

Mining Externalities in Indonesia and Their Implications for Sustainable Development: A Systematic Literature Review

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Abstract: The review identifies consistent environmental impacts, including accelerated deforestation, hydrological degradation, heavy-metal contamination, and persistent post-mining land damage. Social externalities are reflected in rising respiratory and waterborne diseases, livelihood disruptions among agrarian and coastal communities, and recurrent conflicts linked to land tenure disputes and weak recognition of indigenous rights. Economic externalities manifest through unequal benefit distribution, long-term public costs for health and ecosystem restoration, and short-lived employment dominated by non-local workers. Weak regulatory enforcement and short-term, poorly targeted corporate social responsibility (CSR) programs further exacerbate these issues. Overall, the findings reveal a structural imbalance between economic gains and socio-ecological risks in Indonesia's extractive sector. The study proposes policy pathways to strengthen environmental governance, internalize external costs, improve community welfare, and support a transition toward sustainable mineral development.

Keywords: Mining externalities; Environmental degradation; Social impacts; Economic impacts; Sustainable development

Introduction

The mining and mineral sector remains a cornerstone of Indonesia's national and regional economy. Recent analyses show that mining activities including tin, nickel, and coal make substantial contributions to GDP, with tin-producing regions in particular exhibiting strong dispersion effects on local GRDP (Sulista & Achmadi, 2022). In parallel, the Indonesian government has positioned mineral downstreaming as a key driver of a new phase of industrialization aimed at boosting value added and export performance (Zou, Gao, & Ai, 2025). Despite these economic benefits, mining operations also generate a wide range of externalities that directly and indirectly affect regional development sustainability.

Externalities refer to impacts that are not reflected in market prices and are not fully borne by the economic actors who generate them. In the mining context, negative externalities frequently manifest through environmental degradation such as deforestation, pollution, and land degradation declining public health, loss of traditional livelihoods, and

social tensions arising from unequal benefit distribution (Worlanyo & Jiangfeng, 2021). Conversely, positive externalities such as improved infrastructure and temporary increases in local economic activity tend to be short-lived and do not necessarily translate into long-term welfare improvements (Siachiwena, 2025).

Given these complexities, sustainable development in mining-producing regions requires a deeper understanding of how externalities emerge, how they are measured, and how policy interventions can effectively manage them (Butters, 2025). To address this need, the present study conducts a Systematic Literature Review (SLR) synthesizing empirical evidence from national and international research on mining externalities in Indonesia. The review aims to generate an evidence-based policy framework capable of balancing economic growth with social and environmental sustainability.

Research Method

This study adopts a structured and transparent Systematic Literature Review (SLR) approach. The review process follows four sequential stages as outlined by Carrera-rivera, Ochoa, Larrinaga, & Lasa (2022) and Gusenbauer & Gauster (2025): (1) literature search, (2) screening based on inclusion and exclusion criteria, (3) data extraction, and (4) thematic synthesis.

Literature Search.

The search was conducted across major academic databases—Scopus, ScienceDirect, SpringerLink, and Google Scholar—using the following keyword combinations: “mining externalities” AND “Indonesia”; “mining impact” AND “environment” AND “Indonesia”; “coal/nickel mining” AND “health” AND “Indonesia”; and “CSR mining” AND “Indonesia”. The search period spans from 2010 to December 2025 to capture the full range of studies following the expansion of Indonesia’s nickel, coal, gold, and other critical mineral industries.

Inclusion and Exclusion Criteria.

The inclusion criteria encompass empirical studies that: (i) focus on environmental, social, or economic impacts of mining in Indonesia; (ii) are written in English or Indonesian; and (iii) utilize field data, satellite imagery, health surveys, regional economic datasets, or policy evaluation methods. Exclusion criteria include: (i) geological or technical articles with no discussion of externalities; and (ii) opinion pieces, commentaries, or editorials lacking empirical evidence.

