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Research Paper

Corporate Social Responsibility and Climate Action: Assessing Indonesian Mining Companies' Contributions to SDG 13

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Abstract
This study examines how Indonesian mining companies incorporate climate action within their corporate social responsibility (CSR) strategies, with a particular focus on their contributions to Sustainable Development Goal (SDG) 13. Using qualitative content analysis of ten publicly available CSR and sustainability reports, the study identifies recurring themes in corporate disclosures, including operational activities, environmental performance data, target-setting, and collaborative initiatives. The findings reveal both progress and gaps in aligning mining practices with national and international climate objectives. Four thematic areas emerge, including (1) operational decarbonization efforts that increasingly combine low-carbon technologies with nature-based solutions (NbS), although their effectiveness is rarely assessed through standardized indicators; (2) responsibility framing and measurable targets that show greater alignment with frameworks such as the Paris Agreement and Indonesia's Nationally Determined Contributions, yet governance and assurance mechanisms remain underdeveloped, raising concerns of potential greenwashing; (3) while disclosure of environmental data has improved, comparability across firms is constrained by inconsistent adoption of metrics and limited integration of Life Cycle Assessment (LCA); and (4) climate-related risks are widely acknowledged, with firms outlining resilience strategies and engaging in multi-stakeholder partnerships to enhance adaptive capacity. Overall, Indonesian mining companies demonstrate a growing recognition of their role in climate action. However, advancing their contribution to SDG 13 requires systematic evaluation of NbS, stronger ESG governance and accountability, broader institutionalization of LCA, and deeper stakeholder engagement. These improvements are essential to ensure CSR initiatives deliver substantive, measurable, and socially inclusive climate outcomes.

Keywords
Environmental Governance, Sustainability Reporting, Resilience, Accountability, Stakeholder Engagement

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1. INTRODUCTION

The concept of corporate social responsibility (CSR) the notion that companies are accountable not only to shareholders but also to society and a wider group of stakeholders-began to gain prominence in the 1960s. Since then, interest in CSR has steadily increased among scholars and business practitioners globally (Wang et al., 2016). The mining industry, while essential to the global economy for supplying key raw materials and energy to various sectors, often faces criticism for its negative impacts on workers' health, the environment, and surrounding communities. As a result, mining companies are increasingly challenged to reconcile their operational goals with broader social responsibilities (Pons et al., 2021; Asih et al., 2022; Zamroni et al., 2022). In response, the global mining sector has made strides in acknowledging and addressing its environmental and social obligations. This shift is driven by multiple factors, placing the extractive industry at the center of discussions on sustainability. Mining companies often prioritize community-based programs in their CSR agendas, as the social, economic, and environmental impacts of their activities are most directly experienced at the local level (Sharma and Bhatnagar, 2015).

Climate change poses significant challenges to both the present and future of mining operations, particularly through its impacts on surrounding communities and ecosystems (Odell et al., 2018). As the world's fourth-most populous

country and home to the third-largest area of tropical rainforest, Indonesia occupies a critical position in global climate mitigation efforts. Despite policy measures aimed at protecting forests and peatlands, the country's energy system remains heavily dependent on fossil fuels, particularly coal, which continues to undermine its climate ambitions (Fünfgeld, 2020). Progress on climate action has therefore been uneven and relatively slow, driven in part by rising domestic coal consumption associated with mineral downstreaming policies. Critics have argued that Indonesia's downstream mining strategy insufficiently reflects the urgency of the climate crisis (Azzahra et al., 2025). As a signatory to the Paris Agreement, Indonesia has committed to reducing greenhouse gas (GHG) emissions by 29% below the 2010 baseline by 2030 under a business-as-usual scenario, and by up to 41% with international support, with mitigation efforts targeting the energy, waste, industrial processes, agriculture, and forestry sectors (Maskun et al., 2021). These commitments were subsequently strengthened through Indonesia's enhanced Nationally Determined Contribution (NDC), which sets more ambitious targets of an unconditional 31.89% reduction and up to a 43.20% reduction in GHG emissions by 2030. While these enhanced targets underscore Indonesia's increased ambition in supporting global emission reduction efforts, achieving them remains challenging without substantial international financial, technological, and capacity-building support. Beyond emissions mitigation, the enhanced NDC also plays a strategic role in encouraging sectoral transitions toward renewable energy, thereby reinforcing the relevance of climate-oriented policies and corporate actions-particularly within high-emission sectors such as mining (Kurniawan et al., 2024).

