

WHEN MINING TRUCKS RULE THE ROAD: EXTRACTIVE MOBILITY AND THE GOVERNANCE OF PUBLIC RISK IN SUKATANI, INDONESIA

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Abstract

Mining-material distribution in Sukatani District, Purwakarta Regency, generates environmental, road-safety, infrastructure, and community risks that persist despite existing mining and traffic regulations. This study aims to analyze policy-implementation gaps and evaluate governance arrangements for controlling distribution-related public risks. The analysis draws on Policy Implementation, Collaborative Governance, and Risk Governance perspectives. A qualitative case study was conducted using semi-structured interviews, direct observation, document analysis, purposive sampling, and interactive qualitative analysis supported by triangulation. The findings reveal that dust dispersion, material spillage, slippery roads, infrastructure deterioration, and mobility conflicts are reinforced by fragmented institutional responsibilities, inconsistent supervision, weak interagency coordination, and uneven operational compliance. The discussion identifies a distribution-governance failure in which sectoral mandates do not adequately match the integrated nature of public risks. Effective governance requires coordinated supervision, enforceable vehicle standards, clearer operational arrangements, and risk-responsive institutional coordination across the mining distribution corridor to protect communities and shared public infrastructure effectively.

Keywords: Policy Implementation; Mining Governance; Public Risk

A. INTRODUCTION

Indonesia's Ministry of Energy and Mineral Resources recorded non-tax state revenue from the energy and mineral resources sector of IDR 138.40 trillion in 2025, equivalent to 108.56% of the IDR 127.48 trillion target, underscoring the substantial economic value of extractive activities to the national economy (Ministry of Energy and Mineral Resources, 2026b). IQAir reported that Indonesia's annual average PM_{2.5} concentration reached 30 µg/m³ in 2025, approximately six times the WHO annual guideline, indicating that economic activity continues to coexist with considerable environmental pressures (IQAir, 2026). The Government of West Java Province identified mining transport vehicles carrying loads of up to 30 tons during an inspection in Subang and linked such operations to road deterioration and economic burdens imposed on surrounding communities (Government of West Java Province, 2025). The Regional Development Planning, Research, and Innovation Agency of Purwakarta Regency reported that 30.00 km of district roads were classified as damaged and another 150.34 km as severely damaged out of approximately 776.383 km of the total road network in 2025 (Bapperida Purwakarta Regency, 2026). These conditions shift the policy concern from the economic contribution of mining toward the governance of mineral-material distribution and its consequences for

environmental quality, road safety, and public infrastructure.

Mining governance determines the capacity of public institutions to balance economic benefits against the social and environmental risks generated across the extractive value chain. Warburton (2024) demonstrated that mineral-based industrialization can strengthen national economic capacity while transferring substantial social and environmental externalities to producing regions and local communities. Murguía and Bastida (2024) argued that regulatory capacity and law enforcement remain essential foundations of responsible mining because voluntary corporate sustainability standards cannot substitute for effective public institutions. Coral et al. (2024) found that institutional misalignment constrains the ability of local governments and communities to respond consistently to the consequences of extractive activities. This governance problem becomes particularly visible in Sukatani, where mining activities extend beyond extraction sites through the transportation of mining materials along public roads used routinely by local communities.

Mining-material distribution in Sukatani District positions Jalan Raya Cilalawi as a direct interface between the economic interests of mining operations and the public interest. Mining transport vehicles routinely carry dust, mud, and rock fragments from extraction areas onto roads used by residents for commuting, schooling, and other daily activities. Field documentation reveals dusty, slippery, cracked, and material-contaminated road surfaces that increase risks for road users. Vehicle supervision, cleanliness standards, operating-hour restrictions, and distribution-route management remain inconsistently implemented despite the existence of mining and road-traffic regulations. The resulting discrepancy between formal rules and operational practices places policy implementation at the core of the problem and provides a basis for examining how previous studies have approached comparable governance failures.

