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MORALITY BEFORE KNOWLEDGE

Community perception of corporate environmental policy implementation in nickel mining in Indonesia

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ABSTRACT

Background: Morowali Regency, Central Sulawesi, is rich in nickel deposits and has generated significant economic benefits through the government's downstreaming policy. However, its environmental and social impacts on surrounding communities remain subjects of ongoing concern. This study examines community perceptions of the environmental policies of Company X, a nickel mining company operating in Tangofa Village, Bungku Pesisir District. **Methods**: A quantitative approach was employed using a structured questionnaire administered to 101 respondents through purposive sampling based on specific inclusion criteria. Data were analyzed using descriptive statistics, normality testing (Kolmogorov-Smirnov), Spearman rank correlation, and multiple linear regression. **Findings:** Community perceptions of economic aspects were rated highest, driven by local employment absorption and household income improvement. Social aspects received a positive rating, though challenges remain regarding community dependency on corporate assistance programs. Environmental aspects received the lowest rating, with air and water quality scoring in the Poor category. Regression analysis confirms that the social factor is the most dominant predictor ($\beta = 0.772$; $p < 0.001$), while Economic and Environmental factors exhibited significant negative influences on the Environmental Policy implementation variable ($\beta = -0.125$; $p < 0.02$). **Conclusion**: Community acceptance of Company X's environmental policy is primarily driven by social dynamics rather than economic or environmental outcomes. The findings highlight a persistent gap between procedural environmental engagement and substantive environmental quality improvement. **Novelty/Originality of this article:** This study contributes a community-based perception framework for evaluating corporate environmental policy implementation in the nickel mining sector within the context of Indonesia's national downstreaming strategy, integrating sustainable development dimensions into a quantitative assessment model.

KEYWORDS: community perception; corporate environmental policy; nickel mining; social license to operate; sustainable mining.

1. Introduction

Indonesia holds the world's largest nickel ore reserves, accounting for approximately 44% of global reserves (USGS, 2026). Nickel has become a highly critical raw material, particularly for battery production alongside cobalt, manganese, and lithium (Zhang et al., 2023). To maximize domestic economic benefits, the Indonesian government implemented a nickel ore export ban in 2020 to drive nickel industrial downstreaming through Minister of Energy and Mineral Resources (MEMR) Regulation No. 11/2019. This downstream industrialization policy is grounded in Article 33(3) of the 1945 Indonesian Constitution,

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which mandates that natural resources be managed by the state for the greatest welfare of the people, further reinforced by Law Number 4 of 2009 and its amendment, Law Number 3 of 2020, on Mineral and Coal Mining. The economic impact of nickel downstreaming has been substantial. This policy has significantly increased the export value of nickel derivative products, soaring from USD 3.3 billion in 2017 to USD 33.5 billion in 2023, while generating substantial added value through products such as nickel sulfate and battery cells. Projections indicate that by 2040, nickel downstreaming will attract USD 566.7 billion in total investment, contribute USD 209 billion to GDP, and generate over two million employment opportunities by 2040 (Ministry of Energy and Mineral Resources, 2024).

Morowali Regency, Central Sulawesi, occupies a strategically central position within this nickel downstreaming agenda. The regency hosts the Indonesia Huabao Industrial Park (IHIP) and Indonesia Morowali Industrial Park (IMIP), one of the world's largest integrated nickel-smelting industrial zones, and sits atop a laterite nickel belt that accounts for a significant share of Indonesia's national nickel output. Morowali's rapid industrial expansion has generated measurable regional economic growth. Morowali regency's GDP grew from IDR 12.7 trillion in 2015 to over IDR 77 trillion in 2022, yet has simultaneously produced well-documented environmental and social pressures on surrounding communities (Badan Pusat Statistik, 2023; Saputra et al., 2023). Surrounding villages adjacent to active mine pits, haul roads, and ore processing facilities have experienced declining air quality from fugitive dust emissions, water turbidity from surface runoff, and livelihood disruption from land-use changes (Izzudin et al., 2022).

Despite these economic advantages, the open-cast mining methods used for laterite nickel pose substantial environmental and social risks. In Morowali Recency, open-cast laterite nickel mining has contributed to extensive land clearing, hydrological changes, and environmental degradation, highlighting the importance of effective environmental policy implementation. The open-cast method is highly suitable for the formation of thick weathering profiles on the surface of laterite nickel deposits, allowing for terraced mining methods. However, this mechanization process includes extensive land clearing, topsoil removal, overburden stripping, and ore extraction, which collectively result in significant land openings and severe impacts on local hydrology.Mining activities conducted without adherence to Good Mining Practice (GMP) principles have been associated with land degradation, forest area encroachment, and licensing irregularities (Agussalim et al., 2023). Elevated nickel (Ni) content in soil and water poses a threat to human health and food security (Kumar et al., 2023).

Mining operations significantly alter the livelihoods of local communities, particularly in mining villages directly adjacent to mining areas. While mining has positive economic impacts, such as increased household incomes and expanded employment opportunities (Saputra et al., 2023), it also drives shifts in traditional economic practices due to resource depletion (Izzudin et al., 2022). These complex dynamics highlight the critical intersection between mining practices and the Sustainable Development Goals (SDGs), particularly concerning climate action (SDG 13), affordable and clean energy (SDG 7), and poverty alleviation (SDG 1) (Kouhi et al., 2024; Mvile et al., 2024).

Mining companies must implement solid environmental policies to mitigate these adverse impacts and align with sustainable development. Theoretically, corporate environmental disclosure and responsibility positively influence financial and environmental performance, generating favorable responses from investors and regulators (Andayani, 2015). Corporate environmental policy refers to an organization's formal, publicly declared commitment to environmental protection, encompassing environmental objectives, targets, and management programs. As a mandated element of environmental management system standards, environmental policy aims to enhance organizational environmental performance through the systematic management of environmental responsibilities, contributing to sustainable development (El et al., 2016). In Indonesia, the Program for Environmental Performance Rating Assessment (PROPER) system provides a nationally standardized evaluation of corporate environmental compliance, with ratings ranging from Black (severe violation) to Gold (best practice). A Green PROPER rating

indicates beyond-compliance performance, but PROPER ratings are assessed through administrative documentation and self-reporting rather than through direct community-perceived environmental quality outcomes (Setyawan, 2025). Although the PROPER system evaluates corporate environmental compliance, it primarily relies on administrative assessments and may not fully capture community perceptions of environmental policy implementation. Therefore, this study incorporates community perceptions to complement existing environmental performance evaluations.