The Sustainable Development Goals (SDGs), introduced by the United Nations in 2015, outline 17 global targets designed to address pressing environmental, social, and economic challenges by the year 2030. These goals offer a holistic framework for governments, industries, and organizations to pursue a more sustainable future, tackling critical issues such as poverty, education, climate change, and gender equality (Wahid and Magassing, 2025). SDG 13, which focuses on climate action, encourages the adoption of environmentally responsible practices within sectors like mining. It emphasizes three core approaches: emission reduction, integrating climate considerations into planning and investment, and strengthening resilience to climate-related impacts (Kouhi et al., 2024). A strong connection exists between CSR and SDGs, with the latter providing a strategic framework for companies to identify and address broader societal and environmental challenges (Anggusti and Siregar, 2024). Although the relationship between CSR and the SDGs has been widely examined, existing studies in Indonesia largely adopt a generalized approach, focusing on CSR disclosure, governance, or overall SDG engagement across multiple sectors or multinational corporations (Megawati and Pratama, 2024; Mursitama et al., 2025; Muskanan et al., 2025). There is still a dearth of research on resource-intensive and high-emission sectors, especially the mining industry. More importantly, current CSR studies in Indonesian mining companies tend to emphasize environmental management or community development broadly, without systematically assessing how climate action (SDG 13) is operationalized within CSR strategies. Despite the mining sector's substantial contribution to Indonesia's economic development, it is also one of the country's primary sources of environmental degradation and greenhouse gas emissions. While CSR and sustainability reports from mining companies are increasingly accessible, there is a lack of empirical evaluation that critically examines the extent to which climate-related CSR initiatives are aligned with SDG 13 targets and indicators. This study addresses this gap by providing a focused assessment of climate-oriented CSR practices among Indonesian mining companies, evaluating their alignment with SDG 13, and identifying key strengths, gaps, and areas for improvement. By offering a sector-specific and SDG-targeted analysis, this research contributes novel empirical insights into how a high-emission industry can integrate climate action into CSR frameworks and support national and global climate objectives.

2. EXPERIMENTAL SECTION

2.1 Conceptual Framework

Fallah Shayan et al. (2022) introduced an integrated framework that situates CSR within the broader agenda of the SDGs, emphasizing its dual role in promoting environmental, social, and economic sustainability while simultaneously enhancing corporate profitability and organizational growth. In line with this approach, the present study formulates a conceptual framework that explicates the linkage between CSR practices in the mining sector and the attainment of SDG 13 (Climate Action). This relationship is depicted in Figure 1.

The conceptual framework explains the causal pathways through which CSR practices in the mining sector contribute to achieving SDG 13 (Climate Action). CSR is conceptualized using the triple bottom line approach, which integrates environmental, social, and economic responsibilities as mutually reinforcing dimensions of corporate performance (González-Rodríguez et al., 2015). In the mining context, these dimensions translate into concrete CSR mechanisms that influence climate outcomes through mitigation, adaptation, and governance processes. First, the environmental dimension of CSR drives mitigation-oriented actions, such as energy efficiency improvements, the adoption of renewable energy sources, emissions monitoring, and carbon reduction initiatives. These actions directly reduce greenhouse gas emissions, thereby contributing causally to SDG 13 by lowering the carbon intensity of mining operations. Second, the social dimension of CSR operates through adaptation mechanisms, including community-based climate resilience programs, disaster preparedness initiatives, livelihood diver-

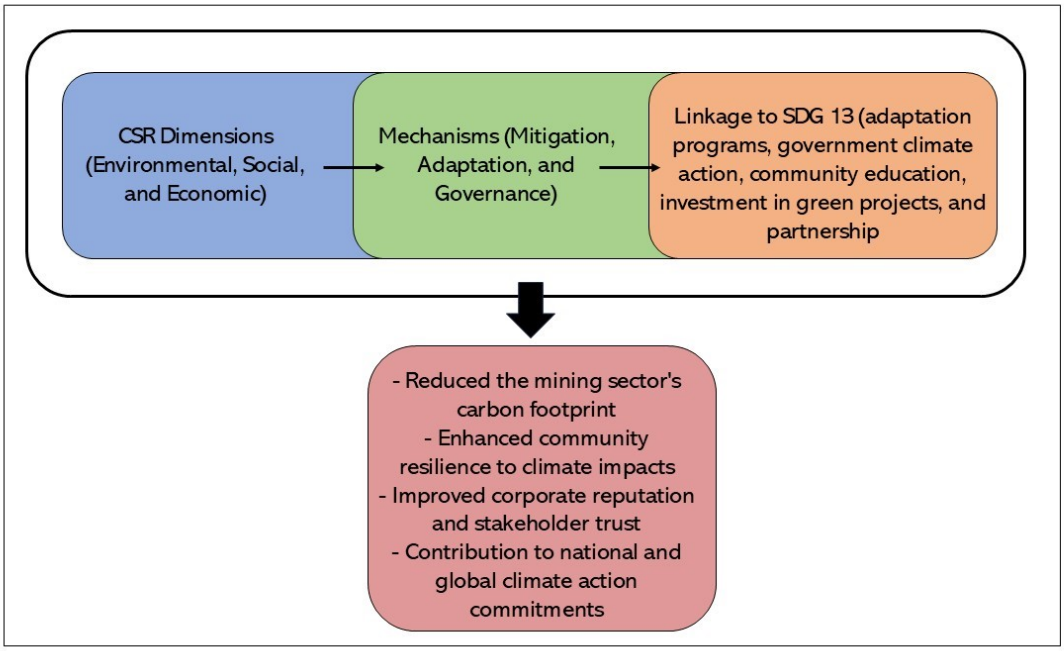

Figure 1. A Conceptual Framework of the Linkage Between CSR in Mining Companies and SDG 13

