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Research paper



Sustainability Accounting Compliance Under IFRS S2: Carbon Emission Disclosure in Indonesian State-Owned Enterprises Across Three Regulatory Phases

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Abstract

Climate change has heightened global demand for clear, comparable carbon emissions reporting. Nonetheless, there is currently no standardized tool to evaluate compliance with carbon emission disclosure requirements under IFRS S2 in the Indonesian context. The purpose of this study is to develop operational indicators for carbon emission disclosure based on IFRS S2, assess how well state-owned enterprises (SOEs) are complying with the rules, and examine how the rules evolve. A mixed-methods approach was utilized. The development of indicators involved desk research, coding processes, and the expertise of professionals. Quantitative analysis included content analysis of annual reports and sustainability reports from SOEs. The Friedman Test and the Wilcoxon Signed-Rank Test were used to assess differences between the phases. The Friedman test indicated substantial differences in compliance levels across the three regulatory phases. Follow-up Wilcoxon tests showed that compliance in Phase 2 and Phase 3 was much higher than in Phase 1. Nonetheless, there was no significant difference between Phase 2 and Phase 3, indicating that enhancements in the final phase signify improved disclosure quality rather than quantity. This research is significant for the development of IFRS S2-based carbon emission disclosure compliance indicators tailored for the Indonesian context; it offers a longitudinal analysis that tracks the evolution of SOE compliance across three national climate regulatory phases; and it presents preliminary empirical evidence indicating that global IFRS S2 standards are impacting corporate reporting behaviour before mandatory implementation.

Keywords: *Disclosure; Carbon Emissions; IFRS S2; State-Owned Enterprises (SOE); Sustainability.*

1. Introduction

In recent decades, climate change has become a major global threat. (Martin, 2022) (Samiullah and Khanum, 2024) (Sudarmaji et al. 2024) (United Nations Environment Programme, 2024) (Sudarmaji, Azizah, & Herlan, 2025a), (Sudarmaji, Azizah, & Herlan, 2025b). Its impacts extend beyond environmental degradation to encompass social, economic, and business sustainability concerns. (Intergovernmental Panel on Climate Change, 2021) (Fujianti, Rizal, et al., 2024) (Fujianti, Azizah, et al., 2024) (Sudarmaji, Azizah, & Nasip, 2025) (Azizah & Wahyoeni, 2025) (Azizah & Fujianti, 2024). In response, the international community has adopted several agreements, most notably the Paris Agreement, signed by 196 countries in 2015. Indonesia ratified this agreement through Law No. 16 of 2016, signaling a formal commitment to reducing greenhouse gas emissions and addressing climate change. This commitment was reinforced by two subsequent policies: Presidential Regulation No. 98 of 2021 on the Implementation of Carbon Economic Value and Ministry of Environment and Forestry Regulation No. 12 of 2024 on Nationally Determined Contributions in Climate Change Management. Together, these regulations reflect Indonesia's gradual and structured approach to climate governance.

At the international level, the International Sustainability Standards Board introduced IFRS S2 in 2023 to strengthen the transparency and comparability of climate-related information. (IFRS Foundation, 2023). IFRS S2 establishes global requirements for climate disclosure, requiring companies to report climate-related risks and opportunities that may reasonably affect cash flows, access to finance, or the cost of capital. Carbon emission disclosure is a central component of this framework, as it provides critical information for investors, creditors, regulators, and other stakeholders. Firms with high emissions face growing exposure to carbon taxes, environmental litigation, and market access restrictions, all of which may threaten long-term business viability. Despite these developments, empirical evidence on the application of IFRS S2 in Indonesia, particularly in relation to carbon emission disclosure, remains limited. (Wahyoeni et al., 2025) (Azizah et al., 2025).

This gap is important because IFRS S2 is principle-based and does not provide prescriptive checklist indicators. As a result, reporting practices vary widely across firms, making it difficult to assess national readiness for the transition to global standards. State-owned enterprises (SOEs) play a strategic role in this context, as they represent both the economic interests of the state and the government's

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commitment to decarbonization and sustainability. Many SOEs operate in carbon-intensive sectors such as energy, infrastructure, mining, and basic industries, and are therefore expected to take a leading role in climate disclosure and transparency. This study addresses three key issues. First, there is a lack of research identifying carbon emission disclosure indicators tailored to the Indonesian context and aligned with the IFRS S2 structure. Second, existing IFRS S2 studies in Indonesia are largely conceptual and normative, with limited quantitative and empirical assessment of compliance. Third, there is a need to evaluate how well SOE disclosure practices align with IFRS S2 indicators across three national regulatory phases: Phase 1 following the ratification of the Paris Agreement (Republik Indonesia Law No. 16/2016), Phase 2 following the implementation of the Carbon Economic Value policy (Presidential Regulation No. 98 of 2021), and Phase 3 following the adoption of the Enhanced Transparency Framework (Ministry Regulation No. 12, 2024).