Companies with strong environmental commitments tend to gain improved market positioning, regulatory compliance advantages, and enhanced corporate legitimacy (Riaz & Saeed, 2020). However, the formal attainment of environmental certifications does not guarantee that community-perceived environmental quality will improve commensurately. A persistent gap exists between institutional compliance metrics measured by regulatory bodies through documentation, monitoring data, and self-reporting and the lived environmental experience of communities who observe the physical outcomes of mining operations daily (Massaro, 2024; Ahmad & Ibrahim, 2025). Community perception is a critical evaluative standpoint. As stakeholders who bear the most direct consequences of mining operations, local communities provide an indispensable measure of the actual effectiveness of corporate environmental policy, going beyond administrative compliance to reflect direct encounters. Prior research has documented this divergence in the specific context of Morowali Regency, but no study has yet quantitatively assessed community perceptions of environmental policy, nor examined the statistical relationships between economic, social, and environmental perceptions and overall environmental policy implementation.

Community perceptions across economic, social, and environmental dimensions reflect the impact of corporate policy on social outcomes. These perceptions, in turn, shape the social license to operate (SLO), a concept that captures the degree of approval or acceptance that a mining operation receives from the local community and other stakeholders (Boutilier & Thomson, 2011). The SLO is hierarchical, with economic legitimacy based on economic benefits at the base; social trust based on perceived fairness and quality of relationships at the intermediate level; and socio-political legitimacy based on transparent environmental governance and genuine inclusion in decision-making at the apex. Prno (2013) identified community perception as the fundamental mechanism through which SLO is granted or withdrawn, emphasizing that companies that achieve economic acceptance without social trust or environmental legitimacy remain structurally vulnerable to community resistance. In the Indonesian mining context, Tewu et al. (2025) demonstrated that community perceptions determine mining project acceptance in a fundamental way, and that participatory, transparent processes have the strongest capacity to transform perceptions into durable acceptance. The SLO framework is the primary theoretical lens for this study.

Community perception refers to the subjective, socially constructed assessment that individuals and communities make about environmental conditions, corporate behavior, and the fairness of governance processes affecting their lives (Panov, 2017; Massaro, 2024). In extractive industry contexts, three primary dimensions shape community perceptions: economic outcomes, social outcomes, and environmental outcomes. These dimensions are not independent, perceptions in one domain can influence assessments in others through cognitive and social mediation processes (Veldhuizen et al., 2022). Critically, Ahmad & Ibrahim (2025) demonstrated that community members assess environmental policy effectiveness not through formal documentation but through tangible field results and their perception of governance fairness, making community perception a fundamentally distinct and indispensable evaluation modality that complements formal regulatory assessment.

This study aims to address this gap by analyzing community perceptions of corporate environmental policy implementation at Company X across economic, social, and environmental dimensions and examining the relationships between these perceptions and overall community acceptance of environmental policy using multiple linear regression. This study is particularly significant because it empirically examines whether formal

environmental performance recognition, such as the PROPER rating, translates into positive community perceptions. This study establishes three distinct hypotheses: H1 proposes a positive relationship between economic perception and community acceptance of environmental policy; H2 suggests that social perception is positively related to community acceptance of environmental policy; and H3 states that environmental perception has a significant relationship with community acceptance of environmental policy, although its specific direction is left open a priori to account for possible suppression effects.

2. Methods

This study employed a quantitative research approach to analyze community perceptions of corporate environmental policy implementation in nickel mining. A quantitative approach was selected because it enables the measurement of community perceptions and the statistical examination of relationships among the study variables. The research was conducted in three sequential phases: a preparation phase involving literature review, administrative preparation, and preliminary field surveys; a data collection phase involving field observation and questionnaire distribution; and a data processing phase involving statistical analysis and interpretation.

The study was conducted from February 2025 to March 2026 in Tangofa Village, Bungku Pesisir District, Morowali Regency, Central Sulawesi Province, Indonesia. Tangofa Village covers an area of 118.70 km^2 which constitutes approximately 13.69% of the total area of Bungku Pesisir District. Tangofa is the second-largest village in the Bungku Pesisir District. Tangofa village is located 5 km via land route from the capital of Bungku Pesisir District and 93 km from the capital of Morowali Regency. Geographically, the village lies within the East Indonesian Ophiolite Belt and is surrounded by numerous nickel and stone mining concessions. The Morowali regency is one of the largest nickel processing hubs in Indonesia. The geological composition of Tangofa Village consists of approximately 60% ultramafic and 40% sedimentary rocks, making it highly suitable for nickel laterite mining (Company X, 2022).

The research area's topography is characterized by extreme variations, with elevations ranging from sea level up to approximately 700 meters above sea level (masl), featuring hilly, mountainous terrains and steep slopes. Specifically, Company X's mining exploration and production activities occur at elevations between 200 and 430 masl. Furthermore, the region has a type B climate (wet), characterized by a high rainfall intensity of approximately 2,000 mm/year. This combination of steep topography and high rainfall intensity significantly elevates the risk of erosion, surface runoff, and subsequent environmental degradation, presenting a substantial challenge for corporate environmental management.

Company X was selected because it represents a mining company with demonstrated environmental management performance, enabling an assessment of whether formal environmental recognition is reflected in community perceptions. Company X holds an Operational Production Mining License covering 5,983 hectares that valid from 2020 to 2031. The PROPER Green rating reflects institutional and administrative compliance performance, including environmental documentation, pollution control infrastructure, and corporate environmental reporting, and does not directly capture community-level perceptions of environmental quality. This study is designed to complement formal regulatory assessments by empirically examining whether the performance of institutional compliance translates into positive community environmental perceptions.

The study population consisted of all residents of Tangofa Village, which comprises 5 sub-villages, totaling 1,112 individuals (Badan Pusat Statistik, 2023). Purposive sampling was employed. This technique was selected because the study required respondents with direct and sustained expertise of Company X's operations, which could not be ensured through simple random sampling of the village population. Purposive sampling was applied based on the following inclusion criteria: age 17 years; residing in Tangofa Village for a minimum of three years; and engaged in activities intersecting with Company X's operations, including direct employment at Company X or contractor companies, or run a

local business such as local diner, convenience stores, or accommodation services within the village. Collectively, these three criteria capture distinctly different levels of economic dependency, ranging from high (direct employees) and intermediate (contractors) to indirect (local businesses). This structure ensures internal diversity in the viewpoints of respondents within the purposively selected, economically integrated segment of the population. Purposive sampling criteria require respondents to be economically integrated into Company X's operational sphere, either as direct employees, contractor workers, or business operators serving its workforce. This sampling strategy may increase the representation of respondents who are economically connected to Company X; therefore, the findings should be interpreted within the context of the selected study population. The sample size was determined using Slovin's formula with a 10% margin of error, yielding a minimum sample of 92 respondents. An additional 10% buffer was added to compensate for potential sampling variation, resulting in a total sample of 101 respondents.