sification, and climate awareness campaigns. By strengthening the adaptive capacity of communities surrounding mining sites, these CSR activities enhance resilience to climate-related hazards and directly address SDG 13 targets on adaptation and vulnerability reduction. Third, the economic and governance dimensions of CSR shape institutional integration and accountability mechanisms. Leadership commitment, organizational culture, and stakeholder engagement influence whether climate considerations are embedded into corporate strategies, investment decisions, and risk management frameworks. Stakeholder engagement functions as a mediating mechanism by aligning corporate incentives with societal expectations, reducing conflict, improving transparency, and encouraging long-term climate-oriented investments (Siahaan et al., 2025). In this framework, CSR governance evolves from a firm-centered approach to a multi-stakeholder, co-financed system in which governments, communities, and independent evaluators jointly design, implement, and assess climate-related CSR initiatives. These mechanisms collectively enable CSR initiatives to support SDG 13 targets by (i) strengthening resilience and adaptive capacity to climate-related hazards; (ii) integrating climate action into corporate governance and policy frameworks; (iii) enhancing climate education and awareness; and (iv) mobilizing financial and institutional resources for climate partnerships (United Nations, 2015). The cumulative effects of these causal pathways result in four interrelated outcomes: reduced corporate carbon footprints, enhanced community climate resilience, improved corporate legitimacy and stakeholder trust, and measurable contributions to national and global climate commitments. Thus, the framework positions CSR not merely as an accountability instrument but as a strategic causal driver linking mining-sector practices to tangible climate mitigation and adaptation outcomes under SDG 13.

2.2 Methods

This study employs a qualitative content analysis method to examine how Indonesian mining companies support climate action (SDG 13) through their CSR and sustainability disclosures. Content analysis is a well-established technique in sustainability research, enabling the systematic review of textual data to derive meaningful interpretations (Krippendorff, 2018). A total of ten CSR or sustainability reports were purposively selected from the official websites of leading mining companies operating in Indonesia. As these documents represent self-reported corporate disclosures, the analysis is subject to inherent limitations, including potential reporting bias, selective disclosure, and the risk of emphasizing positive performance while underreporting challenges or shortcomings. Consequently, the findings reflect how companies frame and communicate their climate-related CSR commitments rather than providing independent verification of actual performance. Despite this limitation, corporate sustainability reports remain a widely used and policy-relevant data source for assessing prevailing CSR narratives, governance practices, and alignment with SDG 13 across the mining sector. This sample size was determined to balance analytical depth

with sectoral representativeness, which is appropriate for qualitative content analysis of CSR-SDG alignment. The selected companies represent a cross-section of the Indonesian mining industry, encompassing both state-owned and privately held enterprises, as well as firms engaged in major mineral and coal extraction activities that contribute significantly to national production and greenhouse gas emissions. Inclusion criteria comprised (1) active involvement in mining operations in Indonesia, (2) availability of a recent CSR or sustainability report published within the past three years, and (3) sufficient disclosure of environmental and climate-related initiatives to enable systematic analysis. Focusing on leading companies was methodologically justified, as these firms typically exhibit more advanced CSR practices, greater regulatory exposure, and higher public accountability, making them particularly relevant for assessing alignment with SDG 13. Moreover, these companies account for a substantial share of Indonesia's mining output and environmental footprint; therefore, their CSR strategies are more likely to influence national climate action efforts. While the sample does not aim for statistical generalization, it provides analytical representativeness, allowing meaningful insights into prevailing CSR-climate action patterns within Indonesia's mining sector. Table 1 presents the profiles of the mining companies analyzed in this study.

This study draws exclusively on publicly accessible CSR and sustainability reports issued by Indonesian mining companies. A primary limitation of this approach is its dependence on self-reported, voluntary disclosures, which may not reflect the full scope of climate-related activities undertaken by these companies. Some initiatives may exist but remain undocumented in formal reports. As a result, the analysis is limited to what companies choose to communicate publicly and does not evaluate the actual execution or effectiveness of these initiatives in practice. To assist with thematic coding, each report was processed using ChatGPT, an artificial intelligence (AI) language model. The integration of AI into qualitative analysis is an emerging approach in social science and policy research, offering efficiencies in pattern recognition and data interpretation (López-Vázquez and Rangel-Pérez, 2024). Nonetheless, this method presents certain limitations, such as a constrained processing window for large documents, inconsistent responses requiring multiple prompt iterations, the need to switch between platforms, and a lack of domain-specific training data for qualitative inquiry (Nguyen-Trung, 2025). Therefore, it remains essential for researchers to carefully verify and interpret AI-generated outputs. The thematic analysis was structured around a set of guiding research questions (Table 2) designed to assess how mining companies address climate action.

To systematically identify climate action-related content, a two-stage qualitative coding and validation process was employed. First, an inductive thematic analysis was conducted through close reading of each CSR or sustainability report theme to identify passages related to climate action and SDG 13. Initial codes were developed from recurring concepts and actions described in the reports and subsequently grouped into higher-order thematic categories. Second, to enhance analytical rigor and coding consistency, a keyword-driven content review was used as a validation step, which is particularly suitable for a small sample of 10 documents. Key terms such as climate change, carbon emissions, climate mitigation, climate adaptation, GHG, renewable energy, net zero, energy efficiency, and sustainability-were systematically applied to re-check each report and cross-verify the inclusion and thematic placement of climate-related content. This triangulation between manual coding and keyword-based verification helped minimize omission bias. It ensured that thematically relevant content was consistently captured across all documents, a practice commonly applied in qualitative document analysis (Hasan et al., 2017). The validated thematic analysis revealed four core areas of Indonesian mining companies' contributions to SDG 13: (1) operational decarbonization and publicly disclosed actions (mapped to Q1 and Q5); (2) responsibility framing, climate targets, and alignment with national and international climate frameworks (mapped to Q2, Q4, and Q8); (3) data transparency, metric consistency, and performance trajectories (mapped to Q3); and (4) climate risk management, resilience strategies, and collaboration ecosystems (mapped to Q6 and Q7). This structured coding and validation approach ensured internal consistency and strengthened the credibility of the analytical findings despite the limited sample size.