Carbon emission disclosure provides essential information on total greenhouse gas emissions, measurement approaches, emission reduction targets, and corporate responses to climate change. As climate-related physical and transition risks intensify, the demand for transparent and comparable emission reporting has become increasingly critical, particularly with global frameworks such as TCFD and IFRS S2 shaping climate reporting practices. Prior research suggests that emission disclosure serves strategic purposes beyond environmental reporting. Tadros and Magnan, (2019), show that firms use emission disclosure to respond to regulatory and societal legitimacy pressures, while Khanchel and Lassoued (2022) find that higher-quality environmental disclosure can reduce the cost of capital by lowering information risk. Ilhan et al., 2023) further demonstrate that institutional investors increasingly incorporate climate risk into investment decisions.

Accordingly, emission transparency influences how firms are perceived by the market and how they are valued. Existing studies provide important insights into the factors driving carbon emission disclosure. Grewal, Riedl, and Serafeim (2020) find that mandatory regulation significantly increases both the level and quality of sustainability disclosure. In contrast, Li, Luo, and Tang (2018) show that firms in developing countries tend to disclose minimally in pre-regulatory periods. Christensen, Hail, and Leuz (2021) argue that the adoption of global standards such as IFRS S2 enhances reporting credibility due to their principle-based design and emphasis on auditable measurement.

From a theoretical perspective, carbon emission disclosure is shaped by three main frameworks. Institutional Theory explains that organizations respond to regulatory, normative, and mimetic pressures to gain legitimacy. Regulatory changes, such as Presidential Regulation No. 98 of 2021 and Ministry Regulation No. 12 of 2024, increase pressure on firms to improve disclosure quality. Legitimacy Theory suggests that companies use emission disclosure to maintain social acceptance, particularly as expectations for environmentally responsible behavior increase (Hummel and Schlick, 2016). Stakeholder Theory emphasizes that disclosure responds to stakeholder information needs, as investors and other stakeholders increasingly view climate risk as financially material. (Ilhan et al., 2023).

Taken together, prior studies and theoretical insights indicate that carbon emission disclosure tends to increase under stronger regulatory pressure (Grewal, Riedl, and Serafeim, 2020), improve in quality with the adoption of global standards (Christensen, Hail, and Leuz, 2021), and remain limited during pre-regulatory stages, especially in developing economies (Li, Luo, and Tang, 2018). These patterns suggest that carbon disclosure practices are highly responsive to institutional change and evolving reporting standards. Given the progression of climate-related regulation in Indonesia and the growing influence of global standards, variations in corporate compliance across regulatory phases are expected. Based on this reasoning, the study proposes the following hypotheses:

H1: There are differences in carbon emission disclosure compliance across the three national regulatory phases (Phase 1, 2, and 3).

H2: Compliance levels in Phase 2 are higher than in Phase 1.

H3: Compliance levels in Phase 3 are higher than in Phase 1.

H4: Compliance levels in Phase 3 are higher than in Phase 2.

This study applies a systematic content analysis of SOE annual and sustainability reports across the three regulatory phases. The research approach involves: (1) developing IFRS S2–aligned operational indicators suited to the Indonesian context; (2) quantitatively assessing carbon emission disclosure compliance using these indicators; (3) conducting a longitudinal comparison across regulatory phases to identify disclosure trends; and (4) interpreting the findings using institutional, legitimacy, and stakeholder perspectives.

The study is expected to make several contributions. First, it provides standardized operational indicators for assessing compliance with IFRS S2 carbon emission disclosure requirements. Second, it offers empirical evidence on actual SOE compliance with global climate reporting standards across different regulatory environments. Third, it demonstrates how regulatory development influences both the extent and quality of corporate disclosure. Finally, the findings support policymakers in evaluating regulatory effectiveness and offer practical guidance for SOEs seeking to strengthen climate disclosure in line with national and international standards.

2. Research Method

This study adopts a mixed-methods approach consisting of three main stages. First, a comprehensive desk study of IFRS S2 documents was conducted to develop operational indicators for carbon emission disclosure in line with the IFRS S2 structure. These indicators were subsequently validated through expert evaluation by sustainability disclosure specialists. Second, a systematic content analysis of SOE annual reports and sustainability reports was carried out to assess the extent to which firms complied with carbon emission disclosure requirements during the observation period. Third, a comparative analysis was performed to examine changes in compliance levels across three national regulatory phases: the post–Paris Agreement ratification phase. (Republik Indonesia Law No. 16/2016) (Phase 1), the Carbon Economic Value policy implementation phase (Presidential Regulation No. 98 of 2021) (Phase 2), and the Enhanced Transparency Framework implementation phase (Ministry Regulation No. 12, 2024) (Phase 3). This research design enables a comprehensive assessment of carbon emission disclosure dynamics and the extent to which SOEs adjust their reporting practices in response to regulatory developments and the introduction of IFRS S2.

