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FROM RESPONSE TO AUTHORSHIP: A SYSTEMATIC REVIEW OF AUTHORITY AND PARTICIPATION IN INDONESIA'S POST-MINING LAND GOVERNANCE

Mohammad Wahyu Diansyah
Universitas Islam Negeri Sultan Aji Muhammad Idris Samarinda
m.wahyu.d@uinsi.ac.id

Syaidah Fitri
Universitas Islam Negeri Sultan Aji Muhammad Idris Samarinda
s.fitri@uinsi.ac.id

Naufal Hafidh Mahdi Sujarwo Putra
Universitas Islam Negeri Sultan Aji Muhammad Idris Samarinda
naufal.hafidh@uinsi.ac.id

Listiana Ningrum
Universitas Islam Negeri Sultan Aji Muhammad Idris Samarinda
l.ningrum@uinsi.ac.id

Azizatul Lutfiah
Universitas Islam Negeri Sultan Aji Muhammad Idris Samarinda
a.lutfiah@uinsi.ac.id

Riska Annisa
Universitas Islam Negeri Sultan Aji Muhammad Idris Samarinda
riska.annisa@uinsi.ac.id

Riyan Riyadlun Najih
Universitas Islam Negeri Sultan Aji Muhammad Idris Samarinda
r.najih@uinsi.ac.id

Abstrak

Masyarakat hidup dengan konsekuensi sosial-ekologis dari pertambangan. Tinjauan sistematis ini mengkaji bagaimana literatur pascatambang di Indonesia membahas kewenangan dalam menentukan arah pascatambang. Dengan mengikuti standar pelaporan ROSES, sebanyak 101 artikel ilmiah yang diterbitkan antara tahun 2000 dan 2025 dari Scopus dan Dimensions disintesis dan dianalisis berdasarkan pengaturan tata kelola, model perencanaan, partisipasi masyarakat, bentuk pemanfaatan lahan, serta kesesuaiannya dengan praktik terbaik internasional dalam penutupan tambang. Hasil tinjauan menunjukkan bahwa tata kelola pascatambang didominasi oleh kepatuhan administratif, yang dibahas dalam 70 artikel, dibandingkan hanya 4 artikel mengenai pengalihan dan redistribusi lahan. Masyarakat umumnya dilibatkan dalam konsultasi, pelaksanaan, dan adaptasi mata pencaharian, tetapi jarang berperan dalam menentukan

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tujuan penutupan tambang. Hanya 6 studi yang mengintegrasikan perencanaan, kewenangan, tenurial, dan pembiayaan pada seluruh tahapan penutupan tambang. Pemisahan antara pihak yang menanggung konsekuensi penutupan tambang dan pihak yang menentukan arah serta ketentuannya dikonseptualisasikan di sini sebagai *response-authorship gap*. Pola ini juga terlihat pada berbagai tingkat pemerintahan, dengan kewenangan penutupan berada pada pemerintah pusat dan provinsi, sedangkan beban lingkungan dan sosial-ekonomi tetap ditanggung oleh pemerintah dan masyarakat lokal. Bukti ilmiah yang tersedia juga tidak merata secara geografis karena terkonsentrasi pada pertambangan batu bara di Kalimantan dan timah di Bangka Belitung, tetapi masih memberikan pemahaman yang terbatas mengenai wilayah pertambangan nikel yang berkembang pesat dalam kebijakan *hilirisasi*. Temuan ini menunjukkan perlunya persetujuan penutupan tambang yang mensyaratkan identifikasi pengguna akhir, pengakuan hak pengambilan keputusan, kepastian tenurial, serta pembiayaan yang mencakup pemantauan jangka panjang.

Kata kunci: *Tata kelola pascatambang; kewenangan dan partisipasi; penutupan tambang; politik ekstraktif; Indonesia.*

Abstract

Communities live with the social–ecological consequences of mining. This systematic review examines how Indonesian post-mining scholarship treats the distribution of authority over what those landscapes become. Following ROSES reporting standards, 101 peer-reviewed articles published between 2000 and 2025 were synthesized from Scopus and Dimensions and coded for governance arrangements, planning models, community participation, land-use pathways, and alignment with international best practice in mine closure. The review shows post-mining governance dominated by administrative compliance, addressed in 70 articles against 4 on land transfer and redistribution. Communities are commonly involved in consultation, implementation, and livelihood adaptation, but rarely in defining closure objectives. Only 6 studies integrate planning, authority, tenure, and financing across the closure sequence. This separation between bearing the consequences of closure and shaping its terms is conceptualized here as the *response-authorship gap*. The same pattern appears across levels of government, where closure authority sits with central and provincial agencies while residual environmental and socioeconomic burdens remain local. The evidence base is also geographically uneven, concentrating on Kalimantan coal and Bangka Belitung tin while providing limited insight into rapidly expanding nickel regions under *hilirisasi*. These findings point toward closure approvals conditioned on identified end-users, recognized decision rights, secure tenure, and financing that extends to long-term monitoring.