Recent mining-governance research consistently identifies institutional coordination, regulatory effectiveness, actor relationships, and supervisory capacity as major determinants of governance performance. Adranyi, Stringer, and Altink (2024) examined policy coherence in artisanal and small-scale gold mining governance in Ghana and found that limited cross-sectoral coordination and ineffective monitoring continued to undermine policy implementation. Devi, Mayes, and Grant-Smith (2025) employed case studies of mining governance in Gorontalo and found that competing rationalities and power relations between industrial mining and artisanal mining shaped the legitimacy and effectiveness of local governance arrangements. Rahayu, Rustamaji, Faisal, and Sari (2025) applied a socio-legal approach to tin mining in Bangka Belitung and found that fragmented supervision, asymmetric bargaining positions, and weak safety provisions reduced the effectiveness of relations between companies and surrounding communities. These findings consistently establish the importance of institutional governance but also reveal the need to examine how governance operates during material distribution after extractive activities leave the production site.

This study shares with previous research an understanding of mining as a public-governance problem involving regulation, supervision, compliance, and consequences for affected communities. Its emphasis on institutional capacity and interorganizational relationships also corresponds with the findings of Adranyi et al. (2024), Devi et al. (2025), and Rahayu et al. (2025) regarding the central role of coordination in controlling the consequences of extractive activities. This study differs by shifting the analytical focus from extraction processes, mining formalization, and company–community relationships toward the distribution of mining materials after transport vehicles leave production areas. This

analytical focus connects mining policy directly with transportation governance, road safety, environmental protection, and infrastructure maintenance within a single local implementation process. The distinction establishes an underexplored analytical space concerning how governments control public risks when mining operations extend from extraction sites into spaces of everyday community mobility.

Existing mining-governance literature has extensively examined coordination, compliance, actor relationships, and supervisory capacity, yet its primary analytical focus remains concentrated on extraction sites and institutional relationships surrounding production activities. An *empirical gap* persists because evidence on policy implementation during the transportation of mining materials through shared public roads remains limited, particularly within local-government settings in Indonesia. This gap has substantive importance because the distribution stage simultaneously activates responsibilities for mining regulation, transportation management, environmental protection, public safety, and infrastructure maintenance across different institutions. Previous studies have not adequately explained how interagency coordination, supervisory capacity, vehicle operating standards, business compliance, and public risks interact as an integrated policy-implementation process along mining distribution corridors. This study addresses that gap by positioning mining-material distribution in Sukatani as a cross-sectoral policy-implementation arena that connects institutional arrangements, operational practices, and direct consequences for the public interest.

Dust exposure, material spillage, slippery roads, infrastructure deterioration, and mobility conflicts in Sukatani demonstrate that mining-material distribution has moved beyond an internal operational issue and has become a matter of public protection and service governance. Limited scholarly attention to the distribution stage may prevent mining-governance literature from adequately explaining how externalities migrate from extraction sites into public spaces used by surrounding communities. Weak operational control may also transfer part of the costs of mining activities to local governments through infrastructure-repair obligations and to communities through heightened safety risks and declining environmental quality. Residents along distribution corridors, motorcyclists, students, workers, local government agencies, supervisory authorities, and mining operators therefore hold direct stakes in the effectiveness of distribution governance. These interconnected consequences require an investigation that moves beyond documenting impacts toward explaining the policy-implementation mechanisms that produce, intensify, or fail to prevent public risks.

The principal *novelty* of this study lies in positioning mining-material distribution after materials leave extraction sites as the central unit of public-policy analysis. The study offers a conceptual contribution by connecting institutional coordination, supervisory capacity, operational compliance, and public risk within an integrated chain of cross-sectoral policy implementation. Its empirical contribution derives from the Sukatani case, where mining transportation simultaneously intersects with shared-road use, environmental risks, traffic safety, and infrastructure deterioration. Its practical contribution lies in providing an analytical basis for local governments to clarify institutional responsibilities, strengthen integrated supervision, establish vehicle operating standards, and regulate distribution routes and operating periods. The study therefore extends mining-governance analysis from identifying extractive impacts toward evaluating the governance mechanisms that shape public risk throughout local distribution processes.

This study aims to analyze policy-implementation gaps in the governance of mining-

material distribution in Sukatani District, Purwakarta Regency, by examining interagency coordination, supervisory capacity, operational compliance, and their relationship with public risks along distribution corridors. It also evaluates the need for operational arrangements capable of integrating mining interests with road safety, environmental protection, and public-infrastructure maintenance.