The study integrates qualitative and quantitative methods, following the approaches of Fujianti, Azizah, and Rizal (2024), Kuswantoro, Solihin, and Djajadikerta (2020), and (Azizah et al., 2024). The qualitative component focuses on indicator development through desk research, coding, and expert judgment to ensure alignment with IFRS S2 requirements. The quantitative component evaluates carbon emission disclosure compliance and examines variations across regulatory phases using statistical analysis. This combination allows for the development of validated disclosure indicators while providing empirical evidence on how Indonesian SOEs report carbon emissions.

The unit of analysis consists of State-Owned Enterprises (SOEs) that consistently published annual or sustainability reports between 2016 and 2024. SOEs were selected due to their strategic role in implementing national climate policies and their expected position as early adopters of global reporting standards such as IFRS S2. The research period is divided into three regulatory phases, which form the basis for longitudinal analysis of disclosure developments over time:

1) Phase 1 (2016–2020): Post-Paris Agreement ratification through Law No. 16 of 2016
2) Phase 2 (2021–2023): Implementation of Presidential Regulation No. 98 of 2021 on Carbon Economic Value

3) Phase 3 (2024): Implementation of the Enhanced Transparency Framework through the Ministry of Environment and Forestry Regulation No. 12 of 2024

Statistical analysis employs a repeated-measures design, as compliance levels were assessed for the same firms across all three regulatory phases. When the normality assumption is satisfied, a Repeated Measures ANOVA is applied to test differences in compliance across phases. When normality is not met, the analysis uses the Friedman Test as a non-parametric alternative. Post hoc comparisons are conducted using the Wilcoxon Signed-Rank Test with a Bonferroni-adjusted significance level ($\alpha = 0.0167$) to identify statistically significant differences between phases.

3. Results and Discussion

The research population consists of State-Owned Enterprises (SOEs). Article 1, paragraph (1), of Law No. 19 of 2003 defines a State-Owned Enterprise as a business entity in which the state owns all or the majority of capital through direct participation in separate state assets. This study applies purposive sampling based on two criteria: (1) SOEs that were consistently listed on the Indonesia Stock Exchange (IDX) from 2016 to 2024, and (2) the availability of complete annual and/or sustainability reports throughout the observation period. The initial screening identified 23 SOEs that met the listing criterion. However, one firm was excluded due to incomplete disclosure, as PT Indofarma (Persero) Tbk did not publish its annual or sustainability report for 2017. Accordingly, the final sample comprises twenty-two (22) SOEs operating across various sectors, including cement, mining, telecommunications, banking, construction, energy, and transportation.

3.1. Development of carbon emission disclosure indicators (based on IFRS S2)

Prior research indicates that companies face both economic and social pressures when disclosing carbon emissions. Emission disclosure functions as a legitimacy mechanism to address regulatory and societal expectations (Tadros and Magnan, 2019) and is associated with a lower cost of capital through reduced information risk (Khanchel and Lassoued, 2022). In addition, institutional investors increasingly integrate climate risk into investment decisions, encouraging firms with comprehensive emission disclosures to gain reputational and valuation advantages. (Ilhan et al., 2023). These considerations highlight the need for disclosure indicators that align with international standards, particularly IFRS S2.

To ensure relevance for capital markets, regulators, and financial statement users, indicator development followed a qualitative deductive approach grounded in the principles, disclosure objectives, and substantive requirements of IFRS S2 Climate-related Disclosures. The process involved three stages: (1) a desk study to identify IFRS S2 provisions related to carbon emissions; (2) thematic analysis to consolidate disclosure items into operational indicators; and (3) validation through expert judgment to ensure relevance, clarity, and applicability within the Indonesian reporting context.

3.1.1. Stage 1: desk study – carbon emission disclosure based on IFRS S2

The first stage involved an in-depth desk review of IFRS S2 Climate-related Disclosures. Three researchers examined all provisions related to greenhouse gas (GHG) emission disclosure, focusing on: (1) Scope 1, Scope 2, and Scope 3 emissions; (2) emission measurement and quantification methods; (3) emission targets and transition strategies; (4) the use of carbon credits in net emission calculations; (5) internal carbon pricing and transition risk; and (6) verification and assurance requirements. This review resulted in an initial list of 27 disclosure points directly related to carbon emissions, which served as the foundation for subsequent thematic analysis and indicator refinement.

3.1.2. Stage 2: thematic analysis and indicator simplification

The second stage applied thematic analysis to the 27 disclosure points identified in Stage 1. The objective was to identify core concepts and structural relationships within the IFRS S2 carbon disclosure framework while maintaining practical applicability for compliance assessment. Two qualitative techniques were employed: open coding to identify the core meaning of each disclosure item, and axial coding to group related concepts and consolidate overlapping or complementary items. Based on the core structure of IFRS S2, the disclosure points were grouped into six thematic categories: (a) GHG Emission Measurement (Scope 1, 2, and 3 classification); (b) Calculation Approaches, Assumptions, and Methodologies; (c) Emission Targets and Decarbonization Performance; (d) Carbon Pricing, Transition Strategy, and Emission Costs; (e) Carbon Credits and Offsetting; and (f) Verification and Certification.

