Board Diversity, Sustainability Committee, And Environmental Performance As Determinants Of Carbon Emission Disclosure: Evidence From Indonesian Listed Companies

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ABSTRACT

This study examines the determinants of carbon emission disclosure among non-financial companies listed in the Top 100 Capitalization market on the Indonesian Stock Exchange (IDX) during the 2020–2024 period. While prior research has yielded mixed findings on the relationship between board characteristics and carbon disclosure, limited evidence exists in the Indonesian context, particularly regarding the combined effects of board diversity, sustainability committees, and environmental performance. Drawing on Stakeholder Theory, Legitimacy Theory, Agency Theory, and Critical Mass Theory, this study employs panel data regression analysis on 80 firm-year observations. The findings reveal that nationality diversity ($\beta = 0.932$, $p < 0.001$) and sustainability committee presence ($\beta = 0.118$, $p = 0.013$) have significant positive effects on carbon emission disclosure. However, gender diversity ($p = 0.859$) and environmental performance measured by the PROPER rating ($p = 0.099$) show no significant influence. The model explains 59.1% of the variance in carbon emission disclosure (Adjusted $R^2 = 0.591$). This research contributes to the literature by providing empirical evidence from an emerging economy context and offers practical implications for corporate governance policies in Indonesia.

ABSTRAK

Sudi ini mengkaji determinan pengungkapan emisi karbon di antara perusahaan non-keuangan yang terdaftar dalam 100 Perusahaan dengan Kapitalisasi Pasar Terbesar di Bursa Efek Indonesia (BEI) selama periode 2020–2024. Meskipun penelitian sebelumnya menghasilkan temuan yang beragam mengenai hubungan antara karakteristik dewan direksi dan pengungkapan karbon, bukti terbatas tersedia dalam konteks Indonesia, khususnya terkait efek gabungan dari keberagaman dewan, komite keberlanjutan, dan kinerja lingkungan. Dengan berlandaskan pada Stakeholder Theory, Legitimacy Theory, Agency Theory, *dan* Critical Mass Theory, *studi ini menggunakan analisis regresi data panel pada 80 observasi perusahaan-tahun. Hasil penelitian menunjukkan bahwa keberagaman kewarganegaraan ($\beta = 0{,}932$, $p < 0{,}001$) dan keberadaan komite keberlanjutan ($\beta = 0{,}118$, $p = 0{,}013$) memiliki pengaruh positif yang signifikan terhadap pengungkapan emisi karbon. Namun, keberagaman gender ($p = 0{,}859$) dan kinerja lingkungan yang diukur melalui peringkat PROPER ($p = 0{,}099$) tidak menunjukkan pengaruh yang signifikan. Model ini menjelaskan 59,1% varians dalam pengungkapan emisi karbon (Adjusted $R^2 = 0{,}591$). Penelitian ini memberikan kontribusi pada literatur dengan menyajikan bukti empiris dari konteks negara berkembang serta menawarkan implikasi praktis bagi kebijakan tata kelola perusahaan di Indonesia.*

INTRODUCTION

Climate change has emerged as a pressing global issue with far-reaching consequences for the environment and humanity. Human activities, particularly the burning of fossil fuels such as coal, oil, and gas, have significantly contributed to the rise in global temperatures by increasing atmospheric carbon dioxide (CO_2) concentrations. This phenomenon has led to a range of adverse impacts, including rising sea levels and increasingly extreme weather events. Al-Qahtani and Elgharbawy (2020) underscore the urgency of addressing climate change by highlighting the accelerating rate of environmental degradation. According to the Intergovernmental Panel on Climate Change (IPCC, 2023), global surface temperatures have risen by approximately 1.1°C above pre-industrial levels, with carbon emissions from fossil fuels being the primary driver.

Indonesia, one of the world's top six greenhouse gas emitters, plays a significant role in the global climate change discourse. Based on data from the World Resources Institute (WRI, 2022), Indonesia's CO_2 emissions have shown a consistent upward trend from 1992 to 2019, with a notable acceleration in the 2000s (Figure 1). Indonesia faces significant challenges in mitigating its carbon footprint and fulfilling its environmental responsibilities, given its substantial contribution to regional carbon emissions. In response, Brazil has committed to several international agreements, including the Kyoto Protocol and the Paris Agreement, to reduce emissions and adapt to the impacts of climate change.

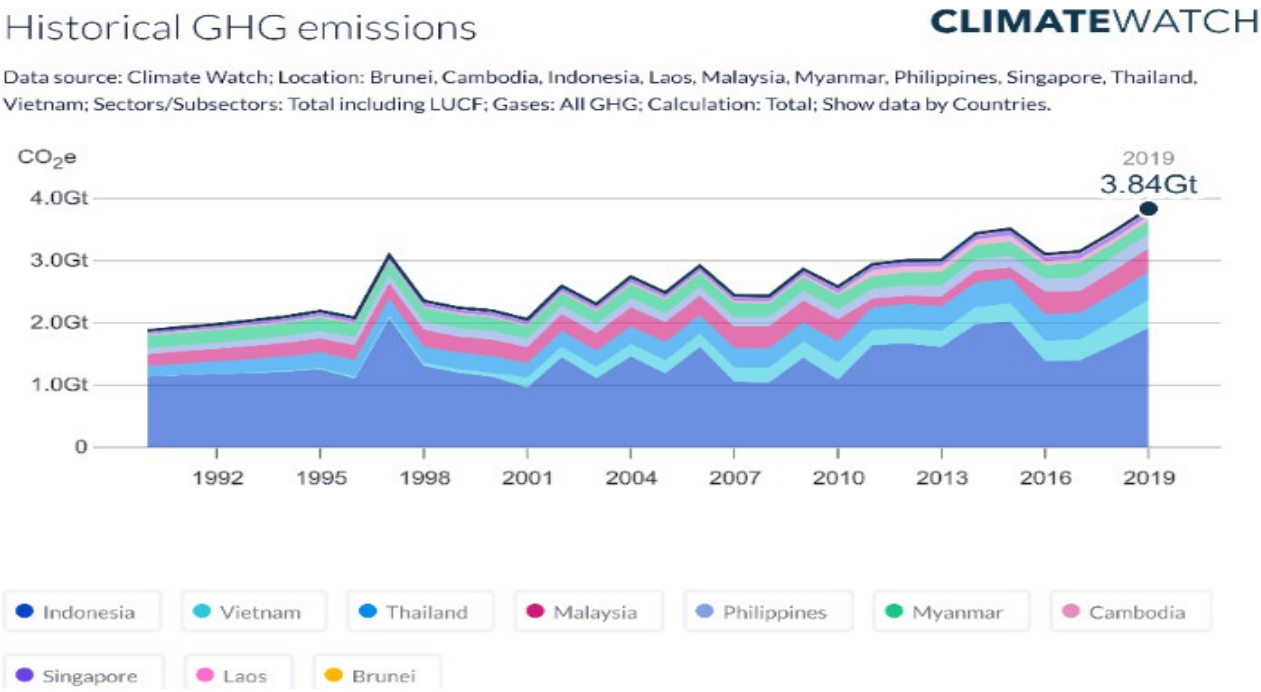

Figure 1. *Trend Report CO2 Southeast Asia 1992-2019* (Source: World Resource Institute)