Screening Process.

A multi-stage screening procedure was employed to ensure the relevance and quality of the selected studies. The initial database search identified 178 publications. After a preliminary review of titles and abstracts, 61 articles were deemed suitable for full-text assessment. These articles were then systematically evaluated using the defined inclusion–exclusion criteria, focusing on contextual relevance, empirical contributions, and explicit examination of mining externalities. Following this assessment, 42 studies met all criteria and were selected for thematic synthesis.

Data Extraction and Thematic Synthesis.

In the final stage, all eligible articles were subjected to systematic data extraction using a pre-defined analytical matrix. Extracted variables included: mining commodity type, study location, methodological approach, impact indicators, and major empirical findings. These data were analyzed to identify patterns, consistencies, and divergences across studies. Based on this mapping, all empirical evidence was categorized into three principal groups of externalities: environmental, social, and economic. This classification enabled the development of a structured and comprehensive thematic synthesis and facilitated the derivation of evidence-based policy implications for managing mining externalities and promoting sustainable development in resource-producing region.

Result and Discussion

Environmental Externalities

Deforestation and ecosystem degradation.

Satellite-based studies in nickel industrial zones of Sulawesi and Maluku (Lo et al., 2024b) reveal substantial declines in primary forest cover due to the expansion of mining areas and associated infrastructure. Such deforestation contributes to habitat loss, increased soil erosion, and disruptions to regional hydrological cycles.

Water and soil pollution.

Research conducted in gold- and coal-mining regions reports elevated concentrations of heavy metals (e.g., Hg, Mn, Fe), alongside heightened turbidity and acidity in rivers surrounding mining sites (Wahyono et al., 2024; Yulia, Harmesa, Budiyanoto, Thoha, & Fitriya, 2025). These pollutants adversely affect agricultural productivity, freshwater aquaculture, and household drinking-water supplies.

Post-mining land degradation.

A consistent theme across the reviewed studies is the low quality of land reclamation following mine closure. Abandoned open-pit landscapes frequently exhibit poor soil fertility (Feng, Wang, Bai, & Reading, 2019; Putri, Sulistyono, Hermawan, & Lovita, 2022), with some sites left unrestored for more than a decade.

Social Externalities

Health impacts.

Public health studies in Kalimantan and Sumatra document higher incidences of respiratory illnesses particularly acute respiratory infections among children in communities near coal-mining operations (Akbar & Kallawicha, n.d.; Pasaribu, Susanto, Keselamatan, Masyarakat, & Kesehatan, 2025). Other research reports skin irritation and gastrointestinal complaints linked to declining water quality.

Livelihood disruptions.

Declining soil and water quality constrains traditional farming and fisheries (Purnama, Prayitno, Muskananfolo, & Suryanti, 2024; Sarianto, Simbolon, & Wiryawan, 2016). Coastal communities located near nickel industrial zones have experienced reductions in fish catch of up to 30-40%, according to independent field-based assessments (Karsadi & Aso, 2023).

Social conflict and indigenous rights.

The expansion of mining operations frequently intersects with indigenous land claims, generating both horizontal and vertical conflicts characterized by overlapping permits, insufficient public consultation, and inequitable benefit distribution. Case studies from Southeast Sulawesi (e.g., Morowali, Konawe, Bombana) and Papua document protests, contested land mapping, and allegations of elite-controlled compensation, all of which exacerbate spatial injustices (Hudayana & Widyanta, 2020).

Economic Externalities

Uneven distribution of benefits.

Although mining contributes to regional GDP and local fiscal revenues, the economic gains are unevenly distributed. Several regional economic studies indicate that mining-dependent regions often exhibit stagnant welfare indicators, a pattern consistent with the broader resource curse literature (Haas & Poelhekke, 2019; Loayza & Rigolini, 2016).

External costs borne by the public.