3. RESULT AND DISCUSSION

3.1 Indonesian Mining Companies' Contributions to SDG 13

To better understand how Indonesian mining companies articulate their corporate social responsibility (CSR) regarding climate action and SDG 13, this study applies a thematic analysis of publicly available disclosures. The analysis focuses on recurring patterns across company reports, highlighting how firms frame their climate responsibilities, disclose operational activities, provide environmental data, set measurable targets, and engage in collaborative efforts. By organizing these findings into four thematic areas, the study captures both the progress made and the gaps that remain in aligning the mining sector with national and global climate commitments.

3.1.1 Operational Decarbonization and Publicly Disclosed Actions

Decarbonization in the mining sector refers to efforts to reduce carbon emissions across the entire value chain, including exploration, extraction, and processing. This concept underscores the industry's responsibility to mitigate environmental impacts while supporting global climate change initiatives. Regulatory instruments such as carbon taxes and emissions caps are increasingly compelling mining companies to adopt low-carbon technologies and practices. Beyond

Table 1. Profile of Indonesian Mining Companies Used in This Study

Mining Companies	Profiles	Sources of CSR or Sustainability Reports
PT Bumi Resources	PT Bumi Resources Tbk traces its origins to June 26, 1973, when it was founded as PT Bumi Modern, with an initial focus on the hotel and tourism sector. The company went public in 1990, listing its shares under the ticker symbol BUMI. In 1998, it diversified its business portfolio by entering the oil, gas, and mining industries. As Indonesia's mining sector experienced rapid growth, the company expanded further into coal processing and other mining-related activities.	https://www.bumiresources.com/en/sustainabilitychild134
PT Timah	PT Timah Tbk holds Mining Business Permits (IUP) covering a total area of 473,310 hectares, encompassing both land and offshore zones across Bangka, Belitung, and Kundur Island. Its business activities include mining, industrial operations, trading, transportation, and related services. Operating mainly as a holding company, PT Timah Tbk manages its mining operations and provides marketing support for its subsidiaries.	https://timah.com/blog/report/sustainability-report.html
J Resources	Indonesia hosts J Resources, a mid-sized gold producer with a notable presence in the global market. The company generates around 200,000 ounces of gold each year, largely sourced from its operations within the country. J Resources specializes in the operation of heap leach systems and the extraction of gold from low-grade ore, which it actively develops and manages.	https://www.jresources.com/post/sustainability-report-2024-psab
ANTAM	ANTAM is a diversified mining and metals company operating with a vertically integrated structure and a strong focus on export markets. As a member of the MIND ID (Mining Industry Indonesia) group, it carries out activities across multiple mineral-rich regions throughout Indonesia. The company is involved in the exploration, mining, processing, and marketing of a range of commodities, including nickel ore, ferronickel, gold, silver, bauxite, and coal.	https://www.antam.com/en/reports/csr-related-reports
PT Vale Indonesia	PT Vale Indonesia operates nickel production in the Sorowako Block, which spans a concession area of 118,017 hectares. This area includes 70,566 hectares in South Sulawesi, 22,699 hectares in Central Sulawesi, and 24,752 hectares in Southeast Sulawesi.	https://vale.com/in/indonesia/laporan-keberlanjutan
PT Adaro Indonesia	Founded in 2004, the Company Group comprising the parent company and its subsidiaries functions as a holding entity with business interests spanning thermal coal, logistics, land development, investments, and power generation. Its operations are primarily located in South Kalimantan, South Sumatra, and Central Kalimantan.	https://adaroindonesia.com/pages/view/laporan-keberlanjutan.html

Indika Energy	Indika Energy has grown into one of Indonesia's leading diversified investment companies, with a wide-ranging portfolio that includes energy, logistics and infrastructure, mineral resources, environmentally focused enterprises, and digital initiatives.	https://www.indikaenergy.co.id/id/esg/lingkungan/
Bukit Asam	PT Bukit Asam Tbk operates under a state-owned coal mining holding company. By the end of 2022, it oversaw five mining sites covering a total area of 65,632 hectares, with confirmed coal resources amounting to 5.85 billion tons and reserves estimated at 3.02 billion tons.	https://www.ptba.co.id/sr/2023/#report
Inalum	Inalum, a state-owned enterprise, focuses on aluminum production and, as of the end of 2021, remained the only aluminum manufacturer in Indonesia, with an annual production capacity of 250,000 tons.	https://www.inalum.id/id/esg/hubungan-investor/laporan-keberlanjutan
TBS Energi Utama	TBS Energi Utama is involved in coal mining and trading, oil palm plantations, and power generation, while also expanding into renewable energy, waste management, wholesale trade, and vehicle retail through its subsidiaries.	https://www.tbsenergi.com/sustainability/2024-highlights

meeting international sustainability standards, decarbonization is critical for reducing the sector's carbon footprint. Effective implementation requires a multi-dimensional strategy encompassing the use of cleaner energy sources, improvements in energy efficiency, and the application of carbon capture technologies (Amegboleza and Ülkü, 2025).