Keywords: *Post-mining governance; authority and participation; mine closure; extractive politics; Indonesia.*

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Introduction

Mining leaves altered landscapes whose future uses must be actively determined. The scale of this challenge is substantial. Between 2000 and 2019,

Indonesia lost approximately 190,000 ha of forest within industrial mining areas—the largest mining-related forest loss recorded across 26 tropical countries (Giljum et al., 2022). Pressures on land and ecosystems have intensified further under the downstreaming policy (*hilirisasi*), which promotes expanded nickel extraction and domestic smelting across mineral-rich regions (Ramadhani & Paksi, 2025; Sawal, 2025). In Morowali, these pressures are already evident in nickel-related sedimentation that has degraded mangroves and fisheries while raising concerns about heavy-metal contamination within local food systems (Syarifuddin, 2022). These impacts make the question of how post-mining land is governed, and who has the authority to determine its future, both increasingly urgent and politically consequential.

Yet, extraction is only one stage in a mining landscape's trajectory, and the damage described above does not end when mining does. At the other end sits closure, which conventionally revolves around remediation, restoration, reclamation, and rehabilitation, determining whether that damage is reduced, reorganized into a viable land use, or prolonged as a liability. Pagouni et al. (2024) identify two further approaches beyond these conventional "4R" actions, i.e., repurposing and co-purposing, that address the social and economic dimensions of closure. Those dimensions are inseparable from the communities who live with a mine's aftermath, and their role in selecting and governing post-mining trajectories is therefore central to procedural and distributive equity, since they bear many of the long-term costs. Post-mining governance must therefore extend beyond procedural compliance, because a technically reclaimed site may still fail socially if livelihoods collapse, land access is restricted, or benefits are captured elsewhere (van Druten, 2017). International research similarly stresses that true post-mining transformation depends on justice, durable institutions, ecological function, and continuous learning rather than technical repair alone (Beckett & Keeling, 2019; Folke, 2016; Michaels et al., 2026).

Making sense of that multidimensionality requires a framework built for it. Post-mining landscapes are best understood as integrated social–ecological systems (Berkes et al., 2003). Managing these altered environments requires departing from traditional restoration, as novel-ecosystem thinking cautions that returning to an exact historical baseline is often neither ecologically feasible nor desirable (Hobbs et al., 2006; Norton, 2018). Where functional replacement is pursued instead, evaluation shifts to whether ecological processes, local livelihoods, governance capacity, public safety, and system feedbacks can

together support a desirable future state, a shift that calls for its own theoretical vocabulary for what such a state actually requires. Grounded in Folke's (2016) distinction between incremental adaptation and systemic trajectory shifts, transformation theory supplies that vocabulary, emphasizing institutional memory, option diversity, authority-bearing governance, and cross-scale dynamics (Michaels et al., 2026).

Realizing such authority-bearing governance requires a far more precise treatment of community participation. In many cases, communities are informed, surveyed, or employed without gaining decision-making authority over closure objectives, land-use options, tenure, or benefit distribution, which is a structural weakness mirrored in Indonesian mining law (Putri, 2023). As such, this review maintains two analytical distinctions. Presence-authority addresses how much decision-making power communities hold, while response-authorship separates acting within a pre-selected trajectory from determining the closure choices that establish it. Communities can therefore possess strong downstream operational control while remaining excluded from upstream authorship.

This review examines how authority over post-mining land use is distributed in Indonesia, and what the scholarship reveals about who determines the trajectories that communities then live within. It maps governance frameworks, distinguishes observed Indonesian planning arrangements from recommended and internationally compared models, assesses the level of decision-making power communities hold, compares land-use pathways against social–ecological evidence, and tests alignment with international closure practice.

Review Design and Framework

Following the ROSES reporting standards for transparent, reproducible synthesis (Haddaway et al., 2018b) and the SIOC (Subject, Intervention, Outcome, Comparator) structure for framing the review question (Pullin & Stewart, 2006), this review conducted a systematic synthesis of evidence on post-mining land use and mine-closure governance in Indonesia. Specifically, the review addressed: *How is authority over post-mining land use distributed in the Indonesian literature, and to what extent do documented governance arrangements extend decision-making power to affected communities, integrate social–ecological and ecosystem-service evidence, and align with international best practice in mine closure?*

No review protocol was registered or published beforehand; the process is documented in Supplementary File 1 and follows ROSES standards. No external stakeholders were involved in formulating the question, screening, data extraction, or interpretation, and the author team conducted the review as an academic evidence synthesis.