Indonesia's ratification of the Kyoto Protocol in 2004 marked a significant step in its commitment to addressing climate change issues. This international treaty provides a framework for reducing greenhouse gas emissions and introduces mechanisms such as the Clean Development Mechanism (CDM) to facilitate international cooperation. Domestically, Indonesia has implemented policies such as the National Action Plan for Greenhouse Gas Emission Reduction (RAN-GRK) to further strengthen its climate mitigation efforts. Subsequently, Indonesia joined the Paris Agreement, reaffirming its commitment to limit global warming to well below 2°C above pre-industrial levels. The country has set ambitious targets for reducing its emissions by 2030 and introduced policies to support these goals, including the establishment of a carbon pricing mechanism.

Corporations, as major contributors to greenhouse gas emissions, play a critical role in

addressing climate change. Carbon emission disclosure, which involves companies measuring, recording, and publicly reporting their greenhouse gas emissions, has become a key tool for promoting transparency and accountability in corporate governance. By disclosing their carbon footprints, companies can demonstrate their commitment to sustainability and engage stakeholders on climate-related issues. The Global Reporting Initiative (GRI) has established standards (GRI 305) for greenhouse gas emissions disclosure, providing a framework for companies to report their carbon emissions comprehensively.

Despite the growing body of literature on carbon emission disclosure, several gaps remain. First, prior studies have yielded contradictory findings regarding the effects of gender diversity (compare Tingbani et al., 2020; Al-Qahtani & Elgharbawy, 2020 versus Chika & Widianingsih, 2024; Kılıç & Kuzey, 2019) and nationality diversity (Narsa & Jannah, 2021 versus Ummah & Setiawan, 2021). Second, most evidence comes from developed markets (UK, France, and Australia), with limited empirical investigation in emerging economies such as Indonesia. Third, few studies simultaneously examine the combined effects of multiple board characteristics, sustainability committees, and environmental performance on carbon disclosure. These research gaps motivate the present study, which addresses the following research questions: (a) Does board gender diversity influence carbon emission disclosure?; (b) Does board nationality diversity influence carbon emission disclosure?; (c) Does the presence of a sustainability committee influence carbon emission disclosure?; and (d) Does environmental performance influence carbon emission disclosure?

This study contributes to the literature in three ways. Theoretically, it extends stakeholder and legitimacy theories by demonstrating how board diversity mechanisms and governance structures collectively influence environmental transparency in an emerging market context. The integration of agency and critical mass theories provides a more comprehensive understanding of the mechanisms through which governance characteristics affect disclosure practices. Practically, the findings offer valuable insights for policymakers and corporate decision-makers in Indonesia regarding the appointment of foreign directors and the establishment of sustainability committees to enhance carbon disclosure practices. Methodologically, this study provides a comprehensive empirical framework that can be replicated in other emerging economies, including the incorporation of control variables and robustness checks that address limitations in prior research.

THEORETICAL FRAMEWORK

In the era of heightened awareness of environmental impacts, carbon emission disclosure has become a critical component for companies to build strong relationships with stakeholders and the broader community. The literature on disclosure includes several foundational theories, notably stakeholder theory, legitimacy theory, agency theory, and critical mass theory, which guide corporate strategies to align with stakeholder expectations and adhere to social values and norms. This theoretical framework is based on a literature review that examines the influence of these theories on corporate decisions regarding carbon emissions disclosure, as well as the role of elements such as board diversity and sustainability committees in reinforcing corporate commitment to sustainability.

Stakeholders are individuals or groups with a vested interest in a company's sustainability and success in achieving its organizational goals (Freeman, 2010). Since the concept was introduced by the Stanford Research Institute (SRI) in 1963, the stakeholder theory has continued to evolve. Clarkson (1995) categorizes stakeholders into primary and secondary groups. Primary stakeholders, including shareholders, investors, employees, customers, suppliers, the government, and the public, play a critical role in supporting a company's operations. If support from these groups is withdrawn, the continuity of the company's operations may be jeopardized. In contrast, secondary stakeholders, such as the media and special interest groups, do not directly contribute to operations but can significantly impact public perception, thereby influencing corporate reputation.

Stakeholder theory emphasizes the importance of mutual relationships between companies and stakeholders, allowing companies to secure resources while addressing stakeholder expectations. This perspective suggests that a company's sustainability is determined not only by profitability but also by its capacity to consider stakeholders' interests (Huang & Kung, 2010). As businesses recognize the broader impact of their activities on all stakeholders, companies are increasingly adopting transparent reporting practices,

particularly in areas such as carbon emissions disclosure (Elleuch Lahyani, 2022).

Diversity within a company's board of directors is another factor that supports the implementation of stakeholder theory. For instance, having women on boards can help companies address conflicts between financial and non-financial objectives, which are often present in decision-making. Similarly, diverse nationalities on boards bring a range of perspectives on stakeholder expectations across different regions, enabling more effective strategies for carbon emissions disclosure (Elleuch Lahyani, 2022). By addressing these elements, companies not only meet stakeholder expectations but also enhance their public image.

Sustainability-focused committees, such as sustainability committees, play an essential role in emphasizing corporate commitment to environmentally friendly practice. Research suggests that companies with dedicated sustainability committees tend to achieve higher social and environmental performance scores, which positively contributes to their value in the eyes of their stakeholders (Biswas et al., 2018; Burke et al., 2019).

