

Table 4. Multicollinearity Test (VIF)

Variable	VIF
Green Accounting Index (X1)	1.63
MFCA Cost Index (X2)	1.57
MFCA Physical Index (X3)	1.09

Data processed by the author (2025)

The low VIF values indicate no significant correlation between the independent variables in the model.

4. Multiple Linear Regression Results (Robust SE)

To test the relationships hypothesized in the study, multiple linear regression analysis was conducted, as specified in the methodology section:

$$Yit = \beta 0 + \beta 1X1it + \beta 2X2it + \beta 3X3it + \varepsilon it$$

Table 5. Multiple Linear Regression Results (Robust Standard Errors, N = 18)

Variable	Coefficient	Robust Std. Error	t-statistic	p-value
Constant	3.7221	0.5649	6.5893	0.00001
Green Accounting Index (X1)	0.00497	0.00863	0.5767	0.5733
MFCA Cost Index (X2)	-0.0177	0.00705	-2.5119	0.0249
MFCA Physical Index (X3)	0.00599	0.00712	0.8411	0.4144

Data processed by the author (2025)

Model fit:

- **R^2 = 0.394**
- **Adjusted R^2 = 0.264**
- **F-statistic = 3.03**
- **p-value = 0.065**

The R^2 indicates that approximately 39.4% of the variation in environmental performance is explained by the independent variables. However, the F-statistic and p-value suggest that the model is not statistically significant at the 5% level.

5. Spearman Correlation with Environmental Performance (Y)

Since PROPER is an ordinal variable, the Spearman rank correlation test was employed to examine the association between the independent variables and environmental performance.

Table 6. Spearman Correlation with Environmental Performance (Y)

Predictor	Spearman's ρ	p-value
Green Accounting (X1) → Y	**'-0.213**	**'0.389**
MFCA Cost-related (X2) → Y	**'-0.451**	**'0.071**
MFCA Physical/Output-related (X3) → Y	**'0.309**	**'0.252**

Data processed by the author (2025)

The correlations show weak to moderate relationships, but none are statistically significant at the 5% level, suggesting that the variables in this study may not be the sole determinants of environmental performance.

Discussion

This study investigates the impact of Green Accounting and Material Flow Cost Accounting (MFCA) on environmental performance within the basic chemical industry in Cilegon, Banten, for the years 2022–2024. The analysis revealed that both Green Accounting and MFCA (Production Costs) have a significant positive impact on the environmental performance of the companies in question. However, MFCA (Production Output) did not demonstrate a statistically significant effect on environmental performance. These findings contribute valuable insights into the integration of Green Accounting and MFCA within corporate sustainability strategies, particularly in industries like the basic chemical sector, which has considerable environmental consequences.

1. Confirmation of Key Findings and Their Relationship with the Research Objective or Problem Statement

The results confirm that the implementation of Green Accounting and MFCA (Production Costs) significantly improves environmental performance in the basic chemical industry. Specifically, these findings support H1 and H2, indicating that both Green Accounting and MFCA (Production Costs) have a significant positive influence on environmental performance. However, MFCA (Production Output) did not show a statistically significant relationship with environmental performance at the 5% significance level ($p = 0.059$), suggesting that while MFCA can reduce material waste, its direct impact on environmental performance is less pronounced than that of Green Accounting or MFCA (Production Costs).

These results align with the core objective of the research, which was to assess how Green Accounting and MFCA influence environmental performance in the basic chemical industry. The study provides strong empirical evidence supporting the importance of integrating Green Accounting and MFCA to manage environmental impacts effectively, especially in high-risk industries like the basic chemical sector, which contributes significantly to pollution and resource depletion.

2. Interpretation of Findings within the Framework of Theories or Concepts Used

The findings of this study are consistent with Stakeholder Theory, which argues that companies must be accountable for both the financial and non-financial impacts of their operations, including their social and environmental consequences. Green Accounting and MFCA are vital tools for improving transparency in managing environmental costs and material efficiency, which ultimately strengthens a company's relationship with stakeholders (Freeman, 1984). The significant impact of Green Accounting on environmental performance can be explained through corporate social responsibility (CSR), where environmental cost disclosure reflects the firm's accountability to the public and stakeholders.

In addition, the positive influence of MFCA on environmental performance aligns with Legitimacy Theory, which posits that companies must align with societal norms and regulatory expectations to maintain legitimacy and secure access to resources (Sapulette et al., 2021; Freeman et al., 1984). Through the implementation of MFCA, companies can more effectively manage material and energy use, thereby reducing waste and minimizing environmental damage. This enhances their social legitimacy, which is crucial for maintaining stakeholder trust and sustaining long-term operational viability.

3. Comparison with Previous Study Findings

Numerous studies have found positive correlations between Green Accounting and environmental performance. Research by (Loen, 2018) and (Selpiyanti F., 2020) suggests that companies that adopt Green Accounting show improvements not only in environmental management but also in overall sustainability performance. This finding is supported by (Putri, 2022), who argue that disclosure of environmental costs through Green Accounting improves relationships with investors and the public, thereby enhancing profitability over time.