Search Strategy

The study conducted searches in Scopus and Dimensions databases, primarily utilizing Scopus for peer-reviewed international literature and Dimensions to supplement open-access and interdisciplinary works (Hook et al., 2018). The search was performed in April 2026 and covered publications from 2000 to 2025, a window opening with the period over which Giljum et al. (2022) recorded mining-related deforestation and extending to the most recent complete publication year at the time of searching. Two parallel search strings were used. The English string combined post-mining and reclamation terms (including mine closure, rehabilitation, reclamation, restoration, revegetation, remediation, post-mining, ex-mining, abandoned mine, mine void, and pit lake) with an Indonesian geographic block. The Indonesian string paired equivalent domestic terminology (including *pascatambang*, *lahan bekas tambang*, *reklamasi tambang*, *rehabilitasi lahan*, *kolong tambang*, and *lubang bekas tambang*) with the same geographic block, ensuring that Indonesian-language scholarship indexed in Dimensions was captured rather than reached only incidentally through English keywords. Both strings are reproduced in full in Supplementary File 1.

Eligibility was limited to peer-reviewed journal articles published in English or Indonesian that addressed post-mining land use, reclamation, closure, or associated governance in an Indonesian context. From an initial yield of 2,431 records (507 from Scopus and 1,924 from Dimensions), 1,854 remained after deduplication for screening, conducted independently by four reviewers with conflicts resolved through blind review. Of 234 articles assessed at full text, five could not be retrieved and 128 were excluded, resulting in 101 primary studies, comprising 27 from Scopus and 74 from Dimensions (Figure 1). Exclusions at full text applied where a record duplicated a higher-priority entry, was itself a review or literature review, appeared as a conference proceeding, reported technical reclamation, remote-sensing, soil, or water outcomes without addressing governance, land use, or community roles, or aligned only weakly with the review's four objectives. No grey literature repositories were examined.

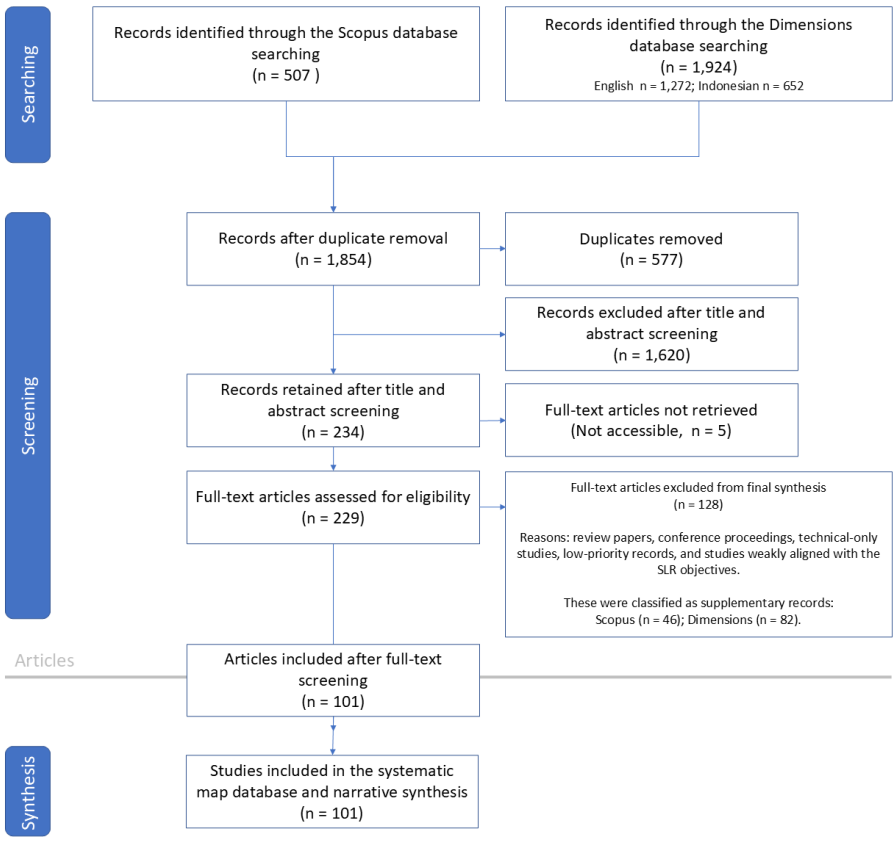


Figure 1. ROSES flow diagram of the study selection, adapted from Haddaway et al. (2018a).

Data Extraction and Coding

For each article, the authors first recorded standard bibliographic and classification details, including publication year, abstract, database source, region, commodity, study type, and method, before turning to the variables central to the review's objectives, i.e., governance framework, planning model, community engagement, social–ecological and ecosystem-service evidence, land-use pathway, and best-practice alignment. Case notes then captured whatever these categories could not. Each article received a single primary classification for region, commodity, method, observed planning model, engagement level, and land-use pathway, with secondary characteristics recorded separately. Observed Indonesian planning models were coded separately from recommended or internationally compared models and consolidated as centralized/top-down, consultative, participatory, hybrid/shared, community-led, or not stated. Community engagement was

coded on the seven-level scale (Table 1). Meanwhile, best-practice alignment was consolidated into strongly aligned, partially aligned, and weakly aligned or mostly divergent categories, based on early closure planning, community authority, ecological-livelihood integration, monitoring, tenure, financing, and handover. Where a study supported different engagement or alignment codes for different aspects of a case, the primary code reflects the activity or practice under examination, with the secondary reading retained in Supplementary File 1.