Through this process, the number of indicators was reduced from 27 to 15 (E1–E15). Although streamlined, these indicators retain the substantive scope of IFRS S2 and reflect the logical sequence of carbon emission disclosure, from measurement and methodology to strategy and verification. This structure enhances usability and facilitates consistent compliance assessment.

3.1.3. Stage 3: validation through expert judgment

The final stage involved expert validation to ensure that the indicators were theoretically sound, aligned with IFRS S2, and suitable for Indonesian corporate reporting practices. Sustainability reporting experts reviewed the indicators to assess four key aspects: (1) alignment with IFRS S2 principles and disclosure requirements; (2) conceptual clarity to minimize subjectivity in content analysis; (3) measurability for objective compliance assessment; and (4) contextual appropriateness given Indonesia's reporting maturity and data availability.

Expert feedback led to refinements in terminology and indicator structure. For example, clarifications were made regarding the distinction between gross and net emissions, the use of location-based Scope 2 measurement, and the required elements of emission target disclosure. Overlapping indicators were simplified to ensure that each represented a single substantive disclosure domain. As a result, the final set of 15 indicators (E1–E15) meets IFRS S2 requirements while remaining practical, measurable, and applicable for assessing carbon emission disclosure compliance among Indonesian SOEs. These indicators form the core measurement instrument used in this study and are presented in Table 1.

Table 1: Carbon Emission Disclosure Indicators Based on IFRS S2

Code	Carbon Emission Disclosure Indicator	Category	IFRS S2 Reference
E1	Absolute gross greenhouse gas (GHG) emissions generated by the company during the reporting period, measured in metric tons of CO_2	GHG Emissions Measurement	Par. 29(a)(i)–(iii)
E2	Classification of emissions by Scope 1, Scope 2, and Scope 3	GHG Emissions Measurement	Par. 29(a)(i)(1–3)
E3	Applied measurement standards (e.g., GHG Protocol) or other recognized standards	Measurement Methodology & Assumptions	Par. 29(a)(ii–iii), B23–B31
E4	Disclosure of measurement approaches, inputs, and assumptions used	Measurement Methodology & Assumptions	Par. 29(a)(iii)(1–3)
E5	Explanation for the selection of the measurement approach	Measurement Methodology & Assumptions	Par. 29(a)(iii)(2)
E6	Disclosure of reasons for changes in measurement methods and assumptions	Measurement Methodology & Assumptions	Par. 29(a)(iii)(3), 29(f)
E7	Application of an internal carbon price	Carbon Pricing & Transition Risk	Par. 29(f)(i)
E8	Carbon price per ton of CO_2 used as an internal carbon cost	Carbon Pricing & Transition Risk	Par. 29(f)(ii)
E9	Disclosure of the type of GHG emission reduction targets	Emission Targets & Decarbonization Performance	Par. 33(a–h)
E10	Method used to establish the target baseline and justification for its selection.	Emission Targets & Decarbonization Performance	Par. 36(a–c)
E11	Explanation of whether emission targets are absolute or intensity-based	Emission Targets & Decarbonization Performance	Par. 33(g)
E12	Sector-specific decarbonization plans or transition strategies	Transition Strategy	Par. 14(a)(iv), 22
E13	Disclosure of net emissions after offsets	Carbon Credits & Offsetting	Par. 36(c), 36(e)
E14	Third-party verification or assurance of emission targets and/or net emissions	Verification & Assurance	Par. 32(a–b)
E15	Explanation of the type of carbon credits used	Carbon Credits & Offsetting	Par. 36(e)(ii–iv)

3.2. Carbon emission disclosure in phase 1 (2016-2020)

Phase 1 corresponds to the period following Indonesia's ratification of the Paris Agreement through Law No. 16 of 2016, marking the country's initial commitment to controlling greenhouse gas (GHG) emissions. During this phase, there were no mandatory requirements for SOEs to disclose carbon emissions. Disclosure practices, therefore, depended largely on voluntary corporate decisions and the level of internal awareness of climate-related risks. This context mirrors early-stage reporting environments in many developing countries, where disclosure levels tend to remain limited (Li, Luo, and Tang, 2018).

Analysis of 22 SOEs over the 2016–2020 period shows that carbon emission disclosure, measured using IFRS S2–based indicators, remained generally low. Most disclosures focused on basic indicators, particularly E1 (total GHG emissions) and E2 (Scope 1, 2, and 3 classification), each appearing 38 times. Indicator E3, relating to measurement standards, appeared 26 times. These disclosures suggest that some firms had begun calculating emissions operationally, but provided limited information on underlying methodologies. This pattern is consistent with Liesen et al. (2015), who find that early-stage disclosures typically report emission figures without detailed explanations of calculation methods or assumptions.