The research examined four variables. The dependent variable (Y) was community acceptance of corporate environmental policy, operationalized as the community's assessment of company responsiveness to environmental issues and its accountability for environmental impacts. Three independent variables were examined: Economic Perception (X_1), Social Perception (X_2), and Environmental Perception (X_3). Data were collected through a structured Likert-scale questionnaire (scale 1–5: Strongly Disagree to Strongly Agree) (Emetumah et al., 2021; Sugiyono, 2018). Community perception categories were determined using a range score formula (Eq 1). This yielded five perception categories with equal range intervals of 0.80: Very Poor (1.00–1.80), Poor (1.80–2.60), Neutral/Sufficient (2.61–3.40), Good (3.41–4.20), and Very Good (4.21–5.00).

$$Range = \frac{(Highest\ score - Lowest\ score)}{Number\ of\ classes} \quad \text{(Eq. 1)}$$

Quantitative data analysis was conducted using several sequential procedures. Prior to multiple linear regression analysis, all relevant regression assumptions, including normality, multicollinearity, homoscedasticity, and independence of residuals, were assessed to ensure model validity. First, descriptive statistical analysis was performed to characterize the demographic characteristics of the respondents and compute the mean scores and standard deviations for each indicator. Second, normality testing was conducted using the Kolmogorov-Smirnov method, which is appropriate for samples with N > 50 (Ghozali, 2018). Third, multiple linear regression analysis was conducted to identify the simultaneous and partial effects of all three independent variables on the dependent variable, following Hair et al. (2019) classical assumption tests, including multicollinearity (VIF) and autocorrelation (Durbin-Watson) testing to validate model reliability.

3. Results and Discussion

The analysis of community perceptions is organized around three sustainability dimensions, namely economic, social, and environmental, followed by an examination of corporate environmental policy perceptions and the results of multiple linear regression analysis. Each dimension reveals a distinct pattern of community assessment, collectively forming a comprehensive picture of corporate environmental policy perceptions and Company X's environmental policy implementation.

3.1 Economic dimension of environmental policy perception

Community perception's economic dimension reflects the tangible material outcomes of mining operations as experienced by communities in their daily livelihoods. Historically, communities surrounding extractive industries have evaluated companies presence primarily through economic lenses, asking whether the company has opened job opportunities, increased income, and local business opportunities (Kemp & Owen, 2013).

The indicators measured in this study span direct income improvement (E1), employment availability (E2), basic needs fulfillment (E3), local business growth (E4), and the effectiveness of corporate social responsibility (CSR) program (E5).

Community perceptions of the economic dimension were rated the highest among all three dimensions, achieving a Very Good category with an overall mean score of 4.30. As presented in Table 1, the employment availability indicator (E2) received the highest mean score (4.50; Very Good; SD = 0.57), reflecting the near-universal community consensus that Company X has significantly expanded local employment opportunities. This is consistent with Company X's reported expansion of mining operations (Company X, 2022), which increased local employment opportunities. This expansion in employment has generated a linear positive impact on household income improvement (E1; mean = 4.40)) and basic needs fulfillment (E3; mean = 4.35) indicators, which similarly received the Very Good category, underscoring the direct economic welfare improvements experienced by households in Tangofa Village. These findings align with the identification of economic legitimacy as the foundational tier of community acceptance in the SLO framework (Boutilier & Thomson, 2011), confirming that Company X has successfully established this baseline.

Table 1. Community perception scores on the economic dimension

Indicator	SDS	DS	N	A	SA	Mean	SD	Category
Income improvement (E1)	0	0	6	49	46	4.40	0.60	Very Good
Employment availability (E2)	0	0	6	39	56	4.50	0.57	Very Good
Basic needs fulfillment (E3)	0	0	4	58	39	4.35	0.53	Very Good
Local business growth (E4)	0	0	21	29	51	4.29	0.75	Very Good
CSR Program effectiveness (E5)	0	2	33	33	33	3.96	0.74	Good

Note. SDS = Strongly Disagree; DS = Disagree; N = Neutral; A = Agree; SA = Strongly Agree.

The mining operations at Company X have generated a multiplier effect within the local economy, as evidenced by the local business growth indicator (E4; mean = 4.29; Very Good). The large influx of migrant workers associated with Company X's operations has created a distinct food, accommodation, and retail services market segment, benefiting the local community through business opportunities. This finding is consistent with that of Dallaire-Fortier (2023), who demonstrated that mining industries can stimulate local business development by increasing corporate demand for services and goods while expanding household expenditure through employment income. The sociological dynamics of Morowali Regency, characterized by substantial migration of workers from other regions, have effectively created a captive consumer base for local entrepreneurs, converting the presence of outsiders into an economic opportunity for local residents of Tangofa Village.

From a theoretical perspective, the economic multiplier mechanism functions as follows: increased household spending creates demand for food services, transportation, accommodation services, and retail goods as Company X absorbs local workers and generates income. Local community members who operate small businesses or provide accommodation services benefit from this increased demand. The chain reaction from employment to income to local consumption to business growth represents a village-level economic multiplier cycle (Dallaire-Fortier, 2023). This multiplier dynamic is particularly significant in the context of Morowali Regency, where the sheer scale of the nickel industry workforce, which encompasses tens of thousands of workers across multiple operations, generates sustained consumer demand that has transformed the local commercial landscape.

The CSR (Corporate Social Responsibility) program effectiveness indicator (E5; mean = 3.96; Good) was the lowest-scoring economic indicator, with 33 respondents (33%) selecting a neutral response. This pattern suggests that while Company X's community development programs have reached a portion of the community, their objectives and practical effectiveness are unevenly distributed. Participants who scored neutral likely acknowledged the existence of programs but did not directly benefit from them or did not

observe tangible outcomes in their own households. This gap between direct economic impact and programmatic empowerment reflects a structural challenge in which communities tend to prioritize visible, immediate economic gains, such as wages and employment availability are over longer-term capacity-building initiatives (Ahmad & Ibrahim, 2025).