In Indonesia, mining companies report a variety of climate-related initiatives that integrate operational decarbonization with nature-based solutions (NbS). For instance, PT Timah has engaged in biodiversity conservation programs including mangrove replanting, restocking marine species (squid, cuttlefish, and mangrove crabs), coral reef transplantation, and the installation of artificial fish shelters while simultaneously introducing eco-friendly machinery, developing solar power plants (PLTS), reclaiming former mining sites, and undertaking other environmental initiatives. The integration of NbS aligns with principles of ecological mine restoration under a carbon-neutral vision. Compared to traditional methods, NbS approaches enhance geomorphological remodeling and soil reconstruction, providing greater resistance to erosion, improved long-term stability, and a more natural resemblance to landscapes. Furthermore, vegetation restoration that combines natural and artificial techniques promotes ecological succession, strengthens landscape resilience, and advances biodiversity management, thereby improving overall ecosystem functions and contributing to sustainable development (Jia et al., 2024; Zamroni et al., 2025).

Public disclosures from mining companies often highlight the adoption of biodiesel, solar panels, and the gradual electrification of vehicles and equipment. For example, J Resources has transitioned toward renewable energy by adopting biodiesel and solar technology while sourcing all operational electricity from the state utility (PLN) since 2018, thus eliminating fossil-fueled generators. These measures are complemented by process optimization to lower energy intensity and investments in overland conveyors and energy-efficient fleets. At the same time, many firms are expanding reclamation and reforestation efforts, restoring mangrove and coral ecosystems, and reusing industrial by-products such as fly ash. Collectively, these initiatives represent a dual strategy: reducing direct emissions through efficiency and renewable energy adoption, while addressing residual impacts through ecological rehabilitation and restoration projects.

3.1.2 Responsibility Framing, Targets, and Alignment with Climate Frameworks

Corporate disclosures increasingly portray climate action as both a strategic obligation and a contribution to national and global climate objectives. Climate-related commitments are typically embedded within broader Environmental, Social, and Governance (ESG) roadmaps, where decarbonization is directly linked to Indonesia's net-zero trajectory and aligned with international frameworks such as the Paris Agreement, Nationally Determined Contributions (NDCs), and the Sustainable Development Goals (SDGs). These initiatives emphasize advancing innovation across exploration, mining, processing, recycling, and raw material substitution, while also promoting international collaboration, strengthening institutional frameworks for sustainable development, and enhancing resource efficiency. Importantly, all corporate

activities are expected to remain consistent with Indonesia's commitment to the United Nations SDGs (Janikowska and Kulczycka, 2021).

Many mining companies have established measurable reduction targets, including short and medium-term greenhouse gas (GHG) intensity goals, renewable energy adoption milestones, and long-term aspirations for carbon neutrality. For instance, Bukit Asam has implemented multiple energy efficiency and emission reduction initiatives, achieving energy savings of 374,927.07 gigajoules (GJ), reducing absolute emissions by 323,396 tCO_2e, and conducting reclamation and revegetation efforts covering 2,222.08 hectares as of the reporting year. The company's commitment to sustainability and environmental stewardship has contributed to the absence of complaints or disputes related to environmental issues. Increasingly, such obligations are supported by governance mechanisms, including climate committees and ESG oversight bodies, underscoring that addressing climate change is integral not only to sustaining a social license to operate but also to meeting the expectations of diverse stakeholders.

3.1.3 Data Transparency, Metrics Consistency, and Performance Trajectories

An increasing number of mining companies are disclosing quantitative environmental data, including indicators such as greenhouse gas emissions, energy consumption, emissions intensity, and progress in renewable energy deployment. Both firms and investors are paying greater attention to measuring and reporting their impacts and dependencies on nature. In this context, biodiversity footprints-quantitative metrics capturing the negative consequences of corporate operations on biodiversity-have emerged as valuable tools. Nonetheless, assessing biodiversity impacts remains highly complex, as such effects are multifaceted and arise from factors such as resource extraction, waste and water management, and greenhouse gas emissions (Roeder and Utz, 2025).

These disclosures are often aligned with international reporting standards, with some firms providing year-on-year performance data and third-party verification to enhance credibility. For example, ANTAM has committed to reducing emissions by 15.8% by 2030 by decreasing reliance on fossil fuels and increasing its renewable energy mix by 10% relative to a 2023 baseline. Similarly, PT Vale Indonesia is advancing a comprehensive strategy that integrates Life Cycle Assessment (LCA) to evaluate impacts across the entire value chain, from upstream to downstream. Energy transition is also a strategic priority for the company, as reflected in the fact that 30.6% of its total energy consumption in 2024 was derived from renewable sources. Moreover, PT Vale Indonesia reused 1,453 tons of hazardous waste and 377,964 tons of slag as construction materials and mine road coatings, demonstrating more responsible waste management practices.

Overall, the inclusion of both absolute and intensity-based indicators represents progress toward more transparent environmental performance monitoring. However, comparability across the mining sector remains constrained by uneven adoption of standardized metrics.