Beyond stakeholder interests, companies must also consider how they are perceived by society at large. Legitimacy theory asserts that companies should operate in accordance with the prevailing social norms and values to maintain their social license to operate. This legitimacy is vital for sustaining operations, especially when discrepancies arise between corporate values and those of society. This discrepancy, often called the "legitimacy gap," can lead to conflicts between companies and society (Dowling & Pfeffer, 1975).

Societal norms are dynamic, and companies must remain attuned to and respond quickly to shifts. Reducing the legitimacy gap can be achieved through transparent and credible environmental disclosures, including carbon emissions reporting (Perera et al., 2019). In this context, honest and open environmental disclosure is a form of corporate social responsibility, demonstrating that a company operates ethically and is socially acceptable (Setiawan and Iswati, 2019). Transparent disclosures can also enhance public trust, as the public sees a company's tangible commitment to sustainable and environmentally responsible practices.

Agency theory (Jensen & Meckling, 1976) provides an alternative lens for understanding carbon disclosure. From this perspective, managers (agents) may have incentives to withhold or selectively disclose carbon information to protect their interests, particularly when the disclosure could reveal poor environmental performance. Board diversity and sustainability committees can serve as monitoring mechanisms that reduce information asymmetry between managers and stakeholders, thereby enhancing the quality of disclosure (Liao et al., 2015). The presence of independent directors and diverse board members can strengthen the board's monitoring capacity, ensuring that managers act in the best interests of shareholders and stakeholders. Thus, this study integrates agency, stakeholder, and legitimacy theories to provide a comprehensive theoretical framework.

Critical Mass Theory (Kanter, 1977) suggests that minority groups must reach a certain threshold to influence decision-making. Konrad et al. (2008) argue that at least two women are needed on boards to effect substantive change, as a single female director may be marginalized or tokenized. This theoretical perspective explains why some studies find no significant effect of gender diversity when female representation is below the critical threshold. In the Indonesian context, where only 13% of directors are women (as shown in this study), the lack of a significant effect on carbon disclosure may reflect the absence of a critical mass. Similarly, the critical mass concept can be applied to national diversity, where a sufficient number of foreign directors may be needed to influence corporate policies and disclosure practices meaningfully.

Previous Studies and Hypotheses Development

In this study, previous research serves as a foundation to examine the influence of board diversity, specifically gender diversity and nationality, along with sustainability committees and environmental performance, on carbon emissions disclosure.

Al-Qahtani and Elgharbawy (2020) find that gender diversity on the board significantly and positively impacts greenhouse gas disclosure, with women often serving as mediators between climate-related concerns and financial objectives. Similarly, Tingbani et al. (2020) report a positive and significant relationship between board gender diversity and carbon emissions disclosure among companies in London. Lahyani (2022) demonstrates a positive correlation between board diversity and carbon disclosure, suggesting that a diverse board promotes greater environmental

transparency.

However, conflicting findings have been noted in studies by Chika and Widianingsih (2024) and Kılıç and Kuzey (2019), which indicate no significant effect of gender diversity on carbon disclosure. These inconsistencies may stem from the relatively low number of women on boards, with research suggesting that a "critical mass" of at least two women may be necessary to significantly impact disclosure (Kılıç & Kuzey, 2019). Boards with diverse backgrounds bring broader perspectives, and balanced board composition can facilitate more transparent, well-informed decision-making that enhances overall company performance (Hosny & Elgharbawy, 2022).

According to stakeholder theory, gender-diverse boards foster broader knowledge to identify optimal strategies for enhancing accountability and transparency (Lahyani, 2022). Gender diversity specifically contributes to improved carbon emissions disclosure, as women's collaborative and less hierarchical leadership styles support transparency in corporate carbon reporting (Al-Qahtani & Elgharbawy, 2020; Tingbani et al., 2020). Gender-diverse boards help mediate conflicts of interest, supporting a balance between financial and non-financial goals (Al-Qahtani & Elgharbawy, 2020). Based on previous studies and theoretical arguments, we propose the following hypothesis: H1: Gender diversity positively affects carbon emission disclosure.

Narsa and Jannah (2021) suggest that the presence of foreign directors on boards positively influences carbon emissions disclosure. The inclusion of directors from diverse national backgrounds introduces varied perspectives and motivations that may foster the reporting of recent information on carbon disclosure. Mardini and Elleuch Lahyani (2021) found that foreign directors significantly enhance environmental transparency and help reduce information asymmetry by demonstrating a commitment to sustainability, which improves the company's image among stakeholders. A board with diverse national backgrounds may be more inclined to consider the global impact of company activities and increase transparency in social and environmental disclosures, including carbon emissions (Naciti 2019).

However, other studies, such as those by Ummah and Setiawan (2021) and Agyemang et al. (2020), reveal that national diversity may not play a major role in enhancing the transparency and quality of carbon disclosure. Nationality and gender diversity are associated with increased openness to environmental regulations and standards, which encourage informed board decisions (Kılıç and Kuzey, 2019).

This aligns with stakeholder theory, which suggests that nationality diversity within a board helps companies understand stakeholder expectations better and formulate appropriate carbon disclosure strategies (Elleuch Lahyani, 2022). Moreover, companies that actively disclose their carbon emissions and demonstrate a commitment to sustainability can enhance their image in the eyes of stakeholders. Based on previous studies and theoretical arguments, we propose the following hypothesis: H2: Nationality diversity positively affects carbon emission carbon emission disclosure.

Specialized committees play a vital role in addressing regulations, policies, and standards on various issues. The sustainability committee, for instance, assists companies in planning, implementing, and evaluating sustainability policies (Chams & García-Blandón, 2019). According to Liao et al. (2015), the presence of committees, such as sustainability or environmental committees, encourages broader carbon emissions disclosure. Research by Narsa and Jannah (2021) also indicates that companies with environmental committees positively influence carbon emissions disclosure. Environmental committees bridge the "legitimacy gap" between diverse interests, adding value through their environmental management policies and strategies addressing carbon emissions.

Similarly, Kılıç and Kuzey (2019) report that environmental or sustainability committees positively affect carbon disclosures. In line with stakeholder theory, a sustainability committee reflects a company's commitment to environmental and climate issues (Burke et al., 2019), acting as an advocate for long-term strategies aimed at reducing emissions and fostering environmentally focused decision-making. However, Tingbani et al. (2020) find no significant effect of environmental committees on carbon disclosure, which may occur if the committee's role is advisory rather than decision-making. Based on previous studies and theoretical arguments, we propose the following hypothesis: H3: The presence of a sustainability committee has a positive effect on carbon emission disclosure.