The gap between E2 (Emplyoment availability; mean = 4.50) and E5 (CSR effectiveness; mean = 3.96) highlights an important distinction between transactional and transformational economic impacts. The relatively lower CSR effectiveness score may indicate a potential risk of increased community dependence on mining-related economic activities, although further investigation is needed to confirm this relationship. Transactional impacts, such as wages and local business revenues, are immediate, visible, and individually experienced. Transformational impacts, such as skills training, entrepreneurial capacity-building, and economic independence from the mining cycle, are longterm, systemic, and require deliberate program design. The relatively lower score on E5 suggests that Company X's community development programs, have not yet fully bridged this gap. This creates a risk of economic dependency. If community members derive the majority of their improved livelihoods directly from employment at Company X or from indirect demand generated by its workers, their economic resilience will be vulnerable to fluctuations in company operations.

In the economic dimension, the findings indicate that while direct economic benefits are strongly perceived, the effectiveness of CSR and community development programs (E5) remains comparatively lower and unevenly distributed. Company X should redesign its community empowerment programs to shift from charity-based or one-off disbursement models to structured, multi-year livelihood development initiatives. This may include vocational training tied to post-mining sectors, cooperative enterprise development for local business clusters, and transparent reporting of program outputs to ensure that benefits are widely visible and understood by the community. Ahmad & Ibrahim (2025) argued that genuine economic justice in the context of environmental policy requires not only compensation and employment but also meaningful participation in economic decision-making and a realistic pathway toward community self-sufficiency beyond the life of the mine. Diversifying Tangofa Village's economic base will reduce its structural dependency on Company X's operational continuity and strengthen the community's long-term resilience.

3.2 The social dimension of environmental policy perception

The social dimension of environmental policy perception captures the relationship between Company X and the community of Tangofa Village. Factors that shape social perception include the degree of company transparency, the quality of communication channels, respect for local cultural values, the extent of community involvement in corporate decision-making, and the social consequences of large-scale labor migration. These factors collectively determine whether a community feels seen, respected, and genuinely engaged as stakeholders or merely managed as a risk to be mitigated.

Community perceptions of the social dimension were categorized as Good, with an overall mean of 3.72 (Table 2). Communication quality and company-community relations (S3; mean = 3.99; Good) received the highest social score, indicating that company X's sustainability and CSR departments have established relatively effective channels for community engagement. The moderately high scores on indicators of positive company influence (S1; mean = 3.86; Good) and community involvement in decision-making (S4; mean = 3.83; Good) suggest that the community of Tangofa Village has acknowledged, if not universally embraced, the company's operational transparency and participatory mechanisms.

Table 2. Community perception scores on the social dimension

Indicator	SDS	DS	N	A	SA	Mean	SD	Category
Company influence (S1)	0	0	33	49	19	3.86	0.70	Good
Cultural respect (S2)	0	2	35	56	8	3.69	0.63	Good
Communication quality (S3)	0	2	27	42	30	3.99	0.81	Good
Community involvement (S4)	0	4	34	38	25	3.83	0.85	Good
Migrant worker impact (S5)	0	6	71	21	3	3.21	0.57	Neutral

Note. SDS = Strongly Disagree; DS = Disagree; N = Neutral; A = Agree; SA = Strongly Agree

According to Que et al. (2019), designing and implementing social dimensions of policy with meaningful community involvement can directly transform community perceptions by fostering transparency, fairness, and participation. Policies implemented as community empowerment programs without community members' substantive participation will generate only superficial social acceptance rather than genuine legitimation. The S3 and S4 scores suggest that respondents generally perceive Company X's communication and consultation mechanisms positively. This participatory approach, supported by Company X's Sustainability and CSR departments, aligns with good practice frameworks in the sector of the extractive industries.

The cultural respect indicator (S2; mean = 3.69; Good) was the second-lowest social indicator, suggesting that Company X could intentionally integrate local cultural values and indigenous practices into its community development programs. Although the score falls within the good category, the relatively lower position among social indicators indicates that community members perceive a gap between formal engagement procedures and deeper cultural recognition. Strengthening cultural respect requires Company X to institutionalize cultural mapping as part of its engagement framework, ensuring that the CSR program design actively incorporates consultations with community elders and local institutions. Strengthening this dimension would move the companny-community relationship beyond transactional engagement toward the meaningful cultural partnership identified by Que et al. (2019) as a requirement for sustainable social acceptance.

The migrant worker impact indicator (S5; mean = 3.21; Neutral) was the identified by Que et al. (2019) as a requirement. A striking 70% of the respondents selected a neutral response to the statement that migrant workers from outside Sulawesi had a positive influence on Tangofa Village. This finding reflects the sociological complexity of Morowali Regency, where large-scale labor migration associated with the nickel industry's expansion has introduced structural pressures on local infrastructure, security arrangements, lifestyle patterns, and domestic waste management. The influx of migrant workers may contribute to demographic and social changes perceived by the local community, although the extent of these impacts requires further investigation.

Rela et al. (2020) warn that fragmented environmental risk management and weak community inclusion can erode trust and generate negative perceptions. While the S5 score has not yet shifted into negative territory, the dominant neutrality among respondents indicates a community that has not found a satisfactory answer to the social disruption accompanying Company X's workforce expansion. This represents a latent risk that social frictions related to migrant worker integration could develop into more visible sources of community grievance and resistance if not proactively addressed.

According to Tewu et al. (2025), community perceptions fundamentally determine the acceptance of mining projects. Corporate policy objectives must incorporate community expectations and fairness principles to secure lasting community acceptance. Transparent and inclusive participatory policy processes have the strongest capacity to transform community perceptions into sustainable acceptance. The results from Tangofa Village support the conclusion that when Company X invests in communication and procedural involvement (S3, S4), community perceptions are more positive. Where social impacts are experienced without corresponding corporate support structures, such as cultural and security pressures from mass in-migration (S5), perceptions remain indifferent.

In the social dimension, cultural integration and migrant worker management require targeted attention. The relatively lower score on the cultural respect indicator (S2; mean = 3.69) suggests that community development programs have not sufficiently incorporated local customs, traditions, and indigenous knowledge systems. Company X should institutionalize cultural mapping as part of its community engagement framework, ensuring that the CSR program design includes consultations with community elders and local institutions and that ritual calendars, communal land-use norms, and indigenous value systems are respected in program activities. The neutral score on S5 (mean = 3.21) indicates unresolved social tensions stemming from large-scale labor in-migration. Based on these findings, Company X may consider strengthening social integration initiatives for migrant workers as part of its community engagement strategy. Proactive management of these social frictions is essential for preventing the escalation of latent tensions into organized resistance.