3.1.4 Risk, Resilience, and Collaboration Ecosystems

The empirical findings indicate that mining companies increasingly acknowledge two principal categories of climate-related risk in their disclosures: physical risks and transition risks, consistent with established climate risk typologies in the literature. Physical climate risks are associated with the direct and indirect impacts of climate change on mining operations, arising from both acute events—such as cyclones, floods, heatwaves, and other extreme weather phenomena-and chronic stressors, including long-term temperature increases, water scarcity, and changing precipitation patterns. These risks can lead to economic and financial losses by disrupting production processes, compromising worker safety, damaging infrastructure, and interrupting supply chains, thereby affecting asset values both directly and indirectly. In contrast, transition risks stem from the structural shift toward a low-carbon economy and are driven by political, legal, technological, and market changes aimed at reducing greenhouse gas emissions and promoting renewable energy adoption. Within the analyzed disclosures, transition risks are commonly reflected through references to evolving climate regulations, carbon pricing mechanisms, the potential for stranded assets, shifting investor and consumer expectations, and volatility in energy and commodity markets. While awareness of both risk categories is evident, the findings suggest that physical risks are more frequently articulated in operational terms, whereas transition risks are often framed at a strategic or regulatory level, with limited discussion of their financial implications or integration into long-term risk management and adaptation planning. This imbalance highlights the need for more comprehensive and differentiated practices for assessing climate risk within the mining sector, aligned with emerging climate governance frameworks (Di Febo, 2025). To address these challenges, firms outline a range of resilience strategies, from energy diversification and process efficiency improvements to the use of nature-based buffers and climate risk assessments aligned with international disclosure frameworks. Effective climate risk assessment requires analysis of three variables: hazards, exposure, and vulnerability. The interaction of these factors enables the identification of areas most susceptible to supply chain disruptions (Del Rio et al., 2023). For instance, PT Adaro Andalan Indonesia acknowledges that its business operations face climate-related risks and opportunities across short, medium, and long-term horizons. In the short term, changes in rainfall patterns and flooding represent key risks, which the company manages by monitoring precipitation levels and developing mitigation measures.

Medium-term risks are primarily regulatory uncertainties that may affect business continuity, while in the long term, global commitments to clean energy transition are expected to reduce coal demand and increase demand for renewable alternatives.

Beyond firm-level measures, collaboration has become a cornerstone of climate strategies. Mining companies frequently engage in partnerships with government agencies, research institutions, industry associations, and international organizations to advance renewable energy deployment, foster technological innovation, and improve sustainability reporting. Corporate reputation, shaped by the perceptions and experiences of multiple stakeholders, plays a crucial role in this process. Understanding the drivers of reputation across stakeholder groups is therefore vital for effective management (Svobodova et al., 2020). For example, Inalum organizes regular stakeholder engagement activities such as customer, vendor, and media gatherings, while also strengthening community empowerment programs with sustainable environmental impacts. Such initiatives not only enhance stakeholder relationships and corporate image but also embed mining sector climate actions within broader national and international climate governance frameworks.

3.2 An Evaluation and Recommendations on the Contributions of Indonesian Mining Companies to SDG 13

The thematic analysis highlights both the progress achieved and the limitations that remain in how Indonesian mining companies integrate climate action within their corporate social responsibility (CSR) strategies. While climate commitments are increasingly visible, their translation into measurable, science-based, and community-oriented practices remains uneven. Four key areas for improvement can be identified: effectiveness of nature-based decarbonization, strengthening governance and accountability mechanisms, life cycle assessment as a tool for comprehensive impact evaluation, and strengthening stakeholder engagement.

3.2.1 Evaluating the Effectiveness of Nature-Based Decarbonization

Indonesian mining companies have increasingly incorporated operational decarbonization strategies alongside nature-based solutions (NbS). Nevertheless, the effectiveness of these initiatives is rarely reported through standardized or measurable indicators. In reclamation practices, for example, it remains critical to assess the extent to which interventions contribute to soil carbon sequestration. Without systematic evaluation, NbS-based decarbonization risks being regarded as symbolic rather than a substantive contribution to climate action. Economically, NbS are estimated to be 1.5-3 times more cost-effective than technological decarbonization options, which incentivizes companies to pursue NbS as part of their green development pathways. Within the business community, there is also recognition that the establishment of a robust carbon credit market requires enabling regulatory conditions, alongside mechanisms that encourage corporate investment in climate-related projects (Ptichnikov and Shvarts, 2023).