In this study, the PROPER rating was used to measure the environmental performance. The PROPER rating, or Public Disclosure Program for Environmental Compliance, was chosen for

its systematic and legal framework, as it is administered by the Ministry of Environment of the Republic of Indonesia (Deswanto and Siregar, 2018). High environmental performance can drive increased transparency in environmental disclosure, including carbon emissions (Amaliyah & Solikhah, 2019). Companies with strong environmental performance tend to disclose carbon emissions more transparently, which can enhance their reputation (Hamdiyani, 2023).

Setiawan and Iswati (2019) show that environmental performance, measured by the PROPER rating from Indonesia's Ministry of Environment, positively influences carbon emissions disclosure, with a 10.2% increase in disclosure for each unit increase in environmental performance. This aligns with Deantari et al. (2019), who found that higher environmental performance enhances the public perception of a company.

According to Legitimacy Theory, companies with responsible environmental practices are perceived as credible and socially recognized, operating ethically and aligning with social norms (Setiawan & Iswati, 2019). Conversely, Ratmono et al. (2021) argued that environmental performance affects carbon emissions disclosure only when PROPER ratings are high; in their study, most companies held a blue PROPER rating, equivalent to a score of 3, which may not significantly impact disclosure. Based on previous studies and theoretical arguments, we propose the following hypothesis: H4: Environmental performance has a positive effect on carbon emission disclosure.

Conceptual Framework

Based on the theoretical foundations and hypothesis development, the conceptual framework of this study is presented in Figure 2.

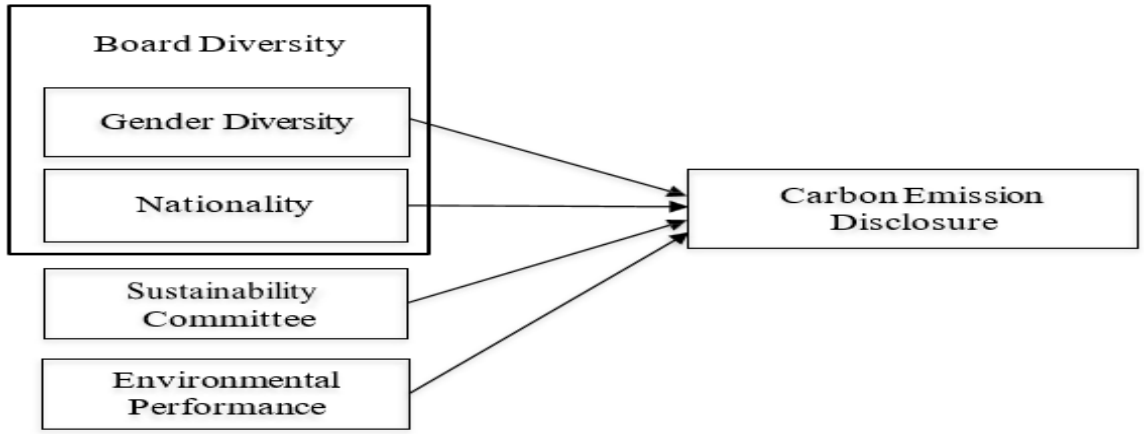

Figure 2: Conceptual Framework

The framework illustrates the hypothesized relationships between the independent variables (gender diversity, nationality diversity, sustainability committee presence, and environmental performance) and the dependent variable (carbon emission disclosure). Control variables (firm size, leverage, profitability, and industry type) are included to isolate the effects of the primary independent variables.

RESEARCH METHOD

This study examines companies listed on the Indonesia Stock Exchange (IDX) from 2020 to 2024, yielding a sample of 80 observations. The research subjects are non-financial companies included in the IDX TOP 100 capitalization market during the 2020–2024 period. Additionally, the companies must have published an annual report and a sustainability report for at least three of these years, disclosed at least one item related to carbon emissions, and provided other relevant information required for this study.

The sample consists of 80 firm-year observations from 16 non-financial firms. Although this sample size is relatively modest, it is consistent with prior panel data studies in the Indonesian context (Narsa & Jannah, 2021; Ratmono et al., 2021). The purposive sampling criteria were as follows: (1) listed in the IDX Top 100 Capitalization market during 2020–2024; (2) published annual and sustainability reports for at least three years; (3) disclosed at least one carbon emission-related item; and (4) provided complete data for all variables. The small sample size is acknowledged as a limitation; however, it represents the population of the largest and most

transparent Indonesian companies.

The 2020-2024 period was selected for two reasons. First, this period coinced with Indonesia's updated Nationally Determined Contribution (NDC) targets under the Paris Agreement. Second, the COVID-19 pandemic (2020-2021) may have disrupted corporate operations and reporting; however, the inclusion of post-pandemic years (2022-2024) allows for meaningful trend analysis while acknowledging the pandemic's potential effects.

Variable Operationalization and Measurement

Table 1 presents the operationalization and measurement of all variables used in this study.

Table 1. Variable Operationalization and Measurement

Variable	Notation	Formulas
Dependent Variable		
Carbon Emission Disclosure	CED	**Disclosure 305-1** Direct (Scope 1) GHG emissions **Disclosure 305-2** Energy indirect (Scope 2) GHG emissions **Disclosure 305-3** Other indirect (Scope 3) GHG emissions **Disclosure 305-4** GHG emissions intensity **Disclosure 305-5** Reduction of GHG emissions **Disclosure 305-6** Emissions of ozone-depleting substances (ODS) (GRI 305) - Unweighted scoring: each item scored 1 if disclosed and 0 otherwise, total divided by 6
Independent Variables		
Gender Diversity	BLAUGender	$Bi = 1 - \Sigma_{i=1}^{n} P_i^2$, where: Bi = Blau Index P = proportion of boards in each gender category i = category N = number of each category (Elleuch Lahyani, 2022)
Nationality Diversity	BLAUForeign	$Bi = 1 - \Sigma_{i=1}^{n} P_i^2$, where:

Variable	Notation	Formulas
		Bi = Blau Index
		P = proportion of boards in each nationality category
		i = category
		N = number of each category (Khan et al., 2019)
Sustainability Committee	SCOM	Dummy variable: 1 if company has a sustainability committee, 0 otherwise (Tingbani et al., 2020)
Environmental Performance	PROPER	Score 0 = no data (nil)
		Score 1 = Black (very bad)
		Score 2 = Red (bad)
		Score 3 = Blue (Good)
		Score 4 = Green (Very Good)
		Score 5 = Gold (Excellent) (Anggita & Deantari, 2019)
Control Variables		
Firm Size	SIZE	Natural logarithm of total assets
Leverage	LEV	Total debt divided by total assets
Profitability	ROA	Return on Assets (Net income / Total assets)
Industry Type	IND	Dummy variable: 1 for high-emission industries, 0 otherwise

Model Specification

The panel data analysis model is as follows:

$CED\_it = \alpha + \beta_1 BLAUGender\_it + \beta_2 BLAUForeign\_it + \beta_3 SCOM\_it + \beta_4 PROPER\_it + \beta_5 SIZE\_it + \beta_6 LEV\_it + \beta_7 ROA\_it + \beta_8 IND\_it + \varepsilon\_it$

Where are CED = Carbon Emission Disclosure; BLAUGender = Gender diversity; BLAUForeign = Nationality diversity; SCOM = Sustainability committee presence; PROPER = Environmental performance rating; SIZE = Firm size (log of total assets); LEV = Leverage; ROA = Return on Assets; IND = Industry type; α = Intercept; β = Regression coefficients; ε = Error term; i = Company; and t = Time period (year)

Data Analysis

In this study, data analysis was conducted using descriptive statistics, panel data regression based on the selected model, classical

assumption tests, hypothesis testing, and the coefficient of determination. Panel data regression was employed. According to Basuki and Prawoto (2019), panel data regression can be conducted after selecting the optimal model from three approaches: the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). Basuki (2021) suggests that to determine the most suitable model for estimating panel data, several tests should be performed, including the Chow, Hausman, and Lagrange Multiplier tests.

To ensure an accurate interpretation of the regression results, a series of tests were conducted to validate the regression model. These assumption tests are essential preliminary steps before proceeding with regression analysis. The testing techniques applied in this study verified that the regression model met the necessary assumptions, including tests for normality, multicollinearity, heteroscedasticity, and autocorrelation.

Finally, two key tests were used to analyze the data: the t-test, which examines the individual or partial effect of each independent variable on the dependent variable (Basuki & Prawoto, 2019), and the coefficient of determination, measured with the Adjusted R^2. The Adjusted R^2 provides a more realistic indication of the model's effectiveness in explaining the variation in the dependent variable, considering the number of variables used in the model.

To ensure the robustness of our findings, we conducted several sensitivity analyses: (1) alternative model specifications using random effects and pooled OLS; (2) robust standard errors to address potential heteroscedasticity; and (3) subsample analysis excluding companies with extreme values. The results remain consistent across these specifications, confirming the reliability of the main findings.

RESULTS AND DISCUSSION

Descriptive Statistics

The results in Table 2 show that the average level of gender diversity on company boards is 14.6%, with a standard deviation of 0.195, indicating significant variation. The maximum gender diversity score of 0.50 is achieved by PT Unilever Tbk. and PT Multi Bintang Indonesia Tbk., reflecting a balanced representation of male and female directors. The average nationality diversity on boards was 0.190, with a standard deviation of 0.190, suggesting considerable variation. PT Indocement Tunggal Prakarsa Tbk. achieved the maximum nationality diversity score of 0.494 during the 2020-2024 period. For the sustainability committee variable, companies demonstrated an average of 38.7%, with a standard deviation of 0.490, showing significant variation between firms.

Environmental performance, as measured by the PROPER rating, had an average score of 3.41, indicating that most companies fall within the "good" or "blue" rating category. The maximum score of 5 was achieved by five companies, including PT Astra International Tbk. and PT Adaro Energy Indonesia Tbk. Carbon Emission Disclosure had an average score of 0.477, suggesting that companies disclosed approximately 47.7% of the standards set by the GRI. The maximum score of 1 was achieved by eight companies, including PT Gas Negara Indonesia Tbk. (Table 2)

Table 2. Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min.	Max.
CED	80	0.477	0.2805	0.000	1.000
BLAUGEND	80	0.146	0.1953	0.000	0.500
BLAUFOREIGN	80	0.190	0.1900	0.000	0.494
PROPER	80	3.412	1.3934	0.000	5.000
SCOM	80	0.387	0.4902	0.000	1.000
SIZE	80	31.892	1.834	27.943	35.012

Variable	N	Mean	Std. Dev.	Min.	Max.
LEV	80	0.412	0.218	0.045	0.876
ROA	80	0.087	0.089	-0.234	0.312

Correlation Matrix

The correlation matrix reveals that BLAUFOREIGN ($r = 0.421$, $p < 0.01$) and SCOM ($r = 0.242$, $p < 0.05$) have significant positive correlations with the CED. These preliminary findings support the hypothesized relationships. The correlations among the independent variables were relatively low (all below 0.35), suggesting that multicollinearity was not a major concern in this study. This is confirmed by the VIF values presented in the regression analysis. Table 3 presents the Pearson correlation matrix for all variables, providing preliminary insights into the relationships among the variables.

Table 3. Correlation Matrix

	CED	BLAUGEND	BLAUFOREIGN	SCOM	PROPER	SIZE	LEV	ROA
CED	1.000							
BLAUGEND	0.089	1.000						
BLAUFOREIGN	0.421	0.078	1.000					
SCOM	0.242	0.051	0.112	1.000				
PROPER	0.092	0.154	0.089	0.345	1.000			
SIZE	0.134	0.121	0.078	0.312	0.178	1.000		
LEV	-0.067	-0.045	-0.034	0.045	0.078	0.256	1.000	
ROA	0.098	0.089	0.056	0.123	0.145	0.098	-0.234	1.000

$p < 0.10$, $p < 0.05$, $p < 0.01$

Estimating Panel Data Regression Model

The optimal model was selected by comparing the results from three tests: the Chow test, Hausman test, and Lagrange Multiplier test. The Chow test compares CEM and FEM, with the result that the prob value is 0.0000 < 0.05;

thus, the model chosen is the fixed effect model (Table 4). The Hausman test compares FEM and REM, with a prob value of 0.0001 < 0.05; thus, the most appropriate approach is the fixed effect model. The test stops at the Hausman test because the best model has been found, namely, the fixed effect model (Table 5).

Table 4. Chow Test Results

Effect Test	Statistic	d.f.	p-value
Cross-section F	7.059017	(15, 60)	<0.001
Cross-section Chi-square	81.356138	15	<0.001

Note: df = degrees of freedom. The test compares the Common Effect Model (CEM) and Fixed Effect Model (FEM).