3.3 Environmental dimension of environmental policy perception

The environmental dimension occupies a strategic position in the analysis of community perceptions because it is most directly connected to the physical quality of the spaces in which residents live, work, and maintain their health. Unlike economic or social perceptions, which may be shaped by individual circumstances or community position, environmental perceptions tend to reflect shared physical realities across the community, such as air that residents breathe, water that residents drink, and land quality that affects food production and well-being. Environmental perceptions also have a particularly high potential to generate conflict, because degradation in these dimensions directly threatens the basic quality of life.

The environmental dimension exhibited the most pronounced variation across indicators (Table 3). Air quality improvement (L1; mean = 2.61; Poor) and water quality improvement (L2; mean = 2.55; Poor) both received ratings in the Poor category, which is the only indicator across all three sustainability dimensions fall below the Neutral threshold. These findings indicate consistently low community perceptions of air and water quality despite the characteristics of the study sample.These findings indicate that more than half of the respondents perceive current air and water quality negatively, despite Company X's beyond-compliance environmental performance (PROPER). The divergence between the company's formal environmental performance credentials and the community's experienced environmental quality constitutes the central empirical tension of this study.

Table 3. Scores for community perception on the environmental dimension

Indicator	SDS	DS	N	A	SA	Mean	SD	Category
Air quality improvement (L1)		41	26	18	4	2.61	1.03	Poor
Water quality improvement (L2)	11	46	29	7	8	2.55	1.03	Poor

Note. SDS = Strongly Disagree; DS = Disagree; N = Neutral; A = Agree; SA = Strongly Agree

Specifically, 52% of the respondents expressed negative perceptions about air quality, and 56% expressed negative perceptions about water quality. Both indicators share a high standard deviation (SD = 1.03), reflecting a structured polarization grounded in directly experienced physical conditions rather than random variation. This high sensitivity is directly related to the community's daily exposure to physical environmental degradation, including dust generated by road transport and heavy equipment operations, turbidity in rivers and groundwater sources caused by mine surface runoff, and proximity to active mine pits. These findings align with those of Saputra et al. (2023) and Ichi (2018), who documented similar patterns of physical environmental degradation in Indonesian villages proximate to open-cast mining operations.

The poor air and water quality scores are partially explained by Company X's operational geography. The company operates in an area within the East Indonesian Ophiolite Belt characterized by steep slopes and extreme topographic relief. The extreme

topography of the mining area significantly complicates hydrological challenges that make within the East Indonesian Ophiolite Belt characterized by steep slopes and extreme topographic relief, particularly during periods of high rainfall intensity (2,000 mm/year), leading to physical impacts that the community cannot ignore. Even with technically compliant mitigation measures, the physical conditions of mining in steep terrain can produce persistent dust from haul roads and sediment loading in water bodies, both of which are directly perceptible to the community of Tangofa Village.

According to Ahmad & Ibrahim (2025), communities assess environmental policy not only through formal documentation but also through tangible field results and their perception of fairness in governance. When a policy generates visible environmental impacts, such as dust-covered vegetation, murky river water, or dry season water scarcity, community members evaluate the policy as ineffective, regardless of whether operational standards have been formally met. This creates a divergence between administrative and social measures of environmental performance that must be deliberately addressed by companies operating in complex biophysical environments.

Massaro (2024) introduced the concept of subjective environmental realities to describe how different groups use selective expertise, knowledge, and data to construct competing claims about environmental policy's impacts and effectiveness. In the context of Tangofa Village, Company X may present its environmental performance through regulatory compliance metrics, such as emission monitoring data, effluent treatment records, and reclamation progress reports, while residents experience a daily physical reality of dust and murky water that is incompatible with formal claims of environmental adequacy. This divergence between institutional and community-level realities is precisely the type of gap that erodes trust and generates socio-political conflict.

In the environmental dimension, the Poor ratings on air and water quality represent the most urgent policy gap identified in this study. These environmental findings challenge the adequacy of PROPER as a sole measure of corporate environmental performance in communities adjacent to active mining operations. Although comprehensive in its administrative scope, the PROPER assessment framework does not incorporate structured community perception surveys as a mandatory performance component. Based on these findings, Company X may consider strengthening both environmental mitigation measures and public environmental communication to improve community perceptions. Moffat et al. (2016) Although comprehensive in its administrative scope, the PROPER assessment framework does strongly correlated with the quality and openness of environmental information disclosure. By making data accessible and interpretable for non-technical community members, Company X can begin to close the credibility gap between its self-reported compliance performance and the daily physical environmental reality experienced by residents.

3.4 Community perceptions of corporate environmental policy

The overall pattern of community perceptions across the three sustainability dimensions revealed a pronounced asymmetry (Fig. 1). Economic perceptions are strongly positive (cumulative means = 4.30; Very Good), driven by tangible employment and income benefits generated by Company X's operations. Social perceptions were moderately positive (cumulative mean = 3.72; Good), supported by functional communication channels and community involvement in procedural activities. Environmental perceptions are poor (cumulative mean = 2.58; Poor), reflecting persistent concerns about daily physical environmental reality experienced by residentshave not been adequately addressed by existing mitigation measures.

These three dimensions of perceptions is theoretically meaningful. This suggests that the community acceptance of Company X follows the logic of the Social License to Operate (SLO) framework articulated by Boutilier & Thomson (2011), which identifies economic legitimacy as the foundational but lowest tier of acceptance, social trust as the intermediate tier, and socio-political legitimacy as the highest and most resilient form of social license,

which is built through transparent environmental management and genuine stakeholder inclusion. The findings suggest that Company X has established strong economic legitimacy and positive social perceptions; however, lower environmental perception scores indicate challenges in strengthening environmental legitimacy.

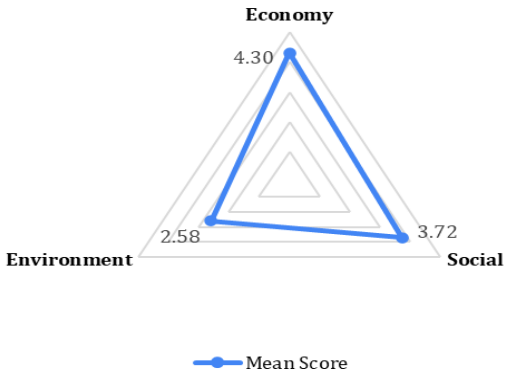

Fig. 1 Radar diagram of mean scores for community perceptionacross economic, social, and environmental dimensions

The asymmetry in perception scores also highlights a risk embedded in the current strategy of Company X. When community acceptance is built primarily on economic benefits, it becomes structurally dependent on the continuation of those benefits. If production levels decline, employment contracts end, or the company exits the area, the economic pillar that currently supports community acceptance would be removed. Without a corresponding foundation of environmental trust, the transition out of mining could generate significant social grievances. This risk is heightened by the dependency dynamics identified in the E5 (CSR Program effectiveness), which suggests that community development programs have not yet built the economic self-sufficiency needed to sustain community well-being independently of ongoing mining activity.