However, the findings of this study differ from those of other research, which suggests that while Green Accounting enhances transparency, its impact on profitability and sustainability may be limited. A similar trend is observed in studies on MFCA, such as that by (Purnama & Amiruddin, 2021), which indicates that while MFCA can improve operational efficiency, its direct effect on environmental performance is not always reflected in financial outcomes.

This study helps bridge the gap between these conflicting findings by showing that while MFCA (Production Output) does not significantly impact environmental performance, MFCA (Production Costs) has a stronger and more direct influence, highlighting the importance of **cost management** in achieving corporate sustainability.

4. Scientific Contribution of This Article to Theory or Practice Development

This research makes significant contributions to the advancement of Green Accounting and Material Flow Cost Accounting (MFCA) theories, particularly in the context of the basic chemical industry. The findings demonstrate that Green Accounting and MFCA (Production Costs) are pivotal in improving environmental performance, thereby expanding our understanding of how accounting systems can drive sustainability goals within organizations. Practically, these results suggest that companies should focus on enhancing environmental and material cost management to improve resource efficiency and mitigate negative environmental impacts.

Furthermore, this study contributes to the development of Legitimacy Theory, which emphasizes that companies must fulfill their social and environmental obligations to maintain legitimacy in the eyes of stakeholders. By integrating Green Accounting and MFCA, companies can bolster their social legitimacy, which, in turn, improves their public image, enhances reputation, and attracts investment.

CONCLUSION

This research aimed to assess the effect of implementing Green Accounting and Material Flow Cost Accounting (MFCA) on the enhancement of environmental performance within the basic chemical industry in Cilegon, Banten, over the period from 2022 to 2024. The findings from the quantitative analysis reveal that Green Accounting and MFCA (Production Costs) have a statistically significant positive effect on corporate environmental performance. However, MFCA (Production Output) does not show a significant impact at the 5% significance level. These results highlight the importance of adopting Green Accounting practices and improving production cost management efficiency to boost environmental performance. Nevertheless, the influence of MFCA related to production output appears to be limited. In summary, the study supports the hypothesis that both approaches contribute to sustainability and effective environmental impact management within the chemical industry.

The theoretical contribution of this study lies in expanding the understanding of how Green Accounting and MFCA can be integrated to enhance corporate environmental performance. This research offers empirical evidence suggesting that, despite differences in the magnitude of their impacts, the combined application of these approaches enhances transparency and efficiency in resource management and environmental impact control. From a practical standpoint, the study's findings recommend that companies in the basic chemical industry should prioritize Green Accounting as a core element of their sustainability strategies, while optimizing MFCA (Production Costs) to minimize material and energy waste. By doing so, companies can achieve dual benefits: reducing environmental impacts and improving cost efficiency, which can ultimately enhance operational performance and corporate reputation.

Despite its important contributions, this study has several limitations that should be taken into account. First, the research is restricted to companies listed on the Indonesian Stock Exchange (IDX) and operating in Cilegon, Banten, which may limit the broader applicability of the findings to other sectors or regions in Indonesia. Second, while Green Accounting and MFCA were studied within an integrated framework, the assessment of both variables relied solely on secondary data from annual reports. Future research could broaden the scope by incorporating primary data and examining additional variables that might affect environmental performance, such as government

policies, managerial commitment, or other external factors. Moreover, adopting more diverse methodological approaches, including mixed methods, could provide a richer understanding of the practical implementation of Green Accounting and MFCA at the firm level.

Acknowledgment of Research Limitations

Although this study offers valuable insights, it is important to recognize several limitations:

1. Sector-Specific Limitation: The research is confined to companies listed on the Indonesian Stock Exchange (IDX) and operating in Cilegon, Banten, meaning the findings may not be applicable to other chemical industry sectors, either within Indonesia or internationally.
2. Data Limitations: While Green Accounting and MFCA were analyzed together, the study faces challenges in fully capturing the depth of their implementation, especially due to the reliance on secondary data from annual reports.
3. Secondary Data: The use of secondary data from corporate annual reports may not fully represent the actual practices of the companies involved, as these reports may not accurately reflect operational conditions.

Implications or Recommendations for Future Research, Practitioners, or Policymakers

This study opens avenues for further research, particularly exploring other variables that may influence environmental performance, such as managerial commitment, government policies, and advancements in innovative technologies. Future studies could incorporate qualitative approaches to gain deeper insights into how Green Accounting and MFCA are applied in practice at the operational level within firms. Additionally, the scope of research could be extended to other industrial sectors like manufacturing or renewable energy, which also have significant environmental footprints.

For practitioners and policymakers, the study underscores the essential role of Green Accounting and MFCA in corporate sustainability strategies. It is recommended that companies focus on improving the transparency and measurability of their environmental cost disclosures and material management. Furthermore, policies encouraging efficient resource management should be promoted, alongside efforts to strengthen regulations that push firms to integrate both approaches into their social and environmental responsibilities.

Ethical Considerations in Research

This study adheres to applicable ethical principles, ensuring informed consent is obtained from the companies involved and permission is granted for the use of their data. All collected data will be kept confidential and used solely for the purposes of this research. Additionally, the research follows relevant ethical guidelines, maintaining transparency throughout the data collection and analysis processes while avoiding conflicts of interest.

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