Methodological indicators were disclosed less frequently. E4 (measurement approaches, inputs, and assumptions) appeared 18 times, E5 (rationale for method selection) 17 times, and E6 (changes in methods or assumptions) only 10 times. This indicates weak methodological transparency and limited formalization of emission measurement practices. Similar patterns have been documented by Grewal, Riedl, and Serafeim (2019), who note that firms tend to disclose only essential information before regulatory enforcement. Disclosure of emission targets also followed this pattern. Indicators E9–E11 appeared between 18 and 21 times, but most targets lacked quantitative baselines, defined timeframes, or measurable performance criteria, functioning more as general commitments than actionable targets.

Forward-looking and strategic disclosures were particularly limited. Internal carbon pricing indicators E7 and E8 appeared only four and three times, respectively. Disclosure of decarbonization strategies (E12) appeared once, while net emissions disclosure (E13) appeared only twice. Prior research shows that internal carbon pricing typically emerges in jurisdictions with formal climate policies and developed carbon markets. (Zhu et al., 2022). conditions that were not yet present in Indonesia during Phase 1. The absence of third-party verification (E14) and carbon credit disclosure (E15) further indicates that assurance and offsetting mechanisms had not yet been adopted.

Overall, disclosure patterns in Phase 1 suggest that SOEs were in the early stages of carbon reporting, with disclosures primarily aimed at maintaining social legitimacy rather than supporting comprehensive climate risk management. From a legitimacy theory perspective, firms appeared to provide minimal information to satisfy stakeholder expectations, particularly in emission-intensive sectors such as mining and energy.

3.3. Carbon emission disclosure in phase 2 (2021-2023)

Phase 2 began with the issuance of Presidential Regulation No. 98 of 2021 on the Implementation of Carbon Economic Value. This regulation introduced incentive–disincentive mechanisms, carbon trading, certification, and sector-based emission reduction obligations. As a result, regulatory pressure increased substantially, particularly for SOEs, requiring improvements in emission reporting quality and climate governance. Theoretical and empirical literature suggests that such regulatory developments encourage greater transparency as firms respond to legitimacy pressures, market expectations, and potential compliance costs. (Cormier & Magnan, 2015; Kalu et al., 2016).

Empirical analysis of 22 SOEs during the 2021–2023 period shows a clear increase in disclosure relative to Phase 1. Basic indicators E1 and E2 appeared 56 and 50 times, respectively, while methodological indicators E3–E5 appeared between 51 and 54 times. Given a maximum possible frequency of 66 observations (22 firms × 3 years), these results indicate substantial improvement in basic and methodological disclosure. This trend reflects the growing need for emission measurement readiness in support of Carbon Economic Value implementation and national carbon market preparation. Consistent with prior studies, increased regulatory pressure appears to encourage more detailed technical disclosure (Liesen et al., 2015).

Disclosure of emission targets also increased significantly. Indicator E9 appeared 53 times, E10 appeared 51 times, and E11 appeared 42 times. Despite this increase, most targets remained qualitative and lacked standardized quantitative baselines. This pattern is common during regulatory transition periods, as firms often expand disclosure before fully adopting standardized target-setting frameworks (Grewal, Riedl, and Serafeim, 2020). Internal carbon pricing disclosure increased modestly, with E7 appearing 15 times and E8 five times. These

disclosures likely reflect early responses to Carbon Economic Value provisions, although the low frequency suggests that most SOEs were still developing internal carbon pricing capabilities.

Strategic and outcome-oriented disclosures showed limited progress. Decarbonization strategies (E12) appeared four times, while net emissions disclosure (E13) did not appear at all. This absence aligns with evidence that firms in developing countries often lack the technological and monitoring capacity required for net emission accounting (Kalu et al., 2016). Third-party verification (E14) and carbon credit disclosure (E15) emerged for the first time, though at low levels, appearing four times and once, respectively.

Overall, Phase 2 reflects a transition from minimal disclosure toward regulatory readiness for carbon economics. Compared with Phase 1, SOEs improved methodological transparency, expanded target-related disclosures, and began engaging with carbon pricing and verification mechanisms. These findings support the regulatory pressure hypothesis (Cormier and Magnan, 2015) and stakeholder theory, which suggests that increasing market and regulatory expectations drive broader disclosure practices (Amel-Zadeh and Serafeim, 2018).

3.4. Carbon emission disclosure in phase 3 (2024)

Phase 3 marks Indonesia's initial move toward alignment with international climate reporting standards through the implementation of the Enhanced Transparency Framework (ETF) and strengthened emission reporting requirements. These developments coincided with the publication of IFRS S2 Climate-related Disclosures in 2023. IFRS S2 introduces a principle-based framework that emphasizes disclosure across four core pillars: governance, strategy, risk management, and metrics and targets, all of which are directly linked to carbon emission measurement and transition planning.