Health expenditures, environmental rehabilitation, and infrastructure degradation caused by heavy machinery are typically not internalized by mining firms. Empirical evidence at the community level shows that mining imposes tangible economic and health losses on nearby populations (Shiquan, Amuakwa-mensah, Deyi, Yue, & Yue, 2022), resulting in long-term fiscal burdens for local governments.

Temporal employment creation.

Although mining generates jobs during the construction phase, operational efficiency reduces long-term labor demand. Moreover, many high-wage positions are filled by workers from outside the region (Mcmahon & Moreira, 2014), limiting local economic spillovers.

Governance and Mitigation

Regulatory enforcement.

Recent investigative reports indicate improvements in law enforcement, including actions taken against illegal mining in forest zones (Iksan, Kamal, & Putri, 2025). However, regulatory effectiveness continues to be constrained by limited institutional capacity and insufficient data transparency (Rahmawati, Endarto, & Santoso, 2025).

Corporate social responsibility (CSR) and sustainability.

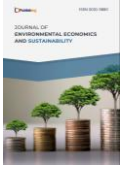
Most CSR initiatives remain focused on short-term infrastructure support and community training. The literature consistently notes that many programs lack long-term strategic orientation and rigorous evaluation (Jenkins & Yakovleva, 2006). CSR effectiveness increases when linked to clear environmental indicators and when communities are directly involved in planning and monitoring processes (Mustangin, 2025).



Table 1: Summary of Key Studies

| Theme | Sub-Theme | Key Findings | Evidence / Representative Studies |
|------------------------------------|--|--|--|
| Environmental Externalities | Deforestation & Ecosystem Degradation | Satellite-based analyses in Sulawesi and Maluku show significant primary-forest canopy loss due to mine expansion and road construction; deforestation disrupts habitat integrity, increases erosion, and alters hydrological systems. | Lo et al. (2024); Feng et al. (2019); Putri et al. (2022) |
| | Water & Soil Contamination | Mining zones exhibit elevated concentrations of heavy metals (Hg, Mn, Fe), higher turbidity, and increased acidity that threaten agriculture, fisheries, and household water sources. | Wahyono et al. (2024); Yulia et al. (2025); Aragón & Rud (2015) |
| | Post-Mining Land Degradation | Poor reclamation practices result in low soil fertility and prolonged landscape degradation, with abandoned pits persisting for more than a decade. | Feng et al. (2019); Putri et al. (2022) |
| Social Externalities | Health Impacts | Communities near coal and gold mining sites experience higher respiratory illness incidence (e.g., ARI among children), as well as skin and gastrointestinal complaints linked to reduced water quality. | Akbar & Kallawicha (n.d.); Pasaribu et al. (2025); Jørs et al. (2013) |
| | Livelihood Disruption | Declining soil and water quality reduces agricultural and fisheries productivity; coastal communities in nickel-industrial zones report 30–40% decline in catch. | Purnama et al. (2024); Sarianto et al. (2016); Karsadi & Aso (2023) |
| | Indigenous Rights & Social Conflict | Mining expansion overlaps with customary lands, leading to horizontal and vertical conflicts, contested land mapping, and allegations of unequal compensation reinforcing spatial injustice. | Hudayana & Widyanta (2020); Bebbington et al. (2018); Gilberthorpe & Hilson (2014) |