B. LITERATURE REVIEW

Policy Implementation

Policy implementation refers to the process through which policy decisions are translated into operational actions and intended public outcomes. Edwards III (1980) argues that successful implementation depends on the interaction of communication, resources, disposition, and bureaucratic structure rather than on policy formulation alone. Communication determines whether implementers receive policy directives accurately, clearly, and consistently, while resources determine whether implementing agencies possess sufficient personnel, information, authority, and operational facilities. Disposition reflects the commitment and willingness of implementers to execute policy objectives, whereas bureaucratic structure shapes implementation through standard operating procedures, organizational arrangements, and the distribution of responsibilities across institutions (Edwards III, 1980). This framework provides the primary analytical foundation for examining why existing mining and transportation regulations may not translate effectively into the operational control of mining-material distribution in Sukatani. Indicators:

- Communication
- Resources
- Disposition
- Bureaucratic Structure

Collaborative Governance

Collaborative governance describes a governance arrangement in which public institutions engage governmental and non-governmental stakeholders directly in collective processes for addressing public problems that cannot be effectively managed by a single organization. Ansell and Gash (2008) conceptualize collaboration as an iterative process shaped by starting conditions, institutional design, facilitative leadership, and the quality of the collaborative process. Starting conditions influence collaboration through existing power relations, resource asymmetries, incentives to participate, and previous patterns of cooperation or conflict among stakeholders. Institutional design and facilitative leadership establish legitimate rules, inclusive participation, transparent procedures, mediation capacity, and conditions that enable actors to develop trust, commitment, shared understanding, and intermediate achievements (Ansell & Gash, 2008). This framework supports an examination of whether government agencies, mining operators, communities, and other relevant actors in Sukatani possess an effective collaborative arrangement for governing mining-material distribution and its public consequences. Indicators:

- Starting Conditions
- Institutional Design
- Facilitative Leadership

- Collaborative Process

Risk Governance

Risk governance explains how institutions identify, assess, evaluate, communicate, and manage risks whose consequences extend across organizational and societal boundaries. Renn (2008) positions risk governance beyond conventional technical risk management by integrating scientific assessment, institutional decision-making, stakeholder concerns, and the social context in which risks emerge. The framework distinguishes risk identification and appraisal from judgments regarding risk acceptability and subsequent decisions concerning prevention, mitigation, adaptation, or control. The International Risk Governance Council further organizes this process into pre-assessment, appraisal, characterization and evaluation, risk management, and cross-cutting activities involving communication, stakeholder engagement, and contextual consideration (IRGC, 2017). This framework enables the study to assess how public authorities recognize and govern the environmental, traffic-safety, infrastructure, and community risks generated by mining-material transportation along public roads in Sukatani. Indicators:

- Pre-assessment
- Risk Appraisal
- Risk Characterization and Evaluation
- Risk Management
- Cross-Cutting Governance

C. RESEARCH METHODOLOGY

This study employs a qualitative case study approach to examine policy implementation in the governance of mining-material distribution in Sukatani District, Purwakarta Regency, because this approach enables an in-depth analysis of institutional processes, interagency coordination, stakeholder interactions, operational compliance, and public risks within their actual context (Yin, 2018). Data are collected through semi-structured interviews, direct observation, and document analysis, allowing the study to integrate institutional perspectives, field conditions along mining distribution corridors, and evidence from regulations, government reports, monitoring records, and other relevant official documents (Creswell & Poth, 2018). The study applies purposive sampling to select information-rich informants with direct authority, experience, knowledge, or involvement in mining-material distribution, including relevant government agencies, mining and transport operators, community representatives, and affected road users, while snowball sampling may be used to identify additional key actors when necessary (Palinkas et al., 2015). Data are analyzed using the interactive qualitative analysis model through data condensation, data display, and conclusion drawing and verification, supported by thematic coding based on policy implementation, collaborative governance, and risk governance dimensions to identify implementation gaps, coordination patterns, compliance problems, institutional constraints, and public risks (Miles, Huberman, & Saldaña, 2020). Research credibility is strengthened through source and method triangulation by comparing interview evidence, field observations, and official documents across different stakeholder groups, enabling the study to produce a contextually grounded explanation of how governance mechanisms either control or fail to control the public risks generated by mining-material distribution (Creswell & Poth, 2018).