Corporate environmental policies were categorized as Good (cumulative mean = 3.44) (Table 4). P1, P2, and P3 measure the company's performance in engaging the community in environmental programs (P1), the company's responsiveness to environmental problems as they arise (P2), and the community's overall assessment of corporate accountability for environmental impacts (P3). These three indicators evaluate environmental policy implementation rather than what environmental outcomes are produced.

Table 4. Community perception scores on corporate environmental policy

Indicator	SDS	DS	N	A	SA	Mean	SD	Category
Community involvement in env. activities (P1)	0	7	20	40	34	4.00	0.88	Good
Environmental issue responsiveness (P2)	0	10	73	18	0	3.08	0.53	Neutral
Overall environmental responsibility (P3)	0	9	63	25	4	3.24	0.62	Neutral

Note. SDS = Strongly Disagree; DS = Disagree; N = Neutral; A = Agree; SA = Strongly Agree

In contrast to the poor scores on physical outcome indicators, the community engagement in environmental activities indicator (P1; mean = 4.00; Good) received the highest score in the corporate environmental policy perceptions. At a procedural level, Company X has successfully engaged residents in environmental programs, such as tree planting activities, environmental socialization sessions, or community cleanups, that create a formal record of participation. However, procedural involvement does not automatically translate into substantive environmental improvement. The sharp contrast between P1 and L1 (air quality; mean = 2.61; Poor) or L2 (water quality; mean = 2.55; Poor) quantifies the policy-to-practice gap directly. The company achieves Good performance on community

engagement processes but Poor performance on the environmental conditions that those processes are supposed to produce. This pattern may indicate a perceived gap between procedural environmental engagement and tangible environmental outcomes.

The environmental responsiveness indicator (P2; mean = 3.08; Neutral) and overall environmental responsibility indicator (P3; mean = 3.24; Neutral) reflect community ambivalence about whether Company X acts effectively when environmental problems occur. Respondents neither strongly endorse nor strongly condemn the company's environmental management; rather, they occupy a posture of guarded uncertainty. This uncertainty is epistemically rational given the disconnect between procedural engagement and physical outcomes. The community has been told that the company manages the environment responsibly, but they continue to observe deteriorating air and water quality in their daily lives. This pattern is consistent with a procedurally compliant but substantively insufficient implementation model, where participatory mechanisms are in place, but their outputs have not translated into perceptible environmental improvement.

Crucially, the gap between corporate environmental policy and the physical outcome indicators (L1 and L2) directly quantifies the policy-to-practice gap, directly which is Company X achieves a good category on corporate environmental policy perceptions but a Poor category on the environmental conditions that those processes are supposed to produce. Company X may perceive its environmental management as compliant with regulatory standards, while the affected communities experience daily exposure to dust, noise, and water discoloration as clear evidence of inadequate performance.

The findings suggest that community acceptance is currently influenced more strongly by perceived economic benefits than by environmental outcomes. The community accepts the company's presence due to immediate economic needs yet harbor deep-seated concerns regarding long-term environmental sustainability. To achieve sustainable policy implementation, the company must move beyond mere administrative compliance (beyond compliance) and address the mining site's physical biophysical challenges. Failing to translate procedural environmental engagement into substantive ecological restoration risks triggering a dependency syndrome, where the community's economic reliance on the mine tarnishes their environmental safety, ultimately threatening the local community's downstreaming industry's long-term viability.

3.5 Spearman's rank correlation analysis

Prior to multiple linear regression, Spearman rank correlation analysis was conducted to examine the bivariate relationships between Economic Perception (X_1), Social Perception (X_2), and Environmental Perception (X_3) and community acceptance of corporate environmental policy (Y). The Spearman rank-order correlation coefficient (rs) was selected for its robustness to the ordinal aggregate nature of Likert-scale data and its independence from normality assumptions (Siegel & Castellan, 1988). Table 5 presents the full correlation matrix. The Spearman correlation results reveal three important patterns that provide essential context for interpreting the subsequent regression findings.

Table 5. The Spearman correlation matrix

Variable	X_1 – Economic	X_2 – Social	X_3 – Environmental	Y – Corporate Environment Policy
X_1 – Economic	1.000	0.421**	0.274**	0.312**
X_2 – Social	–	1.000	0.231*	0.587**
X_3 – Environmental	–	–	1.000	0.189
Y – Corporate Environment Policy	–	–	–	1.000

Note. Primary data analysis, 2025 | ** $p < 0.01$; * $p < 0.05$

Social Perception (X_2) exhibited the strongest positive bivariate correlation with community acceptance of corporate environmental policy (Y) (rs = 0.587; $p < 0.001$). Respondents who perceived higher-quality company–community social interactions, which

encompassed communication quality, cultural respect, community involvement in decision-making, and the management of migrant worker impacts, also reported significantly greater acceptance of Company X's environmental policy. This strong bivariate association is entirely consistent with X_2 emerging as the sole dominant predictor in the subsequent multiple regression model ($\beta = 0.772$; $p < 0.001$), confirming that social trust is the primary mechanism linking community perceptions to environmental policy acceptance at both the bivariate and multivariate levels.

Economic Perception (X_1) showed a moderate positive bivariate correlation with Y ($rs = 0.312$; $p = 0.002$), indicating that respondents who experienced greater economic benefits, particularly in employment availability (E2; mean = 4.50) and household income improvement (E1; mean = 4.40), also tended to favorably accept Company X's environmental policy. This positive bivariate relationship contrasts sharply with the non-significant negative partial coefficient produced in the multiple regression model ($\beta = -0.147$; $p = 0.169$). This divergence may indicate a possible suppression effect; however, additional statistical evidence is required to confirm this interpretation. Social Perception (X_2) is moderately intercorrelated with Economic Perception (X_1) at the bivariate level ($rs = 0.421$; $p < 0.001$), meaning that a substantial portion of the variance in Y that appears to be explained by economic satisfaction is, in fact, attributable to the social trust that often accompanies it. Once Social Perception is held constant in the regression model, the independent contribution of Economic Perception to Y prediction becomes negligible. In practical terms, this means that residents who are economically satisfied with Company X's presence are not necessarily more accepting of its environmental policy because of the economic benefits. Instead, they tend to have stronger social trust in the company, which drives policy acceptance. Economic legitimacy initiates community goodwill, but social trust sustains it (Kemp & Owen, 2013).