| | | | |
|------------------------------------|--|---|--|
| Economic Externalities | Unequal Distribution of Benefits | While mining contributes to GRDP and fiscal revenues, welfare indicators remain stagnant in mining-dependent regions consistent with the “resource curse” phenomenon. | Haas & Poelhekke (2019); Loayza & Rigolini (2016) |
| | Publicly Borne External Costs | Health burdens, environmental restoration, and infrastructure damage are rarely internalized into mining costs, imposing long-term fiscal pressures on local governments. | Shiquan et al. (2022); Aragón & Rud (2015) |
| | Temporal Nature of Job Creation | High employment occurs mainly during construction; operational phases require fewer workers due to mechanization. High-skilled positions are often filled by non-local labor. | McMahon & Moreira (2014) |
| Governance & Mitigation | Regulatory Enforcement | Recent enforcement actions against illegal mining indicate institutional responsiveness, yet monitoring effectiveness remains limited by capacity constraints and data transparency issues. | Iksan et al. (2025); Rahmawati et al. (2025); Bebbington et al. (2018) |
| | Corporate Social Responsibility (CSR) | CSR in mining tends to focus on infrastructure and short-term programs; effectiveness improves when CSR includes measurable environmental indicators and community participation. | Jenkins & Yakovleva (2006); Hilson (2012); Mustangin (2025) |



The evidence synthesized in this review demonstrates that the environmental externalities of mineral extraction in Indonesia mirror global patterns documented in resource-rich developing economies. Rapid expansion of nickel, coal, and gold mining has accelerated primary-forest conversion, with satellite-based assessments in Sulawesi and Maluku confirming substantial canopy loss linked to pit development and supporting roads (Lo et al., 2024a). Similar trajectories are evident in large-scale mining frontiers such as the Amazon and Central Africa, where deforestation is driven not only by extraction sites but by the wider footprint of supply chains and settlement expansion. The degradation of hydrological systems—manifested in elevated heavy-metal concentrations and increasing acidity in river basins near extraction zones (Wahyono et al., 2024; Yulia et al., 2025) corroborates international findings that mining activities disproportionately affect water quality and soil fertility, with long-term consequences for agricultural productivity and ecosystem resilience.

Social externalities exhibit a similarly consistent pattern. Mining-affected communities in Kalimantan and Sumatra experience higher prevalence of respiratory diseases, particularly among children, echoing epidemiological studies from Mongolia, China, and South Africa that link particulate exposure and water contamination to chronic health burdens (Akbar & Kallawicha, n.d.; Pasaribu et al., 2025; Shiquan et al., 2022). The erosion of traditional livelihoods especially small-scale farming and coastal fisheries illustrates the multidimensional vulnerability induced by environmental degradation. Field-based evidence documenting declining fish catch in nickel-affected coastal zones (Karsadi & Aso, 2023) aligns with global research showing that mining pollution disrupts coastal trophic systems, reducing catch stability and food security. These pressures intensify social fragmentation, particularly when land-use conflicts intersect with indigenous territorial rights. Consistent with case studies in Papua New Guinea, Peru, and the Philippines, mining expansion in Sulawesi and Papua has produced vertically and horizontally contested claims due to insufficient consultation and elite-mediated compensation (Hudayana & Widyanta, 2020).

Economic externalities reflect the paradoxical nature of mining-led regional development. While mining boosts local GDP and fiscal revenues, the benefits remain spatially and socially uneven. The stagnation of welfare indicators in resource-dependent districts echoes global empirical evidence on the “resource curse,” which shows that extraction-based growth frequently coexists with persistent poverty, low human-capital formation, and weak institutional capacity (Haas & Poelhekke, 2019; Loayza & Rigolini, 2016). Moreover, significant public costs such as health burdens, degraded land, and damaged infrastructure remain unpriced and are often borne by local governments, consistent with findings that externalities from extractive enclaves depress long-term development outcomes (Shiquan et al., 2022). Employment effects are also transitory: although construction phases generate temporary labor absorption, long-term employment

declines as capital-intensive technologies dominate production. The concentration of high-skill, high-wage positions among non-local workers reflects broader tendencies observed in Latin America and Sub-Saharan Africa, where mining enclaves fail to produce deep labor-market linkages (Mcmahon & Moreira, 2014).