D. RESULTS AND DISCUSSION

Mining-Material Distribution and Public Risks in Sukatani

Field observations along Jalan Raya Cilalawi identified recurring public risks associated with the movement of mining-material transport vehicles through roads shared with local residents. Heavy vehicles carried dust, mud, and residual rock material from mining areas onto the public road surface, particularly when vehicle bodies and wheels entered the corridor without adequate cleaning. Visual documentation recorded dense airborne dust during truck movements, material-contaminated road surfaces, and slippery conditions that increased exposure for motorcycles and other road users. Road sections along the distribution corridor also showed cracks and surface deterioration in locations experiencing intensive heavy-vehicle movement. These simultaneous environmental, safety, and infrastructure conditions indicate that mining-material transportation produces interconnected risks shaped by operational practices along the distribution corridor.

The observed risks reflect an operational pattern in which mining transportation transfers part of the physical consequences of extraction from production areas into public spaces. Uncontrolled material residues increase road contamination, while repeated truck movements redistribute deposited particles and prolong exposure beyond the immediate passage of individual vehicles. Shared road use increases the severity of these conditions because mining trucks interact directly with motorcycles, private vehicles, school-related mobility, and routine community activities. Road deterioration further compounds the problem by reducing surface quality and increasing the vulnerability of users to dust, mud, standing water, and unstable driving conditions. The interaction between vehicle operations, road conditions, and community exposure requires empirical comparison with evidence from other mining and quarrying contexts.

Quarry-road monitoring found that active gravel transportation substantially increased total suspended particles, PM₁₀, and PM_{2.5} concentrations compared with non-operational periods, demonstrating the direct contribution of transport activity to roadside fugitive dust (Seo, Seo, Jung, & Park, 2024). Mining-truck simulations also demonstrated that wheel rotation and vehicle-induced airflow disperse fine particles across identifiable exposure zones, confirming that moving trucks constitute an active mechanism of dust propagation rather than a passive transport source (Lu, Zhang, Xiao, & Wang, 2024). Residents living near quarry operations reported environmental degradation, road damage caused by trucks and heavy machinery, and broader disturbances to community livelihoods, indicating that extractive transportation creates consequences beyond production boundaries (Taiwo & Ogunbode, 2024). Integrated environmental and community assessments around quarry areas identified elevated dust exposure alongside respiratory health problems among workers and nearby residents, strengthening the association between weakly controlled quarry operations and public-health risks (Hailu, Alemayehu, & Abay, 2026). Field monitoring of open-pit mining roads further showed that haul-truck movements intensify particulate dispersion and extend dust exposure across surrounding areas, reinforcing the need to examine transportation practices as a distinct component of mining-related risk (Assefa et al., 2025).

Evidence from Sukatani indicates that dust, slippery surfaces, road deterioration, and mobility conflicts operate as mutually reinforcing consequences rather than isolated environmental or transportation problems. Material deposited by mining vehicles changes road-surface conditions, subsequent traffic redistributes the material, and repeated heavy-

vehicle movements sustain public exposure throughout the distribution period. The concentration of different risks within the same corridor increases the burden placed on residents because environmental exposure and traffic vulnerability occur within routine mobility spaces rather than within controlled mining areas. The condition also shifts responsibility for mining impacts beyond the extraction site because public roads become part of the operational chain used to generate and distribute economic value. Effective control consequently depends on operational standards capable of interrupting the mechanisms that transfer mining-related risks into shared public infrastructure.

Operational control requires more than responses to visible dust, damaged roads, or individual traffic incidents because the field evidence points to recurring conditions embedded in the distribution process. Vehicle cleaning, load containment, roadworthiness, operating schedules, route management, and field supervision represent interconnected control points that determine the level of exposure created along public roads. Weak control at one point can reduce the effectiveness of other measures because material leakage, unrestricted vehicle movement, and inconsistent monitoring reproduce the same risks across different periods. Persistent risk therefore indicates a governance problem in which operational practices depend on the clarity of rules, enforcement capacity, institutional responsibility, and compliance among mining and transport actors. The persistence of these conditions places policy implementation and interinstitutional coordination at the center of explaining why mining-material distribution continues to generate public risks in Sukatani.

Policy Implementation and Institutional Coordination in Mining-Material Distribution

Field findings identified a persistent gap between existing mining and traffic regulations and the operational control of mining-material transportation in Sukatani. Mining trucks continued to use public roads without a locally specific distribution route or operating-hour arrangement that separated heavy-vehicle movements from periods of intensive community mobility. Vehicle-cleanliness requirements, load-security practices, roadworthiness control, and compliance monitoring did not operate consistently across the observed distribution process. Institutional supervision remained fragmented across transportation, environmental, public-order, and other relevant authorities, while coordinated field enforcement had not developed into a routine and integrated control mechanism. These conditions indicate that the persistence of distribution-related risks originates not only from operator behavior but also from weaknesses in translating regulatory authority into coordinated implementation.