NbS, including reforestation, ocean carbon cycling, rewilding, and biodiversity conservation, are widely recognized as potential contributors to sustainable net-zero transitions. However, their effectiveness remains highly context-dependent and cannot be assumed in the absence of robust and standardized evaluation frameworks. The successful implementation of NbS requires careful management of interconnected terrestrial, aquatic, and atmospheric systems, as well as attention to equitable socio-ecological outcomes. While integrated process-based modeling, value-oriented approaches embedded in life cycle assessment (LCA), life cycle sustainability assessment (LCSA), and long-term observational methods have been proposed to strengthen the assessment of NbS performance, their application remains fragmented and lacks harmonized indicators across sectors (Mukherjee and Hridhya, 2024). To fix this problem, the International Union for Conservation of Nature (IUCN) has created a global NbS Standard to help everyone understand what good practice looks like in NbS design and implementation. Rather than providing prescriptive performance metrics, the IUCN NbS Standard offers a structured set of interrelated criteria-covering the type of intervention and societal challenges addressed, governance arrangements, benefit and trade-off assessment, scale of implementation, and integration into policy and strategic frameworks—to guide consistent and transparent evaluation of NbS initiatives (IUCN French Committee, 2019). The effectiveness of NbS is increasingly framed within adaptive, learning-oriented governance approaches rather than outcome-based certification. The IUCN NbS framework emphasizes continuous self-assessment throughout the project cycle, enabling implementers to identify strengths, weaknesses, and unintended consequences while avoiding premature claims of effectiveness. Consequently, the contribution of NbS to climate mitigation should be interpreted with caution, particularly when such solutions are scaled up to support national and international climate commitments. For large-scale NbS deployment to work, it must follow not only the IPCC and Paris Agreement's guidelines for reducing emissions but also governance-oriented standards like the IUCN NbS framework. In this context, shared financing responsibilities-especially involving the corporate sector-are essential to support long-term monitoring, adaptive management, and ecological integrity, thereby reducing the risks of overstated mitigation outcomes or unintended environmental trade-offs (Ptichnikov and Shvarts, 2023). Parallel to NbS-based approaches, energy efficiency interventions within mining operations represent a critical technological pathway for emissions reduction. One prominent example is the electrification of mining systems, which replaces fuel-based equipment with electricity-powered alternatives.

Table 2. Guiding Research Questions for Thematic Analysis of Mining Companies' Climate Action

Code	Question
Q1	What types of climate-related activities-such as emissions reduction, reforestation, or adoption of green technologies-are publicly disclosed?
Q2	In what ways does the company define its role and responsibility in responding to climate change, whether through operational practices or community engagement?
Q3	Does the company provide quantitative environmental data, such as greenhouse gas emissions, energy consumption, or emissions intensity, and if so, how consistently is this reported over time?
Q4	Are there clear, measurable targets in place related to climate action, including emissions reduction goals, commitments to net-zero, or benchmarks for renewable energy use?
Q5	What efforts or technologies has the company implemented to enhance energy efficiency or incorporate renewable energy into its operations?
Q6	Does the company identify and disclose climate-related risks-such as those stemming from regulation or physical environmental impacts-and outline any strategies to enhance resilience?
Q7	What forms of collaboration or partnerships does the company engage in to support climate action or broader sustainability goals?
Q8	How are the company's climate initiatives connected to national or international climate frameworks, such as the Paris Agreement, Nationally Determined Contributions (NDCs), or the Sustainable Development Goals (SDGs)?

Electrification programs such as the transition from diesel-driven machinery to electric shovels operating alongside conventional haul trucks-have been identified as effective operational strategies for improving energy efficiency and controlling costs in mining activities (Gusman et al., 2018). When integrated with broader climate governance frameworks, such energy efficiency measures can complement NbS initiatives by delivering more immediate and measurable emissions reductions. Together, adaptive NbS governance and operational energy efficiency improvements illustrate the importance of combining nature-based and technology-driven strategies to advance credible, scalable, and verifiable climate action within the mining sector.

3.2.2 Strengthening Governance and Accountability Mechanisms

The empirical analysis of CSR and sustainability disclosures indicates that while several mining companies report the establishment of climate committees or ESG oversight structures, these governance arrangements are often described in broad and non-operational terms. In particular, the reviewed reports rarely specify the decision-making authority of climate or ESG committees, the clarity of accountability lines within corporate hierarchies, or the existence of performance-linked incentives for executives and employees responsible for achieving climate-related objectives. This lack of disclosure limits the ability to assess whether governance mechanisms function as symbolic commitments or as enforceable instruments of climate action.

The sampled companies have seen an increase in ESG reporting due to more pressure from regulators, investors, and the public. However, the results show that increased disclosure does not always lead to greater accountability. The absence of standardized assurance practices and explicit governance mandates in the reports creates conditions that may facilitate "greenwashing" the presentation of misleading, selective, or unsubstantiated ESG information. Such risks are not merely reputational but may expose firms to financial and regulatory consequences, which emphasizes the necessity of credible governance structures. In this context, audit committees and internal audit functions emerge as critical yet underutilized actors. Although some companies reference internal control or assurance processes, few provide detailed explanations of how audit committees actively oversee ESG data quality or how internal audits are integrated into climate-related assurance mechanisms. These empirical gaps reflect broader weaknesses in ESG governance frameworks within the Indonesian mining sector, where board-level expertise in climate and assurance issues appears limited or insufficiently disclosed. The findings therefore recommend future empirical research that directly engages with boards, audit committees, and assurance professionals to examine how governance structures operate in practice and how accountability mechanisms can be strengthened. Addressing these issues is essential not only to mitigate greenwashing risks but also to enhance the credibility and effectiveness of climate-related CSR initiatives. Developing actionable guidance for corporate boards, internal auditors, and assur-

ance providers would contribute to more robust ESG governance and support meaningful alignment between reported commitments and actual climate performance (Mohammed, 2023).