Table 1. Community engagement coding scale.

Level	Category	Interpretation
0	No engagement	No community presence or identifiable role.
1	Affected population	Communities appear as affected groups, beneficiaries, victims, or rights holders.
2	Information	Communities receive information or outreach but do not shape decisions.
3	Consultation	Communities provide opinions, perceptions, or local information.
4	Implementation	Communities implement activities while final authority remains external.
5	Shared governance	Communities share planning or management roles with other actors.
6	Community-led activity or management	Communities initiate, control, or substantially direct the activity or management arrangement examined; this does not automatically establish authorship of upstream closure decisions.

Results and Discussion

Structure and Biases of the Evidence Base

Between 2000 and 2025, the literature is heavily skewed toward recent years. Only six articles predate 2019, while 95 were published afterward, with 34 in 2025 alone (see Figure 2). This trend probably reflects the timing of publications in the dataset rather than indicating that policy issues or community impacts are new. Indonesian regulations linking academic promotion to Scopus-indexed publications, introduced in 2017 and reinforced in 2024, led to a noticeable increase in Indonesian-authored papers in this database from the late 2010s onward (Sujarwoto et al., 2025). This policy-driven increase inflates recent-year counts for searches like this one, regardless of whether the governance or community issues are actually recent.

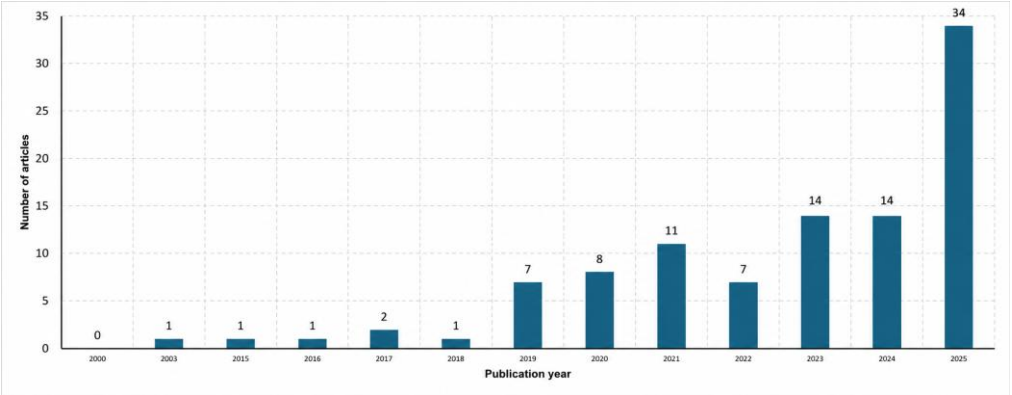


Figure 2. Temporal distribution of the selected articles.

The evidence base is similarly uneven in its sources and geographic coverage. Dimensions contributed 74 studies, compared with 27 from Scopus. Geographically, 43 articles focus on Sumatra or Bangka Belitung, and 27 on Kalimantan, with 16 classified as national or multi-region; the remaining 15 span Java (eight), Sulawesi (three), Maluku/Halmahera (two), and Papua (two) (Figure 3). Bangka Belitung studies center on tin legacies, kolong, tourism, and restoration (Aryanto et al., 2022; Herdiyanti et al., 2022), whereas Kalimantan studies focus more on coal reclamation, mine voids, and contested closure (Absori et al., 2021; Toumbourou et al., 2020). This concentration leaves key regions like Sulawesi, which is experiencing rapid mining under *hilirisasi*, among the least studied in the literature.

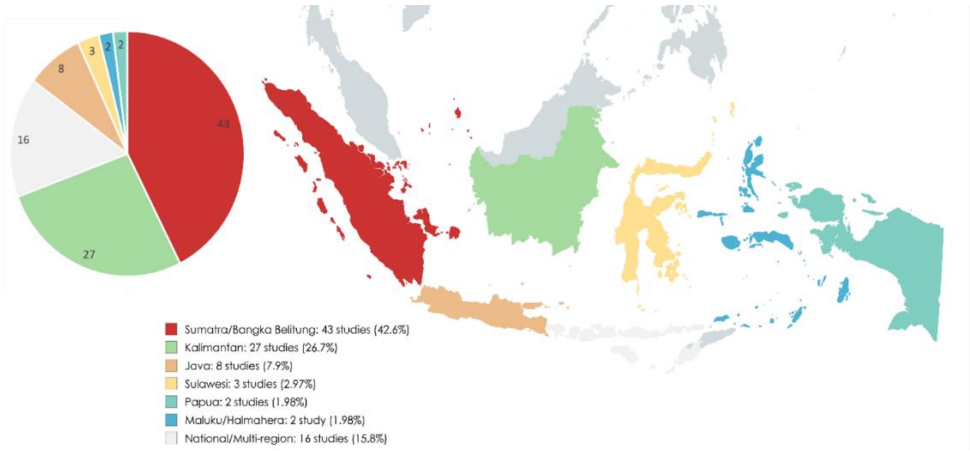


Figure 3. Geographical distribution of the reviewed articles.