Regulatory availability cannot produce effective control when implementing institutions lack clear operational arrangements, consistent supervision, and coordinated enforcement. Unspecified routes and operating periods create implementation ambiguity because public agencies and mining operators lack a common operational reference for controlling vehicle movements. Fragmented supervision weakens accountability because separate institutional mandates divide responsibility for environmental impacts, traffic safety, vehicle compliance, and road conditions across different authorities. Inconsistent enforcement further allows operational compliance to depend heavily on individual business practices rather than on predictable regulatory control. The interaction between implementation ambiguity and fragmented institutional responsibility therefore explains why formal regulation has not generated consistent control over mining-material distribution.

Cross-sectoral mining governance in Ghana similarly showed that partial policy coherence, limited intersectoral coordination, and ineffective monitoring weakened the implementation of regulatory objectives, which closely parallels the coordination problems identified in Sukatani (Adranyi, Stringer, & Altink, 2024). Governance research in Gorontalo found that competing institutional rationalities and actor interests shaped regulatory processes, although the central conflict concerned the interface between industrial and artisanal mining rather than post-extraction transportation through public roads (Devi, Mayes, & Grant-Smith, 2025). Policy-implementation research in Tanzania demonstrated that information sharing, institutional resources, actor motivation, and power relations determine whether extractive-sector regulations translate into meaningful participation and implementation, providing a contrast to the weak operational integration observed in Sukatani (Mwanyoka & Mdemu, 2024). Evidence from local governance of mines and quarries in Australia showed that limited authority, technical capacity, and human resources restrict local governments from influencing extractive-sector outcomes despite their detailed knowledge of local conditions (Tully et al., 2026). Regulatory analysis of extractive-sector compliance further demonstrated that weak detection capacity, insufficient sanctions, and institutional fragmentation can reproduce persistent non-compliance even under an established regulatory framework (Jahangiri & Bahramian, 2026).

The Sukatani case reveals a distinctive distribution-governance gap in which regulatory fragmentation becomes most visible after mining materials leave production areas and enter infrastructure governed as a public service. Institutional responsibilities remain formally distributed across different agencies, yet the actual distribution process combines environmental contamination, vehicle safety, traffic management, road maintenance, and community protection within the same operational corridor. Separate sectoral mandates therefore fail to match the integrated character of the risks generated by mining transportation. Weak coordination transforms administrative fragmentation into an implementation mechanism that permits repeated operational deficiencies even when individual agencies possess relevant regulatory authority. The central finding positions institutional integration, rather than the mere addition of regulations, as a critical condition for improving compliance and controlling distribution-related public risks.

Institutional integration requires a governance arrangement that connects regulatory responsibilities with shared operational objectives across the entire mining-material distribution process. Clear distribution standards must define vehicle requirements, operating periods, route arrangements, supervisory responsibilities, enforcement procedures, and mechanisms for responding to community risks. Coordinated implementation must also align government agencies with mining operators and affected communities because each actor possesses different authority, resources, information, and exposure to distribution-related consequences. Persistent gaps in communication, resources, enforcement commitment, bureaucratic arrangements, and interorganizational cooperation determine whether those responsibilities function collectively or remain institutionally fragmented. The convergence of implementation weaknesses, coordination failures, operational non-compliance, and public-risk exposure therefore provides the analytical basis for explaining the broader governance mechanism underlying mining-material distribution in Sukatani.

Governance Gaps and the Management of Public Risks

The combined findings show that public risks along the Sukatani mining corridor

emerge from the interaction between uncontrolled transport practices and fragmented policy implementation. Dust dispersion, material spillage, slippery road surfaces, infrastructure deterioration, and mobility conflicts persist alongside inconsistent vehicle standards, limited field supervision, and unclear operational arrangements. Government agencies address environmental protection, transportation, public order, and infrastructure through separate administrative mandates even though mining-material distribution generates these problems simultaneously within the same public space. Mining operators consequently face a governance environment in which formal regulatory obligations do not consistently translate into integrated operational controls throughout the distribution process. This convergence between physical risks and institutional fragmentation requires a closer explanation of how administrative arrangements shape the effectiveness of public-risk control.