Analysis of carbon emission disclosures by 22 SOEs in 2024 reveals a shift from the quantitative expansion observed in Phase 2 toward qualitative and structural improvements. Indicators E1–E5 remained the most frequently disclosed, appearing between 17 and 19 times, indicating that emission measurement and methodology had become the foundation of climate reporting. This pattern is consistent with IFRS S2 requirements for Scope 1–3 emissions and transparent disclosure of measurement methods and assumptions. Disclosure of emission targets (E9–E11) also remained relatively consistent, appearing between 13 and 18 times. Compared with earlier phases, target disclosures were more structured, reflecting clearer baselines, timeframes, and strategic alignment, even though many targets remained qualitative.

Strategic disclosures continued to emerge gradually. Internal carbon pricing indicators E7 and E8 appeared three and two times, respectively, suggesting early adoption among a small number of SOEs. Some firms appear to be integrating carbon pricing into broader transition risk management, in line with IFRS S2 guidance. Disclosure of decarbonization strategies (E12) appeared twice, while net emissions (E13) remained undisclosed. As noted by Kalu et al. (2016), net emission reporting requires advanced monitoring, reporting, and verification (MRV) systems, which are still developing in Indonesia. However, the appearance of third-party verification (E14) in two cases signals growing attention to the reliability and credibility of climate information.

In summary, Phase 3 indicates meaningful progress toward alignment with international standards, particularly IFRS S2. While Phase 2 was characterized by increases in disclosure quantity driven by regulatory pressure, Phase 3 reflects improvements in disclosure quality. These include greater methodological consistency, clearer emission classification, emerging verification practices, and closer integration of long-term targets with IFRS S2 metrics and targets requirements. This shift suggests that Indonesian SOEs are beginning to move from compliance-driven reporting toward more structured and internationally aligned climate disclosure practices.

3.5. Comparative analysis of carbon emission disclosure compliance across regulatory phases

Descriptive statistics provide an initial overview of carbon emission disclosure compliance across the three regulatory phases. Phase 1 (2016–2020) represents the period following Indonesia's ratification of the Paris Agreement. Phase 2 (2021–2023) corresponds to the implementation of Presidential Regulation No. 98 of 2021 on Carbon Economic Value, which introduced national emission calculation systems and incentive–disincentive mechanisms. Phase 3 (2024) marks the introduction of Enhanced Transparency Framework–based reporting under Ministry Regulation No. 12 of 2024, as well as the beginning of substantive alignment with the global IFRS S2 Climate-related Disclosures issued in 2023.

The descriptive results show a clear and gradual improvement in carbon emission disclosure compliance across phases. In Phase 1, the average compliance score was 0.129, indicating very limited disclosure. The minimum value was 0, suggesting that some firms did not disclose any carbon-related information, while the maximum value was 0.560, recorded by PT Perusahaan Gas Negara Tbk, which disclosed approximately half of the indicators used in this study.

In Phase 2, the average compliance score increased substantially to 0.449. This improvement reflects SOEs' responses to stronger regulatory pressure following the implementation of Presidential Regulation No. 98 of 2021, which encouraged more systematic emission reporting. The highest compliance score in this phase reached 0.733 at PT Bukit Asam Tbk, indicating disclosure of more than 70 percent of the indicators. This pattern is consistent with evidence that mandatory non-financial regulation enhances both the scope and quality of corporate disclosure (Grewal, Riedl, and Serafeim, 2020). In Phase 3, the average compliance score increased slightly to 0.460. Although this increase was smaller than the change from Phase 1 to Phase 2, the minimum and maximum values of 0.067 and 0.933 indicate a wide range of disclosure practices. The highest score was recorded by PT Adhi Karya (Persero) Tbk, while the lowest was observed at PT Krakatau Steel (Persero) Tbk.

The dispersion of disclosure practices, reflected in standard deviation values, further illustrates the dynamics of disclosure development. In Phase 1, the relatively low standard deviation of 0.134 indicates that most SOEs exhibited similarly low compliance levels. In Phase 2 (standard deviation 0.163) and particularly in Phase 3 (standard deviation 0.232), variability increased, suggesting that some firms adapted more rapidly to regulatory changes and global standards, while others progressed more slowly.

3.6. Statistical testing results

Before conducting inferential analysis, two key assumptions for Repeated Measures ANOVA were assessed: sphericity and residual normality. Mauchly's Test of Sphericity produced a value of $W = 0.945$ with $p = 0.567$ ($p > 0.05$), indicating that the sphericity assumption was satisfied. This suggests that variance differences across the three regulatory phases were homogeneous. However, the Shapiro–Wilk normality test revealed that residuals for Phase 1 were not normally distributed ($p = 0.000$), while residuals for Phase 2 ($p = 0.061$) and Phase 3 ($p = 0.443$) met the normality assumption. Because normality was violated in at least one condition, the assumptions for Repeated Measures ANOVA were not fully satisfied. Methodological studies caution against using ANOVA under such conditions, as non-normal repeated-measures data may lead to biased estimates and inflated Type I error rates. (Ghasemi and Zahediasl, 2012).

3.7. Friedman test results

The Friedman test was therefore applied to examine differences in carbon emission disclosure compliance across the three regulatory phases. The test yielded a Chi-Square value of 28.259 with two degrees of freedom and a significance level of $p = 0.000$, indicating statistically significant differences in compliance between Phase 1, Phase 2, and Phase 3.