Among commodities, coal appears in 38 articles and tin in 35, together accounting for 72.3% of the literature, while nickel, gold, copper-gold, iron ore,

and quarry cases remain sparse. Existing nickel literature offers technical reclamation assessments but not enough for robust comparison across closure stages (Kamarullah et al., 2025). This is partly a matter of timing. Coal and tin operations span the full mining lifecycle, from active extraction to long-abandoned sites, whereas most nickel operations remain mid-lifecycle, so closure-stage evidence for nickel simply does not yet exist for comparison. This concentration is not incidental and points to a temporal misalignment between the evidence base and Indonesia's changing mineral economy in the context of hilirisasi. Kalimantan coal and Bangka Belitung tin dominate the literature because their longer histories, with coal exploration beginning in the mid-19th century and tin mining in the 17th and 18th centuries (Friederich & van Leeuwen, 2017; Pratiwi et al., 2025) have produced the institutional memory that Michaels et al. (2026) treat as a marker of transformative capacity. Meanwhile, nickel shares none of it. To see why, it helps to look at what that vocabulary actually assumes. Coal's governance vocabulary formed around discrete forest permits, and tin's around a shift from corporate estates to *kolong* tourism. They both assume a single domestic operator responsible for extraction and reclamation alike. Nickel breaks that assumption. Instead, it is extracted through foreign-financed, vertically integrated smelting complexes with a different capital structure entirely (Ramadhani & Paksi, 2025), a chain of investors, processing contractors, and smelting operators whose respective closure obligations existing regulation does not clearly assign. Hyldmo et al. (2025) trace one consequence of that gap directly in Sulawesi, where licensing has recently been recentralized rather than adapted to local conditions, restricting local participation even as extraction accelerates under global energy-transition demand. Where no established, locally grounded governance vocabulary exists for nickel, central authorities appear to have filled the space by default. International experience underscores the stakes of this, as shown in the Ravensthorpe nickel case in Australia, which shows how an abruptly announced closure can produce lasting emotional dislocation and institutional distrust even where the decision is framed as economically rational (Pini et al., 2010), a warning Indonesia's still-forming nickel governance has yet to absorb.

This same imbalance appears in how the literature has been produced, not just in what it covers. Case studies and legal-policy analyses dominate the methodological distribution by a wide margin, followed by mixed or spatial assessments, surveys, and applied interventions, with environmental assessment the least common (Table 2). Together, the two leading methods

account for 61% of the literature, and both document conditions at a single point in time rather than test whether those conditions change across the stages of a mining project's lifecycle. A case study shows what happened at one site and moment, and a legal-policy analysis shows what a regulation requires on paper, but neither can establish whether authority actually expanded over time or on the ground. This leaves the kind of longitudinal evidence that could test whether nickel's governance vacuum closes over time, or persists, comparatively thin. It also explains the review's own contribution. The later discovery that just six out of 101 articles combine early planning, authority, ecological-livelihood alignment, monitoring, tenure, and financing is a tendency across the entire literature. This pattern only becomes clear when all 101 pieces are examined together, which is a kind of insight that a synthesis can provide but a single case study or legal analysis cannot.

Table 2. Methodological composition and primary evidentiary contributions.

Method category	Percentage	Primary contribution
Qualitative case study	30.7%	Participation, institutions, livelihoods, tourism
Legal or policy analysis	30.7%	Obligations, enforcement, liability, regulatory gaps
Mixed, spatial, or planning assessment	21.8%	Suitability, design, feasibility, integrated planning
Quantitative survey	6.8%	Perceptions, readiness, adaptive capacity
Applied community intervention	5.0%	Training, outreach, livelihood implementation
Environmental or biophysical assessment	4.0%	Ecological condition and reclamation
Other or unclear	1.0%	Hybrid evidence not assignable to one group

Governance, Planning, and Community Engagement

Mine closure and spatial planning are frequently discussed in the literature, but issues like land transfer, land banks, and redistribution are less often addressed (Table 3). This imbalance naturally aligns with what legal-policy scholarship typically studies best. Statutory duties are documented clearly with specific triggers and enforcement mechanisms, making them easier to record. In contrast, the fate of land and its benefits after a duty is fulfilled depends on decisions made across multiple institutions over an open-ended period, making it more difficult to trace and hold any single actor accountable. The existing literature mainly focuses on who has the duty of reclamation, as shown in Listiyani et al. (2023), but is less comprehensive on who controls the land after

the duty is discharged, a gap highlighted by Saputra et al. (2024) and Wardhani (2025) specifically in Indonesia's land-transfer regulations and Land Bank framework.

Table 3. Frequency of governance framework themes across the selected articles.