Fragmented authority weakens risk control because each institution addresses only part of a distribution process that functions as an interconnected system. Limited coordination separates environmental monitoring from vehicle supervision, traffic management, infrastructure protection, and enforcement even though failure in one area directly increases pressure on the others. Inconsistent operational control also shifts compliance from an institutional requirement toward discretionary practices among mining and transport operators. Weak integration allows recurring violations to persist because no single operational mechanism connects prevention, monitoring, enforcement, and corrective action across the entire distribution corridor. Effective governance therefore depends on institutional capacity to convert separate sectoral responsibilities into coordinated controls that correspond to the integrated character of mining-related public risks.

Evidence from Ghana demonstrates that partial policy coherence, weak intersectoral coordination, and ineffective monitoring reduce the capacity of mining governance to achieve regulatory objectives across interconnected sectors (Adranyi, Stringer, & Altink, 2024). Research on extractive governance in Gorontalo shows that competing institutional rationalities and unequal actor positions shape governance outcomes when multiple interests operate within the same mining system (Devi, Mayes, & Grant-Smith, 2025). Institutional analysis of responsible mining confirms that regulatory quality and enforcement capacity remain essential because corporate standards cannot substitute for effective public institutions (Murguía & Bastida, 2024). Research on artisanal mining governance further demonstrates that institutional fragmentation encourages actors to develop alternative operational practices when formal governance arrangements fail to provide coherent direction (Balag'kutu, 2024). Studies of extractive governance also show that institutional gaps and mismatches constrain the ability of local governments and communities to respond effectively to mining-related environmental and social pressures (Coral, Plieninger, Sieber, & Graw, 2024).

The Sukatani evidence identifies a distribution-governance failure in which public risk emerges primarily at the administrative interface between mining operations and shared public infrastructure. The problem does not result solely from insufficient operator compliance because fragmented institutional responsibilities also prevent government agencies from controlling the distribution chain as a unified policy object. Environmental contamination, road safety, infrastructure deterioration, and community exposure become mutually reinforcing when supervision remains divided according to sectoral mandates rather than organized around the actual movement of mining materials. This pattern positions interagency integration as a mediating governance mechanism between formal

regulation and operational compliance because coordinated supervision determines whether separate regulatory authorities can produce consistent control in the field. The resulting governance logic shifts policy attention from isolated violations toward the institutional architecture required to prevent risk throughout the distribution chain.

An integrated governance response must connect operational standards, supervisory responsibilities, enforcement mechanisms, risk monitoring, and stakeholder participation within a single distribution-control arrangement. Vehicle cleaning, load containment, roadworthiness requirements, route designation, operating-hour restrictions, and field inspections require clear institutional ownership and coordinated implementation rather than separate administrative interventions. Government agencies also need shared information and enforcement procedures that allow environmental, transportation, infrastructure, and community risks to inform the same operational decisions. Mining operators and affected communities require predictable rules and accessible accountability mechanisms so that compliance and public protection do not depend on episodic enforcement. These requirements establish a policy basis for strengthening mining-material distribution governance through coordinated implementation, enforceable operational standards, and risk-responsive institutional arrangements in Sukatani.

E. CONCLUSION

This study concludes that mining-material distribution in Sukatani generates interconnected environmental, road-safety, infrastructure, and community risks because fragmented policy implementation, weak interagency coordination, inconsistent operational supervision, and limited compliance prevent existing regulations from functioning effectively along public distribution corridors. The findings confirm that the research objectives were achieved by explaining how implementation gaps and institutional fragmentation shape public-risk exposure and by identifying the operational arrangements required to integrate mining interests with road safety, environmental protection, and infrastructure maintenance. The study contributes to mining-governance research by positioning post-extraction material distribution as a distinct governance arena in which public risks emerge through the interaction of regulatory authority, institutional coordination, operational practices, and shared public infrastructure. Local government should establish integrated supervision, clear vehicle-cleanliness and load-containment standards, enforceable operating-hour and route arrangements, coordinated sanctions, and accessible community-reporting mechanisms to strengthen compliance and reduce recurring risks along mining distribution corridors. Future research should extend the analysis to multiple mining regions, incorporate longitudinal observations and quantitative measurements of traffic, road deterioration, and environmental exposure, and address the limitation of this single-case qualitative design to test whether the identified distribution-governance mechanism remains consistent across different regulatory and territorial settings.

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