These results demonstrate that SOEs responded noticeably to changes in national and international climate policy. The most pronounced increase occurred between Phase 1 and Phase 2, following the implementation of Presidential Regulation No. 98 of 2021. This regulation introduced incentive–disincentive mechanisms, carbon trading, and stricter requirements for emission inventories, prompting firms to expand and improve their disclosures. This finding is consistent with prior evidence showing that mandatory sustainability regulation significantly increases disclosure quality and scope (Grewal, Riedl, and Serafeim, 2020).

The transition from Phase 2 to Phase 3 showed more moderate improvement. During this phase, disclosure enhancements were largely driven by the implementation of the Enhanced Transparency Framework under Ministry Regulation No. 12 of 2024 and the growing influence of IFRS S2 as a reference for sustainability reporting. This stage was characterized by greater methodological consistency, improved structural clarity, and the integration of long-term objectives, signaling a shift from compliance-driven disclosure toward alignment with global reporting standards. This pattern aligns with Christensen, Hail, and Leuz (2021) who argue that international standards enhance the comparability and accountability of sustainability information.

3.8. Wilcoxon signed-rank test results

Following the Friedman test results indicating significant differences across regulatory phases, Wilcoxon Signed-Rank tests were performed to determine which phases exhibited variations in carbon emission disclosure compliance levels. Testing was conducted on three-phase pairs, using the Bonferroni correction with $\alpha = 0.0167$. The analysis revealed substantial differences between Phase 1 and Phase 2 ($Z = -3.945$; $p = 0.000$) and between Phase 1 and Phase 3 ($Z = -4.075$; $p = 0.000$), whereas no significant difference was observed between Phase 2 and Phase 3 ($Z = -0.060$; $p = 0.952$).

The significant differences between Phase 1 and Phase 2 indicate that SOEs responded strongly to stricter rules during the Carbon Economic Value period. This policy implementation required companies to conduct emission inventories and establish incentive-disincentive mechanisms alongside enhanced reporting governance, thereby fostering greater transparency. The results corroborate the conclusions of Grewal, Riedl, and Serafeim (2020), which assert that mandatory non-financial regulations substantially enhance the quality and intensity of company disclosures due to compliance pressures and the mitigation of reputational risk.

There are also big differences between Phase 1 and Phase 3. This shows that SOEs not only increased the number of indicators they reported, but also improved the structure and depth of their reports after adopting the Enhanced Transparency Framework (ETF) policy and the global IFRS S2 Climate-related Disclosures standard. Research by Christensen, Hail, and Leuz (2021) substantiates that alignment with international standards, such as IFRS S2, compels companies to enhance the accountability and comparability of climate information, as evidenced by the notable increases in disclosures during Phase 3.

However, the lack of significant differences between Phase 2 and Phase 3 indicates that, quantitatively, carbon emission disclosure compliance levels have stabilized since Phase 2, as evidenced by average compliance values of 0.449 in Phase 2, which increased only marginally to 0.460 in Phase 3—a negligible and statistically insignificant difference. But just because the numbers stayed the same doesn't mean that there wasn't any real growth. In Phase 3, companies began improving the quality of their reports, particularly by strengthening their measurement methods, setting clearer goals, and including climate risk and transition strategy, as required by the Enhanced Transparency Framework (ETF) and IFRS S2 Climate-related Disclosures.

In the context of Indonesian sustainability reporting, IFRS S2 is still very new and is only just starting to be used. This means that the increase in disclosures may not seem very important yet, but improvements in quality are already showing. This phenomenon corresponds with the findings of Andeobu, Warr, and Grandhi (2022), which indicates that following the successful enhancement of disclosure levels during initial regulatory phases, subsequent stages in the evolution of sustainability reporting primarily emphasize quality improvements, consistency, and the verifiability of information, rather than merely increasing the quantity of disclosed indicators.

The results of the Wilcoxon test show that changes in regulations affect how companies report their carbon emissions. The biggest changes happened when the Carbon Economic Value policy was put into place. Phase 3 shows that the reporting is in line with international standards. The results show that SOEs' compliance with carbon emission disclosure rules is affected by both their awareness of sustainability and the pressures of policies, global standards, and stakeholder expectations as the world moves toward low-carbon economies.

4. Conclusions and Implications

4.1. Summary of findings

This study evaluated compliance with carbon emission disclosure requirements among Indonesian state-owned enterprises (SOEs) using 15 indicators based on IFRS S2 Climate-related Disclosures, and investigated the influence of national climate regulations on reporting practices over time. The study is particularly important because Indonesia is moving toward stricter global climate reporting standards, especially after IFRS S2 is published in 2023 and begins to be used worldwide in 2024. SOEs are expected to be the first to implement these standards because they are strategic entities. The study aimed to achieve three objectives: the creation of standardized carbon emission disclosure indicators grounded in IFRS S2, the evaluation of SOE compliance levels, and the examination of compliance variations across three phases of Indonesian climate regulation.