Framework	Articles	Main implication
Mining law and reclamation obligations	70	Defines compliance, plans, guarantees, and sanctions.
Collaborative or multi-stakeholder governance	52	Broadens actor involvement, but authority remains variable.
Regional authority and recentralization	48	Structures licensing, supervision, and local responsibility.
Environmental regulation and accountability	44	Links closure to pollution, safety, monitoring, and liability.
Customary, village, and community governance	40	Supports locally organized reuse and stewardship.
CSR and community development	33	Supports transition but may remain company-dependent.
Mine-closure planning	32	Translates obligations into proposed future uses.
Spatial, zoning, and land-use planning	25	Allocates land among tourism, farming, conservation, and other uses.
Tourism, heritage, and ecotourism governance	22	Creates cultural and livelihood value from former mines.
Abandoned-pit and environmental-risk governance	17	Frames unresolved sites as safety and accountability failures.
Land transfer, land banks, and redistribution	4	Determines post-mining access, control, and distributive outcomes.

This focus on compliance, however, does not indicate that Indonesia has built a similarly robust system for managing future landscapes either. While the literature covers permits and obligations extensively, it tends to neglect end-use selection, land transfer, monitoring finance, and post-reclamation authority. The 22 legal-policy articles later coded as lacking a specified end use (see the following subsection) are more than a residual category; they reflect a system in which procedural proof of obligation has superseded social and ecological outcomes as the final goal. Global mine-closure scholarship reveals the same pattern, showing that despite multi-domain risks (Laurence, 2006), regulatory frameworks consistently prioritize compliance duties over real-world stakeholder delivery (Bainton & Holcombe, 2018; Santos et al., 2025). The gap is also political, in that law can specify what a company must submit or fund without resolving what the landscape should become, for whom, or through whose knowledge. Framing remediation as a purely technical exercise obscures historical responsibility and environmental injustice (Beckett & Keeling, 2019), a problem compounded by the fact that severely altered ecosystems cannot

simply return to a single historical baseline (Norton, 2018). Because choosing among potential future states is inherently value-laden, technical feasibility alone cannot therefore substitute for genuine governance. Indonesian mine-closure plans may identify technically viable land uses while decision-making authority remains tightly held by regulators, corporations, and experts. Distributive questions regarding land transfer, land banking, and redistribution are consequently sidelined until procedural compliance has already dictated outcomes (Saputra et al., 2024; Wardhani, 2025).

Addressing this problem requires shifting from reclamation compliance to trajectory governance. While compliance merely asks whether mandatory tasks were checked off a list, trajectory governance asks whether ecological recovery, land tenure, financing, long-term monitoring, and handover were collaboratively decided and kept open to revision over time. This aligns with Norton's (2015) adaptive approach to environmental decision-making, in which sustainability is achieved through ongoing deliberation under uncertainty rather than fixed targets set in advance. For example, a site can satisfy narrow reclamation requirements while still causing water pollution or community displacement, just as profitable commercial reuse can mask unresolved long-term liabilities. Therefore, post-mining success must be judged by the continuity of the entire closure, reuse, and long-term care sequence, not by formal certification alone.

Planning arrangements tend to follow a similar pattern (see Table 4). Centralized, top-down approaches are most common, while community-led and participatory methods are less frequent. Hybrid or shared arrangements and consultative formats are seen as intermediate options. However, the term "hybrid/shared" mainly indicates the involvement of various actor types rather than an equal distribution of authority. Kristanti et al. (2020) highlight a multi-institutional reclamation process where strategic control remains external despite diverse participants. Likewise, consultative arrangements include local knowledge, but ultimate land-use decisions usually fall to companies, governments, or experts (Sutrisno et al., 2023; Yudo & Hernaningsih, 2020).

Table 4. Planning models across the reviewed articles.

Planning model	Articles (%)	Interpretation
Centralized/top-down	32 (31.7%)	State or company actors retain dominant planning authority.
Hybrid/shared	28 (27.7%)	Multiple actor types are involved; authority distribution varies.
Consultative	22 (21.8%)	Community input is sought, but final authority remains external.
Community-led	8 (7.9%)	Communities substantially direct the local activity or management arrangement.
Participatory	5 (5.0%)	Joint planning extends beyond consultation but is not clearly community-led.
Not stated	6 (5.9%)	The articles provide insufficient evidence to identify the observed model.

Community engagement, coded separately from the planning model on a 0-6 scale, operationalizes presence-authority, which reflects how much decision-making power communities hold, independent of when that power is exercised in the closure timeline. No article was coded at Level 0. Twenty-one articles (20.8%) fall at Levels 1-2, 58 (57.4%) at Levels 3-4, and 22 (21.8%) at Levels 5-6, appearing mainly as consulted parties (29) or implementers (29). Even the Level 5-6 articles indicate shared or community-led roles in the specific activity examined rather than verified authority over site-level closure outcomes. This is precisely why the review tracked planning model and engagement level as separate variables rather than folding them into one scale, since the two describe different facts about a case. A case may be hybrid because several organizations participate while community authority remains confined to implementation, while a locally initiated tourism activity may be community-led within an otherwise centralized regulatory system.