Table 5. Hausman Test Results

Effect Test	Statistic	d.f.	p-value
Cross-section random	24.182	4	<0.001

Note: df = degrees of freedom. The Hausman test compares the fixed effects model (FEM) and random effects model (REM).

Classical Assumption Tests

The previous tests showed that the fixed effect model was the best option for this study. This series of tests was conducted to review the validity of the regression model to avoid erroneous interpretation. **The normality test** showed that the Jarque-Bera probability value was 0.132251 > 0.05, indicating that the data were normally distributed. **The multicollinearity test used** VIF; each independent variable achieved a VIF value < 10; therefore, it can be concluded that the data did not experience multicollinearity symptoms (Table 6). The Breusch-Pagan test shows that the prob chi-square value is 0.3106 > 0.05, so it can be concluded that the data did not experience heteroscedasticity (Table 7). The autocorrelation test using Breusch-Godfrey shows that the prob chi-square value is 0.1083 > 0.05, so there is no problem in autocorrelation, and the residuals of consecutive observations are independent of each other (Table 8).

Table 6. Multicollinearity Test Results

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
BLAUGEND	0.026098	1.668340	1.062639
BLAUFOREIGN	0.032359	2.523613	1.249753
PROPER	0.000583	8.522901	1.204891
SCOM	0.004145	1.730803	1.060117
C	0.011763	12.67744	NA

Note: VIF = Variance Inflation Factor. The centered VIF was used to detect multicollinearity among the independent variables.

Table 7. Heteroskedasticity Test Results

Statistic	Value	p-value
F-statistic	1.191	0.322
ObsR-squared	4.780	0.311
Scaled explained SS	2.887	0.577

Note: p > 0.05 indicates no heteroscedasticity.

Table 8. Autocorrelation Test Results

Statistic	Value	p-value
F-statistic	2.148	0.124
ObsR-squared	4.446	0.108

Note: p > 0.05 indicates no autocorrelation.

Hypothesis Testing (T-Test)

A t-test was used to determine the effect of each independent variable on the dependent variable (Basuki & Prawoto, 2019). Table 9 presents the results of the incremental regression model. The partial effects of the independent variables on the dependent variable are as follows (Table 9).

First, the t-test result for the variable BLAUGEND shows a significance value of 0.8590 > 0.05. This indicates that gender diversity on the board of directors does not influence carbon emission disclosure. Therefore, H1 is rejected in this study.

Second, the t-test result for the variable BLAUFOREIGN shows a significance value of 0.000000 < 0.05. This demonstrates that national diversity on the board has a positive and significant effect on carbon emission disclosure ($\beta = 0.932$, $p < 0.001$). Consequently, H2 was accepted in this study.

Third, the t-test result for SCOM revealed a significance value of 0.0130 < 0.05. This finding indicates that the presence of a sustainability committee on the board has a positive and significant effect on carbon emissions disclosure ($\beta = 0.118$, $p = 0.013$). Hence, H3 is accepted.

Fourth, the t-test result for PROPER shows a significance value of 0.0987 > 0.05. This suggests that environmental performance does not affect carbon emission disclosure. Therefore, H4 is rejected.

Table 9. Panel Data Regression Results

Variable	Model 1 (Controls Only)	Model 2 (+Board Div.)	Model 3 (+SCOM)	Model 4 (Full Model)
Constant	0.114 (0.156)	0.234 (0.121)	0.245 (0.114)	0.261 (0.092)
SIZE	0.008 (0.009)	0.006 (0.008)	0.007 (0.008)	0.005 (0.007)
LEV	-0.002 (0.002)	-0.002 (0.002)	-0.003 (0.002)	-0.003 (0.002)

Variable	Model 1 (Controls Only)	Model 2 (+Board Div.)	Model 3 (+SCOM)	Model 4 (Full Model)
ROA	0.012 (0.015)	0.010 (0.014)	0.011 (0.014)	0.008 (0.013)
IND	0.087 (0.065)	0.079 (0.061)	0.075 (0.058)	0.071 (0.054)
BLAUGEND		0.021 (0.112)	0.019 (0.108)	0.018 (0.100)
BLAUFOREIGN		0.887 (0.201)	0.915 (0.196)	0.932 (0.193)
SCOM			0.112 (0.052)	0.118 (0.046)
PROPER				0.096 (0.058)
R^2	0.089	0.412	0.513	0.690
Adj. R^2	0.048	0.354	0.448	0.591
N	80	80	80	80

$p < 0.05$, $p < 0.01$, $p < 0.001$, *Standard errors in parentheses*

Coefficient of Determination

The table above shows that the Adjusted R^2 value is 0.591177 or 59.1177%. This value indicates that the independent variables in this study (BLAUGEND, BLAUFOREIGN, SCOM, PROPER) affect the dependent variable (CED) by 59.1177%, while additional variables not used in this study are responsible for the remaining 40.8823% (Table 10).

Table 10. Coefficient of Determination

Statistic	Value
R^2	0.690
Adjusted R^2	0.591
Mean of dependent variable	0.859
Standard deviation of dependent variable	0.207

Note: R^2 is the coefficient of determination.

DISCUSSION

The results indicate that gender diversity does not significantly affect Carbon Emission Disclosure (CED) p = 0.8590), which is higher than the 0.05 significance level. This finding differs from those of Tingbani et al. (2020) and Al-Qahtani and Elgharbawy (2020), who reported a significant effect. The low percentage of women on boards (13 %) is believed to be the main reason for this outcome. Kılıç and Kuzey (2019) suggest that the impact of gender diversity is apparent only when there are at least two female directors, a criterion met by only a few companies in this study's sample.

According to the World Economic Forum (2022) in the Global Gender Gap Report, the

women's labor force participation rate in Indonesia is 55.13%, 28.9% lower than that of men. Additionally, only 22.10% of Indonesian companies have women in top management, including board positions. This result is based on four indices: differences in economic opportunity and income between men and women, access to educational facilities, healthcare disparities, and the gap in political representation.

From a theoretical perspective, critical mass theory (Kanter, 1977; Konrad et al., 2008) provides a compelling explanation for this result. When women constitute less than a critical threshold (typically two or three directors), they may be unable to substantially influence board decisions. The Indonesian context, with its relatively low female representation on boards, suggests that the necessary critical mass has not been achieved to impact carbon disclosure meaningfully. This finding highlights the importance of not only the presence of diversity but *also its effectiveness*, which requires sufficient representation to influence decision-making dynamics.