Environmental Perception (X_3) exhibited the weakest bivariate correlation with Y ($rs = 0.189$; $p = 0.058$), a relationship that was borderline non-significant at $\alpha = 0.05$. This near-zero bivariate correlation stands in striking contrast to the statistically significant negative partial coefficient observed in the regression model ($\beta = -0.125$; $p = 0.020$). This pattern may suggest a possible suppression effect; however, further statistical analysis is needed to verify this interpretation. Respondents who perceive marginally better environmental conditions tend to be only weakly and non-significantly more accepting of corporate environmental policy. However, once Social Perception is controlled in the regression model, the relationship between environmental perception and policy acceptance reverses direction and becomes statistically significant, which demonstrates that when social trust is held constant, community members who perceive poorer environmental quality are significantly less likely to accept Company X's environmental policy. Therefore, Social Perception acts as a suppressor variable, masking the true negative relationship between deteriorating environmental conditions and policy acceptance at the bivariate level. This finding carries an important warning for Company X, because the company's current level of social trust is effectively buffering the negative impact of poor environmental quality on community policy acceptance, but this buffer is not permanent. As environmental conditions continue to be perceived as Poor, community tolerance may erode even where social trust remains strong, consistent with the SLO framework's identification of environmental legitimacy as the most resilient and ultimately indispensable form of social license (Boutilier & Thomson, 2011; Prno, 2013).

The inter-predictor correlations further contextualize the regression findings. Economic and Social Perception were moderately correlated ($rs = 0.421$; $p < 0.001$), indicating that community members who experience direct economic benefits from Company X also tend to perceive better company–community social relations, a logical dynamic given that employment creates sustained points of communication, mutual engagement, and reciprocal obligation. Economic and Environmental Perception were weakly to moderately correlated ($rs = 0.274$; $p = 0.006$), and Social and Environmental Perception showed the weakest inter-predictor correlation ($rs = 0.231$; $p < 0.05$). Importantly, none of the inter-predictor correlations exceeded 0.50, confirming that while

the three perception dimensions share common variance, they remain sufficiently distinct constructs to justify their independent treatment as separate predictors in the regression model. The Spearman correlation results establish that Social Perception is the dominant driver of environmental policy acceptance at both the bivariate and multivariate levels, highlight the important role of social perception in explaining community acceptance of corporate environmental policy.

3.6 Multiple linear regression analysis

Multiple linear regression analysis was conducted to assess the simultaneous and partial effects of Economic Perception (X_1), Social Perception (X_2), and Environmental Perception (X_3) on community perceptions of corporate environmental policy (Y). Before regression analysis, normality testing was conducted using the one-sample Kolmogorov-Smirnov (K-S) method. The Kolmogorov–Smirnov test yielded a statistic of D = 0.01 (p = 0.001). Based on the test results, the residual distribution was non-normal. The Kolmogorov–Smirnov test yielded a statistic of D = 0.01 ($p < 0.05$), indicating that the residuals deviated significantly from a normal distribution. However, the residual skewness of 0.021 and kurtosis of 0.073, both of which approach zero, confirm that the residual distribution is highly symmetric and does not exhibit heavy tails. With a sample size of n = 101 ($n > 30$), the Central Limit Theorem (CLT) ensures that the sampling distribution of regression coefficients converges to normality asymptotically (Hair et al., 2019; Field, 2013). The departure from normality is primarily attributable to the discrete nature of Likert-scale averages rather than systematic model misspecification. Accordingly, the normality assumption for inferential purposes is satisfied, and the analysis proceeded without transformation. The results of multiple linear regression analysis to assess the simultaneous and partial effects of X_1, X_2, and X_3 on Y are presented in Table 5.

Table 6. Results of multiple linear regression

Variable	Coefficient (β)	Std. Error	t-value	p-value	Result
Constant	1.521	0.442	3.438	0.001	—
X_1 – Economic	−0.147	0.106	−1.385	0.169	Not Sig.
X_2 – Social	0.772	0.114	6.789	< 0.001	Sig.
X_3 – Environmental	−0.125	0.053	−2.365	0.020	Sig. (neg.)

Note. $R^2 = 0.361$; Adjusted $R^2 = 0.342$; $F = 18.292$ ($p < 0.001$); Durbin-Watson = 2.091

The overall regression model was statistically significant ($F = 18.292$; $p < 0.001$), confirming that the three dimensions jointly predict environmental policy implementation. The coefficient of determination ($R^2 = 0.361$) indicates that the model explains 36.1% of the variance in Y. The Durbin-Watson statistic of 2.091 (within the acceptable range of 1.5–2.5) confirmed the absence of autocorrelation. The resulting regression equation is as follows:

$$Y = 1.521 - 0.147\,X_1 + 0.772\,X_2 - 0.125\,X_3 \quad \text{(Eq. 2)}$$

The constant term ($\alpha = 1.521$) indicates the baseline level of environmental policy acceptance when all independent variables are held constant, representing the minimum level of acceptance attributable to factors outside the model. Regarding the Economic Perception variable (X_1), the coefficient of −0.147 ($p = 0.169$) indicates a non-significant negative relationship in the partial model. This result does not mean that economic benefits are unimportant to the community. The descriptive data clearly demonstrate that economic gains are highly valued (mean = 4.30; Very Good), the model explains 36.1% of the variance in Y. This finding is consistent with Kemp & Owen (2013), who argued that economic contributions in extractive industries serve as initiating rather than sustaining mechanisms of acceptance that attract initial goodwill without generating endorsement of environmental policy frameworks. For Company X, the economic legitimacy it has established in Tangofa Village creates a favorable entry point but cannot substitute for social trust and environmental legitimacy in consolidating community acceptance.