This concentration at consultation or implementation reflects a broader pattern in participation theory. Kemp et al. (2011) distinguish distributive justice from procedural and interactional justice, arguing that meaningful dialogue differs fundamentally from time-limited consultation and that equity requires power-aware processes and organizational mechanisms that work in practice, not just the fact of a meeting having occurred. Arnstein's (1969) ladder of participation names this same distinction more precisely. Informing and consultation sit near the bottom of the ladder, one rung above nonparticipation, while partnership, delegated power, and citizen control occupy the top. The 29 articles coded as consulted and the 29 coded as implementers (the two largest categories in this review's own data) correspond almost exactly to Arnstein's

lower and middle rungs. This does not contradict the earlier finding that many arrangements formally involve multiple actors, since Arnstein's whole point is that involvement without redistributed power is precisely what the lower rungs look like. Multi-actor participation and low-rung tokenism are not mutually exclusive; the pattern in this review shows they routinely coexist.

Jurisdictional asymmetry compounds this problem along a different axis. Central agencies retain primary authority over licensing and closure approvals, the upstream decisions this review treats as the threshold for authorship, while provincial, district, and village institutions inherit unsafe pits, degraded landscapes, and long-term management liabilities once a mining company's obligations lapse. The two levels of government (local and central) are not equal partners in addressing a problem; one decides, and the other absorbs the consequences. In Indonesia, recentralized state authority routinely coexists with localized risk and fiscal exposure in exactly this pattern (Jamin et al., 2023; Toumbourou et al., 2020), meaning the response-authorship gap already documented at the community level recurs inside government itself.

Post-Mining Pathways and Social–Ecological Evidence

Nine distinct post-mining land-use pathways were identified in the literature. The most common among them are tourism, ecotourism, geotourism, or heritage uses, accounting for 25 articles. Next are legal or policy planning without a specific end use (22 articles), forest rehabilitation or conservation (18), abandoned or unresolved landscapes (13), livelihood diversification and community enterprises (11), agriculture or agroforestry (4), aquaculture, fisheries, or mine-void use (4), settlement or integrated landscape reuse (3), and renewable energy or industrial reuse (1). These counts reflect research focus rather than pathway success, although the largest groups indicate some operational implementation. Tourism, the largest group, demonstrates strong community involvement (Anggrainy et al., 2023; Aryanto et al., 2022), even when permit or land status remains unresolved. In contrast, forest rehabilitation shows a different trend, with significant vegetation and soil recovery reported in a Papua tailings landscape, but ecological control remains uncertain, and Indigenous participation is mainly at the implementation stage (Yoom et al., 2025). A hybrid forest-governance model has been proposed but remains largely theoretical elsewhere (Saining et al., 2025).

Further along this distribution, smaller pathways for productive reuse reveal trade-offs that a single label might conceal. For example, post-mining

agriculture in East Kalimantan scored highly on infrastructure and economic factors but only moderately on ecological and legal aspects (Ansahar et al., 2025). Similarly, North Kalimantan's aquaculture in a coal void required treating suspended solids, phosphate, ammonia, and lead to meet technical conditions (Christian et al., 2023). Another pathway, livelihood diversification, shows different trade-offs. Cases driven by local agency demonstrate greater independence in farming, fish cultivation, and enterprises, supported by social capital (Herdiyanti et al., 2022, 2025). In contrast, some corporate social responsibility (CSR) cases grouped under this pathway still involve company control over program design or funding (Nurhayati et al., 2020; Triwibowo, 2021).

These livelihood and tourism pathways most clearly show the community-led activities highlighted by the review, which are not just reactive. Tourism, agriculture, and diversification of livelihoods demonstrate genuine adaptive capacity, leveraging the social–ecological memory held by village governments, village-owned enterprises (BUMDes), tourism awareness groups (Pokdarwis), cooperatives, and informal networks after disturbances (Anggrainy et al., 2023; Fitrianto et al., 2024; Herdiyanti et al., 2022, 2025). Folke's (2016) distinction remains relevant here, in that adaptation keeps development on the same trajectory, whereas transformation signifies a complete change. Local adjustments, therefore, are necessary but do not necessarily indicate a change in governance, as communities can absorb disruptions and achieve real outcomes within existing power structures—without influencing land control, tenure, or closure decisions. Often, local initiatives act as interim solutions for insecure land tenure and unclear closure pathways, forcing communities to create value on degraded land while bearing unearned liabilities. This directly raises Folke's (2016) resilience questions about *what*, to *what*, and for *whom*. When livelihoods adapt, but land ownership and decision-making stay static, such adaptation can unintentionally reinforce existing inequalities.