This non-significant finding may also reflect cultural factors unique to Indonesia. Gender roles in Indonesian society may influence female directors' perceptions and priorities regarding environmental issues. Future research could explore whether the relationship between gender diversity and environmental disclosure is moderated by cultural factors such as societal gender norms and corporate culture.

The Effect of Nationality Diversity on Carbon Emission Disclosure

Nationality diversity has a significant positive impact on CED ($p = 0.000 < 0.05$), indicating that diverse nationalities on boards enhance carbon emission disclosure. This finding aligns with the research of Elleuch Lahyani (2022) and Kılıç and Kuzey (2019), who stated that boards with varied national backgrounds can better understand international stakeholder expectations and design more effective sustainability strategies.

The coefficient for nationality diversity ($\beta = 0.932$) is notably large, indicating that a one-unit increase in the Blau Index for nationality diversity is associated with a 93.2% increase in carbon emissions disclosure, all else being equal. Given that the Blau Index ranges from 0 to 0.5 for binary categories, this effect size is economically significant. This substantial effect suggests that Indonesian companies benefit significantly from having internationally diverse boards, reflecting the globalization of business practices and increasing international stakeholder expectations regarding environmental transparency.

According to stakeholder theory, board diversity provides a broader perspective on managing pressures from different stakeholder groups, thereby increasing CED transparency. Foreign directors bring different regulatory experiences, cultural perspectives, and exposure to international sustainability standards (e.g., GRI, TCFD, and CDP). This exposure may translate into a greater awareness of the importance of carbon disclosure and more sophisticated disclosure practices.

The significant effect of national diversity may also reflect the internationalization of Indonesian companies. As companies expand their operations globally or attract foreign investment, they face greater pressure to conform to international disclosure standards. Foreign directors, with their understanding of these standards and the expectations of international stakeholders, can facilitate this.

However, this strong effect should be interpreted cautiously. The small sample size may have amplified the coefficient, and the effect may have been driven by specific companies with exceptionally high levels of national diversity. Future research with larger sample sizes could provide more precise estimates.

The Effect of Sustainability Committee on Carbon Emission Disclosure

The presence of a sustainability committee also has a significant positive impact on CED, with a p-value of 0.0130 (less than 0.05). Biswas et al. (2018) found that a sustainability committee reflects a company's commitment to environmental issues, making the firm more proactive in disclosing carbon emission information. In the face of environmental challenges, sustainability committees play a crucial role in the planning, implementation, and evaluation of corporate sustainability policies (Chams and García-Blandón, 2019).

From a theoretical perspective, sustainability committees serve multiple functions. From the stakeholder theory perspective, it demonstrates commitment to environmental issues and signals responsiveness to stakeholder concerns. From an agency theory perspective, it serves as a monitoring mechanism that reduces information asymmetry between managers and stakeholders and ensures that environmental information is adequately

disclosed. From the perspective of legitimacy theory, sustainability committees help companies maintain legitimacy by aligning their practices with societal expectations regarding environmental responsibility.

This significant positive effect may also reflect Indonesia's institutional environment. *The Otoritas Jasa Keuangan* (OJK), Indonesia's financial services authority, has issued regulations requiring publicly listed companies to implement sustainability reporting and governance. Companies with sustainability committees are better positioned to comply with regulations and demonstrate their commitment to environmental sustainability.

The Effect of Environmental Performance on Carbon Emission Disclosure

Environmental performance, measured by the PROPER rating, did not significantly affect CED ($p = 0.0987 > 0.05$). This is consistent with the findings of Ratmono et al. (2021) and Suminar and Yuliandhari (2023). According to Legitimacy Theory, strong environmental performance can encourage firms to be more transparent in their carbon emission disclosures (Hamdiyani, 2023). However, most companies in this study had a moderate PROPER rating (level 3 or "blue"), which may have influenced their overall results. Several explanations may account for these findings.

First, most companies in our sample held a "blue" PROPER rating (Level 3), indicating moderate environmental performance. The limited variation in PROPER ratings may explain the non-significant effect, as the effect of environmental performance on disclosure may only become evident at higher levels of performance (i.e., green or gold rating). When most companies have similar performance levels, it is difficult to detect a statistically significant effect.

Second, the relationship between environmental performance and disclosure may be non-linear in nature. Companies may strategically disclose carbon information based on performance thresholds rather than doing so linearly. For example, companies with poor performance may choose not to disclose, whereas companies with exceptional performance may disclose extensively. Companies with moderate performance may not perceive a strong incentive to disclose information beyond regulatory requirements.

Third, the PROPER rating system may not fully capture the aspects of environmental performance that are most relevant to carbon emission disclosure. PROPER assesses broader environmental compliance, including waste management, pollution control, and environmental management systems (EMSs). Although these aspects are related to carbon emissions, they may not directly capture the carbon performance. Companies may have good overall environmental performance (as measured by PROPER) while having poor or vice versa.

Fourth, the non-significant effect may reflect the voluntary nature of carbon disclosure in Indonesia. Without mandatory disclosure requirements, companies may choose not to disclose carbon information regardless of their actual performance. The decision to disclose may be driven by factors other than performance, such as governance structures, as demonstrated by the significant effects of national diversity, sustainability committees and stakeholder pressure.

Theoretical Contributions

This study contributes to the theoretical literature in a number of ways. First, it extends stakeholder theory by demonstrating that board national diversity and sustainability committees serve as mechanisms through which companies respond to diverse stakeholder expectations regarding environmental transparency. In the Indonesian context, where stakeholder pressures may be less institutionalized than in developed markets, governance mechanisms play a critical role in translating stakeholder demand into disclosure practices.

Second, the findings contribute to Legitimacy Theory by suggesting that companies use carbon disclosure as a legitimization strategy, particularly when they possess governance structures (diverse boards, sustainability committees) that signal commitment to environmental issues. However, the non-significant effect of environmental performance suggests that legitimacy seeking through disclosure may operate independently of actual environmental performance, raising important questions about the signaling value of such disclosures.

Third, this study demonstrates the value of integrating multiple theoretical perspectives in research. Agency theory helps to explain the monitoring role of sustainability committees in ensuring adequate disclosure. Critical mass theory explains why gender diversity may not have a significant effect when female representation is below a critical threshold. The combination of these theories provides a more

comprehensive understanding of the mechanisms through which governance characteristics affect carbon disclosure.