The results show that SOE carbon emission disclosure is clearly and steadily improving in line with changes in national regulations. In Phase 1, the average score was only 0.129, indicating that reporting was voluntary after the Paris Agreement was ratified. When Phase 2 began in 2021 and ended in 2023, compliance increased significantly, to an average of 0.449. This was when Presidential Regulation No. 98 of 2021 on Carbon Economic Value went into effect. Statistical analysis using the Friedman and Wilcoxon tests confirmed a significant difference between Phase 1 and Phase 2, indicating that formal incentive-disincentive regulations markedly affected SOE carbon disclosure behavior, as anticipated by institutional theory and corroborated by empirical evidence from Grewal, Riedl, and Serafeim (2020).

In 2024, Phase 3 raised average compliance to 0.460, an improvement over previous years. This was because reporting was aligned with the Enhanced Transparency Framework, as set out in the Ministry of Environment and Forestry Regulation No. 12/2024, and with early IFRS S2 implementation. Statistical tests did not show a significant difference between Phase 2 and Phase 3. However, this change was

still important because companies began improving the quality of their reports rather than simply increasing the number of disclosures. Improvements included more technical indicators, greater transparency about methods, and better ways to incorporate climate risks into business plans. This pattern aligns with what Christensen, Hail, and Leuz (2021) found: that following international standards such as IFRS S2 makes companies more responsible and better able to compare climate information.

The research definitively demonstrates that the evolution of national regulations, especially the adoption of Carbon Economic Value and Enhanced Transparency Framework policies, in conjunction with early alignment with IFRS S2, has substantially increased SOEs' compliance with carbon emission disclosure requirements. These findings suggest that Indonesian SOEs have commenced an initial phase of climate reporting maturity, thereby creating an essential groundwork for the comprehensive implementation of IFRS S2. The shift from Phase 2's focus on quantity to Phase 3's on quality marks a major change in how companies govern their climate. This progression shows that regulatory pressure and the adoption of global standards can lead to real changes in corporate transparency. This supports theoretical frameworks that say institutional pressure, concerns about legitimacy, and stakeholder expectations are the main reasons why sustainability reporting has changed in emerging markets.

4.2. Theoretical implications

The research results have significant implications for theory development. The findings indicate that national climate regulatory modifications, spanning from the ratification of the Paris Agreement to Law No. 16 of 2016, the implementation of Carbon Economic Value via Presidential Regulation 98/2021, and the application of the Enhanced Transparency Framework through Ministry Regulation No. 12/2024, have significantly impacted compliance levels in carbon emission disclosure. Significant increases from Phase 1 to Phase 2 reinforce Institutional Theory, especially regarding the roles of coercive pressure as primary catalysts of changes in climate reporting practices, as noted by Grewal, Riedl, and Serafeim, (2020), and Christensen, Hail, and Leuz (2021). Moreover, substantial disparities between Phase 1 and Phase 3 indicate that companies not only augmented the quantity but also the quality of disclosures to preserve public legitimacy. This aligns with the Legitimacy Theory, which posits that companies respond to stakeholder expectations by enhancing transparency. This research contributes fresh empirical evidence to the literature on global standard adoption, as IFRS S2, newly published in 2023 and commencing global adoption in 2024, has already begun to impact company reporting structures.

4.3. Managerial implications

From a managerial point of view, research shows that SOEs need to improve their emission measurement systems by adopting standard-based calculation methods, better managing emission data, and obtaining third-party verification to comply with IFRS S2. Strengthening climate governance is also important, especially by establishing a climate risk committee, improving director oversight, and integrating climate risk into long-term business planning and strategy. Companies also need to set clearer, more measurable emission goals based on a baseline, with clear deadlines for when they must be met. These goals should also align with Indonesia's NDC commitments.

4.4. Policy implications

This research highlights the need to expedite the integration of Carbon Economic Value frameworks, ETFs, and IFRS S2 to establish comprehensive national reporting systems that align with international standards. Because IFRS S2 is still new, the government needs to provide national technical guidance on calculating emissions, reporting them, and setting climate targets. The research results also show that it is important to establish national assurance mechanisms for climate reporting, especially given Phase 3's finding that third-party verification is low. The government can also use SOEs as leaders in implementing IFRS S2, as they can improve compliance under regulatory pressure. This could make them models for national climate reporting and help Indonesia get ready to join international carbon markets.

4.5. Limitation

However, these findings should be interpreted with caution, as the analysis is confined to state-owned enterprises (SOEs), which operate under distinct governance structures, regulatory obligations, and public accountability compared to private-sector firms. Consequently, the observed compliance dynamics and regulatory responsiveness may not be directly generalizable to non-SOE or privately owned companies, particularly those facing different market pressures and ownership incentives. Future research is therefore encouraged to extend this framework to private firms or cross-country contexts to enhance the external validity of IFRS S2, based disclosure assessments.

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