Social Perception variable (X_2) emerged as the sole positive and dominant predictor ($\beta = 0.772$; $p < 0.001$). Each one-unit increase in social perception translates into a 0.772-unit increase in environmental policy acceptance, representing the largest effect size in the model and confirming that social trust and relational quality are the primary drivers of community endorsement of Company X's environmental policy. This result has important strategic implications. It suggests that investments in communication quality, cultural respect, community involvement, and social program delivery, rather than purely technical environmental management improvements, yield the highest returns in terms of community acceptance of environmental policy. This coefficient's strength (0.772) reflects the primacy of relational trust in the community-company dynamic in Tangofa Village. This finding aligns with Tewu et al. (2025) finding in Indonesian mining contexts that participatory, transparent processes are the most powerful drivers of community acceptance, and with Que et al.'s (2019) evidence that meaningful community involvement transforms perceptions by fostering a sense of governance fairness.

The Environmental Perception variable (X_3) exerted a statistically significant negative partial effect ($\beta = -0.125$; $p = 0.020$). This negative coefficient warrants careful interpretation. The negative regression coefficient should be interpreted with caution, as further statistical analyses would be required to explain the underlying relationship, when social trust is high, community members may accept environmental policy even when environmental conditions remain poor. Conversely, when communities perceive environmental deterioration, their acceptance of policy declines significantly and independently of social and economic factors. This dynamic illustrates the risk that Company X faces, which is that persistently poor environmental quality could erode even the strong social capital that currently sustains community acceptance over time.

These results collectively confirm the study hypothesis that all three sustainability dimensions have meaningful relationships with the acceptance of environmental policies. The dominance of the social dimension aligns with the social license to operate (SLO) framework of Boutilier & Thomson (2011), which states that economic legitimacy alone represents the lowest level of community acceptance. Mining companies remain exposed to social resistance without socio-political legitimacy built through transparent environmental impact management. Kemp & Owen (2013), similarly argued that extractive companies primarily use direct economic contributions to initiate community acceptance rather than to sustain it, which is a distinction of critical policy relevance.

The finding that community acceptance operates primarily through social capital rather than through environmental performance or economic metrics challenges conventional assumptions in corporate environmental management. This suggests that Company X's current environmental policy implementation, which is procedurally adequate, has not successfully converted community participation into environmental quality improvements that are perceptible and meaningful to the community. These findings may indicate a potential risk of increased community dependence on mining-related economic benefits; however, further longitudinal research is needed to confirm this relationship.

From a policy perspective, these regression results highlight the strategic priority of investing in social legitimacy as the foundational condition for effective environmental policy acceptance. Programs that strengthen communication transparency, expand genuine community participation in environmental monitoring, and deliver demonstrable improvements in air and water quality will work synergistically to consolidate both social trust and environmental legitimacy, positioning Company X on a more resilient trajectory toward a sustainable social license to operate.

4. Conclusions

This study demonstrates that a pronounced asymmetry across the three sustainability dimensions characterizes community perceptions of corporate environmental policy implementation in Company X, a nickel mining company operating in Tangofa Village,

Morowali Regency, Central Sulawesi. Economic perceptions are strongly positive, driven by tangible employment and income benefits generated by Company X's operations. Social perceptions are moderately positive, supported by functional communication channels and community involvement in procedural activities. Company X has achieved strong community recognition of its economic contributions such as employment availability (mean = 4.50; Very Good) and income improvement (mean = 4.40; Very Good) and has made meaningful progress on social engagement, with communication quality (mean = 3.99; Good) and community involvement (mean = 3.83; Good) reflecting functional participatory mechanisms. Collectively, these economic and social dimensions place the company solidly in the Good to Very Good performance range in community perception, indicating positive community perceptions of the company's economic contributions and social engagement, consistent with the economic and social dimensions of the SLO framework. Environmental perceptions are poor, reflecting persistent concerns about deterioration in air and water quality that have not been adequately addressed by existing mitigation measures.

Multiple linear regression analyses indicate that the social factor is the dominant predictor of environmental policy acceptance, whereas environmental perception shows a significant negative association that should be interpreted with caution. These findings highlight that social trust and relational dynamics fundamentally shape community acceptance of environmental policy rather than economic benefit or environmental compliance. The policy-to-practice gap between procedural environmental engagement and substantive environmental quality improvement, represents a crucial challenge for Company X's environmental policy strategy. The results reinforce the conceptual framework of the Social License to Operate, affirming that enduring community acceptance in the extractive sector depends on the integration of economic, social, and environmental dimensions into a coherent and transparent policy strategy. For Company X, this means maintaining its economic contributions while simultaneously strengthening transparency in environmental communication, expanding access to community monitoring, and delivering measurable improvements in air and water quality management. An integrated approach may strengthen community perceptions and contribute to a more sustainable relationship between the company and the local community. Several limitations characterize this study, most notably its localized scope. The findings are contextually bound to Company X and Tangofa Village, which may limit their broader generalizability. Furthermore, the use of purposive sampling potentially results in aggregate perception scores that are more favorable than those of a representative community-wide sample. Future research should expand to comparative multi-site studies across Indonesia's nickel-producing regions. Furthermore, stratified random or community-wide sampling strategies were deployed to to actively include non-mining-integrated residents and subsistence laborers.

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Author Contribution

onceptualization, C.T.R., E.F., and S.W.S.; Methodology, C.T.R., E.F.; Software, C.T.R.; Validation, E.F., S.W.S.; Formal Analysis, C.T.R.; Resources, C.T.R.; Data Curation, E.F., and S.W.S.; Writing – Original Draft Preparation, C.T.R.; Writing – Review & Editing, E.F., and S.W.S.; Visualization, C.T.R.; Supervision, E.F., and S.W.S.; Project Administration, C.T.R.

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Ethical Review Board Statement
The study was conducted in accordance with the ethical principles of the Komite Kaji Etik Sekolah Ilmu Lingkungan Universitas Indonesia and approved by the Komite Kaji Etik Sekolah Ilmu Lingkungan Universitas Indonesia (protocol code KET-052/UN2.F13.D1.KE1/ PPM.00/2025; date of approval: 18 July 2025). The ethics review was conducted under the original Indonesian research title 'Strategi Kebijakan Lingkungan Perusahaan Tambang Terhadap Desa Lingkar,' which corresponds to the research reported in this manuscript. The ethics committee reviewed researcher competency, research protocols and instruments, funding information, and the ethical protection of respondents involved in the study.

Informed Consent Statement
Informed consent was obtained from all subjects involved in the study.

Data Availability Statement
We encourage all authors of articles published in this journal to share their research data. This section provides details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. A statement is still required when no new data is created or unavailable due to privacy or ethical restrictions.

Conflicts of Interest
The authors declare no conflict of interest.

Declaration of Generative AI Use
During the preparation of this work, the authors used Grammarly to assist in improving grammar, clarity, and academic tone of the manuscript. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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