Governance outcomes further moderate the distribution of risks and benefits. Despite progress in enforcement—such as expanding actions against illegal mining (Iksan et al., 2025) persistent weaknesses in regulatory capacity and transparency hinder effective oversight. These institutional gaps mirror cross-country assessments showing that environmental compliance in the mining sector is strongly correlated with state capacity, fiscal autonomy, and access to real-time monitoring data (Rahmawati et al., 2025). In the absence of strong regulatory incentives, post-mining reclamation remains inadequate, as documented both in Indonesia and in other extractive economies such as China and India, where reclamation quality significantly lags behind statutory requirements (Feng et al., 2019; Putri et al., 2022; Zhang, Kumar, Huang, & Yuan, 2023).

Finally, the role of corporate social responsibility (CSR) remains mixed. While companies often highlight infrastructure donations and community training programs, much of the literature finds that these interventions are fragmented, short-term, and poorly aligned with local development priorities (Jenkins & Yakovleva, 2006). The review confirms this pattern and further indicates that CSR achieves greater sustainability when embedded in clear environmental-performance indicators and participatory planning mechanisms, consistent with broader evidence from Southeast Asia and Africa showing that inclusive governance and measurable impact frameworks significantly enhance CSR effectiveness (Mustangin, 2025). This suggests that the transformation of CSR from philanthropic gestures to accountable, impact-driven development partnerships is essential for reducing the social and ecological trade-offs of extractive industries.

Conclusion

Mining plays a significant role in Indonesia's economic development, but it is accompanied by substantial externalities that are often not fully internalized. Ensuring long-term sustainability therefore requires policies that incorporate comprehensive accounting of long-term environmental and social costs, the enforcement of stricter environmental standards, and the establishment of compensation and community-empowerment mechanisms for affected populations. Future research is needed to monetize these externalities, assess the effectiveness of land reclamation efforts, and design evidence-based governance mechanisms capable of balancing economic gains with environmental and social integrity.

Future research should focus on monetizing the environmental and social externalities of mining by integrating life-cycle assessment, health cost analysis, and ecosystem service valuation to better reflect long-term public costs. Longitudinal and spatially disaggregated studies are also needed to evaluate the sustained impacts of land reclamation, livelihood recovery, and CSR effectiveness across different mining regions and commodities. Practically, policymakers should institutionalize mandatory externality

accounting, strengthen regulatory enforcement, and expand independent monitoring systems using satellite and community-based data. Mining governance should further enhance community participation through formal recognition of customary land rights, transparent benefit-sharing mechanisms, and targeted public health surveillance in mining-affected areas. Finally, supporting economic diversification and local skill development is essential to reduce regional dependence on extractive activities and promote more resilient and sustainable development outcomes.

Implications

1. Strengthening Environmental Governance
 - a. Indonesia should institutionalize mandatory externality accounting, integrating long-term ecological costs into mining permits.
 - b. Independent environmental monitoring units with satellite-based tracking can reduce data asymmetry between firms and regulators.
2. Reforming Revenue and Compensation Mechanisms
 - a. Introduce ecological fiscal transfers that reward regions achieving successful reclamation and low deforestation.
 - b. Require mining companies to deposit environmental performance bonds to prevent abandonment of damaged land.
3. Enhancing Community Rights and Participation
 - a. Formal recognition of customary land through participatory mapping reduces conflict.
 - b. Local communities should be represented in CSR planning, environmental monitoring, and benefit-sharing schemes.
4. Reducing Long-Term Public Health Burdens
 - a. Implement community-based health surveillance around mining zones.
 - b. Internalize health costs into mining taxation or mandatory corporate contributions.
5. Supporting Livelihood Diversification
 - a. Promote alternative rural economies (agroforestry, aquaculture, ecotourism) to reduce dependence on extractive cycles.
 - b. Provide training for local workers to reduce reliance on imported labor and enhance local employment absorption.
6. Ensuring Sustainable Industrial Downstreaming
 - a. Indonesia's mineral downstreaming strategy must include:
 - b. strict emission controls,
 - c. responsible waste management for smelters,
 - d. local industrial cluster development to generate linkages beyond mining

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