3.2.3 Life Cycle Assessment as a Tool for Comprehensive Impact Evaluation

Although several mining companies have begun to adopt Life Cycle Assessment (LCA), its implementation across the sector remains limited. Wider adoption of LCA and comprehensive emissions accounting would enable a more holistic evaluation of environmental impacts along the entire value chain, from upstream to downstream activities. LCA serves as a structured methodological framework for assessing the environmental burdens associated with products and services. A distinctive feature of this approach is its capacity to consistently capture indirect impacts arising across supply chains and production systems. Accordingly, LCA facilitates the evaluation of environmental effects throughout all stages of a product's life cycle, encompassing raw material extraction, product manufacturing, use-phase impacts, and eventual disposal or recycling (Northey, 2018).

To promote continuous environmental improvement in the mining sector, it is imperative to systematically evaluate the ecological consequences of mining and mineral processing operations from a life cycle perspective. While LCA is well established as a tool in environmental systems analysis, its application within mining remains emergent and requires further institutionalization (Song et al., 2017). From an LCA perspective, the supply chain impacts of GHG emissions covering raw material procurement, production, consumption, and end of life treatment have been increasingly examined. Among these, energy consumption across the entire supply chain consistently emerges as the primary driver of GHG emissions. Importantly, emissions are not confined to core extraction and processing activities but also extend to ancillary operations such as logistics. Multiple determinants of energy use and associated GHG emissions have been identified, including mine grade (surface versus underground), the geographical location of processing facilities, and the production technologies employed. These factors collectively shape the magnitude and distribution of emissions across the mining supply chain (Sharma et al., 2024).

3.3 Strengthening Stakeholder Engagement

Strengthening stakeholder engagement is essential for building and maintaining corporate reputation in the mining sector. Companies should establish inclusive platforms that incorporate the perspectives of diverse stakeholder groups ranging from local communities and employees to regulators and investors while embedding measurable environmental and social outcomes within empowerment programs. Such an approach ensures that CSR initiatives move beyond symbolic commitments and evolve into substantive contributions to both national and global climate objectives. Establishing strong relationships and maintaining open, inclusive dialogue with stakeholders should therefore be a central objective of mining companies as part of their social responsibility. Stakeholder engagement is recognized as a critical factor in securing the social license to operate, with community engagement constituting a core element of social acceptability. Dialogue processes are commonly informed by comprehensive stakeholder mapping, where priority groups such as employees, local communities, governments, suppliers, and shareholders are identified. Additional stakeholders often include nongovernmental organizations, customers, industry associations, media, universities and research institutions, business partners, and Indigenous communities.

To improve the effectiveness of engagement, mining companies should develop standardized tools, software, or strategic frameworks to monitor progress. This can be complemented by internal and external stakeholder perception surveys as well as impact assessments. Employee engagement can be facilitated through internal communication channels such as newsletters, intranet platforms, social media, employee surveys, performance tracking, and training programs. Broader stakeholder engagement can be achieved through structured mechanisms, including site visits, audits, annual financial and sustainability reporting, multi-stakeholder partnerships, memberships in external initiatives, stakeholder surveys, and grievance systems (Ivic, 2020).

Beyond fostering dialogue for shared understanding and mutual objectives, stakeholder engagement also functions as a process of organizational learning. Engagement enables companies to learn both from and with their stakeholders, particularly when common interests emerge around climate issues. From a knowledge-based perspective, collaborations with non-profit organizations (NPOs) are especially valuable, as NPOs can provide expertise and insights into environmental challenges linked to mining operations. Knowledge diffusion within stakeholder networks occurs more effectively when engagement is not solely driven by economic considerations (Matikainen, 2020).

4. CONCLUSIONS

This study examines how Indonesian mining companies frame CSR in relation to climate action and SDG 13. The thematic analysis of corporate disclosures reveals measurable progress alongside persistent structural limitations. Mining companies are increasingly reporting efforts to decarbonize their operations, such as using low-carbon technologies and nature-based solutions (NbS). However, these efforts are rarely backed up by standardized and measurable indicators, which makes them less credible as real climate change actions. Governance mechanisms, such as climate committees and ESG oversight structures, are becoming more prevalent, yet deficiencies in decision-making authority, technical expertise, and assurance processes continue to undermine accountability and heighten greenwashing risks. While life

cycle assessment (LCA) is emerging as a tool for environmental impact evaluation, its application remains fragmented and insufficient to capture emissions and ecological effects across the mining value chain. Climate-related risks both physical and transition are increasingly acknowledged, reflecting growing awareness of climate-related financial and operational exposure. Stakeholder engagement has likewise gained prominence, although practices remain largely compliance-oriented rather than geared toward meaningful co-creation and learning. From a policy and industry point of view, these results show that the mining industry needs clearer rules and standards for climate-related CSR. Regulators could strengthen accountability by promoting standardized indicators for NbS and emissions reporting, mandating robust ESG assurance mechanisms, and encouraging the integration of life cycle-based assessments into sustainability disclosure requirements. For industry stakeholders, particularly mining companies and industry associations, the results indicate the value of investing in internal climate expertise, strengthening board-level oversight, and moving beyond symbolic compliance toward science-based and verifiable climate actions. Collectively, these measures would support more credible alignment between CSR practices and SDG 13, enabling Indonesia's mining sector to contribute more effectively to national climate commitments and global sustainability goals.

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