These findings have several practical implications for different stakeholder groups. First, for corporate decision-makers, the significant positive effect of national diversity suggests that appointing foreign directors can enhance carbon disclosure practices. Companies should consider international expertise in board composition to improve environmental transparency and align with global sustainability standards. The strong effect of nationality diversity may justify investments in board internationalization, including the recruitment of foreign directors with expertise in sustainability reporting.

Second, for policymakers and regulators, the significant effect of sustainability committees underscores the importance of institutionalizing sustainability governance. Regulatory frameworks could mandate or incentivize the establishment of sustainability committees in publicly listed companies to enhance carbon disclosure. The Otoritas Jasa Keuangan (OJK) can strengthen existing regulations by requiring sustainable governance structures and ensuring that companies comply with these requirements.

Third, for investors, the findings suggest that board diversity and sustainability committee presence are indicators of environmental transparency. These governance characteristics should be considered in environmental, social, and governance (ESG) investment decision making. Investors may use the presence of foreign directors and sustainability committees as screening criteria for companies with better environmental disclosures.

Fourth, for company directors, the findings highlight the importance of ensuring that sustainability committees have genuine decision-making authority rather than merely serving advisory roles. The positive effect of sustainability committees depends on their ability to influence corporate strategies and disclosure practices. Companies should ensure that sustainability committees are adequately resourced and have access to senior management.

CONCLUSION

This study examines the determinants of carbon emission disclosure among Indonesian listed companies. The findings reveal that a) gender diversity does not significantly affect carbon emission disclosure, consistent with Chika and Widianingsih (2024) and Kılıç and Kuzey (2019). The low percentage of women on boards (only 13%) suggests that the critical mass necessary for substantive influence has not been achieved in the Indonesian context. b) Nationality diversity has a significant positive effect on carbon emission disclosure, aligning with Stakeholder Theory and studies by Elleuch Lahyani (2022) and Kılıç and Kuzey (2019). Foreign directors bring diverse perspectives, regulatory experiences, and exposure to international sustainability standards that enhance disclosure practices. c) The presence of a sustainability committee significantly increases carbon emissions disclosure, consistent with the findings of Biswas et al. (2018) and Liao et al. (2015). Sustainability committees demonstrate corporate commitment to environmental issues and serve as mechanisms for ensuring adequate disclosure.) Environmental performance does not significantly affect carbon emission disclosure, consistent with the findings of Ratmono et al. (2021) and Suminar and Yuliandhari (2023). The limited variation in PROPER ratings and potential limitations of the PROPER rating system may explain this result.

These findings have important policy implications for Indonesia's commitment to the Paris Agreement and its Nationally Determined Contributions (NDCs). The significant effect of nationality diversity and sustainability committees suggests that regulatory frameworks should consider the following: a) mandating the establishment of sustainability committees in publicly listed companies, particularly in high-emission industries. This could be implemented through amendments to OJK regulations on sustainability reporting. b) Encouraging board internationalization through policies that facilitate the appointment of foreign directors, potentially through recognition of international qualifications and experiences. This could include providing incentives for companies to recruit foreign directors with sustainability expertise. c) Strengthening the PROPER rating system to better capture carbon-specific performance indicators and provide incentives for companies to achieve higher ratings. The Ministry of Environment could revise the PROPER criteria to include more explicit carbon performance indicators, and d) integrate carbon disclosure requirements more explicitly into existing corporate reporting regulations, moving from voluntary to mandatory disclosure for major emitters. This aligns with international best practices and enhances Indonesia's environmental transparency.

Limitations and Future Research

While this study provides valuable insights, several limitations should be considered when interpreting the findings: (1) The small sample size (80 observations from 16 companies) limits the generalizability of the results to the broader Indonesian corporate sector, particularly SMEs. The focus on large, listed companies means that the findings may not apply to unlisted or smaller firms. Future research could expand the sample to include more companies and a longer time period; (2) The study relies on checklist-based disclosure measurement that captures the *extent* but not the *quality* of carbon disclosure. Companies may engage in "greenwashing" by disclosing minimal information without substantive action. Future research could employ qualitative content analysis to assess disclosure quality; (3) The PROPER rating system may not fully capture carbon-specific performance. Companies with good PROPER ratings may have poor carbon performance, and vice versa. Future research could use alternative environmental performance measures, such as actual carbon emissions data or third-party environmental certifications (e.g., ISO 14001); (4) The study covers 2020-2024, including the COVID-19 pandemic years (2020-2021). The pandemic may have affected corporate operations and reporting practices in ways that influenced the results. Future research could examine longer time periods to identify trends and assess the pandemic's lasting effects.\; and (5) The findings are specific to the Indonesian context. Future research could compare the results across different emerging economies to understand how institutional and cultural factors moderate the relationships examined in this study.

Despite these limitations, this study contributes to the growing literature on carbon emission disclosure in emerging economies and provides valuable insights for policymakers, corporate decision-makers and investors interested in enhancing environmental transparency in Indonesia.

Future research could build on this study in several ways: (a) conduct industry-specific analyses focusing on high-emission sectors (energy, manufacturing, and mining), where carbon disclosure is most critical; (b) employ qualitative methods, such as content analysis, to assess disclosure quality rather than mere extent, providing richer insights into corporate carbon communication strategies; (c) investigate the role of institutional pressures (regulatory, normative, and mimetic) in driving carbon disclosure in Indonesia; (d) examine moderating effects, such as how corporate culture or CEO characteristics influence the relationship between governance structures and carbon disclosure; (f) compare Indonesian findings with other Southeast Asian emerging economies to provide regional insights; (g) investigate longitudinal trends in carbon disclosure to understand how disclosure practices evolve over time in response to changing regulatory and stakeholder pressures; and (h) explore the actual emission reduction outcomes associated with carbon disclosure practices to assess whether disclosure translates into real environmental improvements.

Despite these limitations, this study contributes to the growing literature on carbon emission disclosure in emerging economies and provides valuable insights for policymakers, corporate decision-makers and investors interested in enhancing environmental transparency in Indonesia.

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CONFLICT OF INTEREST

The authors declare that they are free from conflicts of interest in this research, whether financial, professional, personal, organizational membership, relationships with relevant entities, or personal beliefs related to this research topic.

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