The same principles apply at the institutional level. International research on mining-town normalization, drawing on cases from Australia, Canada, and South Africa, shows that when responsibilities for maintenance, monitoring, and safety shift to local governments or communities lacking sufficient budgets and capacity, the formal transfer often results in fiscal displacement (Cheshire et al., 2014; Marais et al., 2018). This means the obligation is only on paper, with the real costs falling on the new inheritors of the site. CSR initiatives in the literature demonstrate a similar pattern from another perspective: many cases remain

company-managed and financially reliant, causing community engagement to typically fade once project funding ceases (Nurhayati et al., 2020; Triwibowo, 2021). These same institutions, the village governments, BUMDes, and informal networks that earlier enabled real adaptive capacity, are exactly what Michaels et al. (2026) treat as markers of institutional memory and option diversity, the raw material of transformative capacity. Yet the recurring pattern across all three examples above (adaptation without power transfer, handover without capacity, engagement ending with funding) shows why that raw material remains only a marker of potential rather than evidence of actual structural change.

At the opposite end of the pathway distribution is the abandoned or unresolved pathway, which clearly indicates ongoing governance failures. Out of its 13 articles, nine are classified at Level 1, meaning communities are only seen as affected populations suffering from unsafe pits, fatalities, weak oversight, and unresolved illegal mining responsibilities, rather than actively participating at any stage (Absori et al., 2021). Two articles are at Level 2, one at Level 3, and only one reaches Level 5. Nevertheless, even this exception does not fully break the pattern. The only Level 5 case involves civil-society activism influencing provincial regulation, yet the unsafe pits, unresolved responsibility, and weak oversight documented across this pathway persisted at the site level regardless (Toumbourou et al., 2020). Even the pathway's strongest instance of community influence, in other words, changed policy on paper without changing conditions on the ground.

Across the pathways discussed above, social–ecological indicators are documented extensively but rarely connected to one another. Livelihood recovery appears in 74 articles, water quality in 48, cultural identity in 47, forest recovery in 37, and biodiversity in 36, but these are typically reported side by side rather than linked through causal analysis. A single study may report vegetation recovery, livelihood activity, and community participation simultaneously without showing how progress in one domain drives, or depends on, change in another. Barnaud et al. (2018) explain why this matters, since ecosystem services are social interdependencies between providers and beneficiaries rather than isolated ecological metrics, so presenting indicators side by side risks concealing who actually benefits and who bears the cost. The reviewed literature illustrates this disconnect in three distinct ways. Ansahar et al. (2025) find economic readiness outpacing ecological compliance; Christian et al. (2023) find technical feasibility saying nothing about community

preferences; and Yoom et al. (2025) find measurable environmental recovery revealing nothing about who holds authority over a project's endpoint. That endpoint, Norton (2018) argues, is itself a choice rather than a fixed target, because severely degraded landscapes may be better managed as novel ecological states than judged against an unachievable historical baseline. This makes deliberate attention to trade-offs and beneficiaries more important, as labels like restored or sustainable can otherwise obscure the decisions embedded in a chosen endpoint.

The review's own best-practice criteria, distinct from but related to Michaels et al.'s (2026) framework, show the same pattern of isolated components. Six articles demonstrate strong alignment, 83 partial alignment, and 12 weak or divergent alignment. Using Michaels et al.'s (2026) transformative capacity framework, the Indonesian literature often addresses institutional memory and option diversity, but underrepresents authority-bearing governance and long-term feedback. Most studies address individual components, such as early planning, authority, ecological-livelihood balance, monitoring, tenure, financing, and handover, but few integrate them together. Closing this integration gap starts with how monitoring itself is conceived. Framed as iterative learning rather than a static compliance record, monitoring becomes the adaptive process (Norton, 2015) through which transformative capacity can actually be built over time, rather than assumed to already exist. That kind of monitoring does specific work. It traces who provides ecosystem functions and who bears the cost of maintaining them (Barnaud et al., 2018), the same accounting Beckett and Keeling's (2019) *relations of care* framework asks for. Without it, visible land reuse can be mistaken for a durable transition.

Conclusions

Indonesian post-mining research depicts an institutionally plural landscape still organized primarily around regulatory compliance, creating a fundamental disconnect between formal reclamation duties and the collectively governed trajectory that follows. Although community engagement is widely documented through land restoration, livelihood diversification, and local tourism, it functions overwhelmingly as late-stage consultation or downstream implementation. This demonstrates genuine adaptive capacity without conferring authority over the upstream decisions that define closure objectives, directly illustrating the response-authorship gap where local adaptation expands without altering underlying governance structures. This governance deficit is, furthermore, unevenly distributed across Indonesia's mineral

geography. Coal and tin governance assumes a single domestic operator responsible for both extraction and reclamation, an assumption that nickel's foreign-financed, vertically integrated extraction model does not fit, leaving rapidly expanding nickel frontiers under *hilirisasi* without the governance vocabulary or institutional memory that coal and tin have accumulated.

Synthesizing 101 studies across governance, planning, engagement, and social–ecological outcomes gives the response-authorship gap an empirical foundation that no single case study could establish. That synthesis reveals a second pattern invisible at the level of any individual study: components such as early planning, authority, monitoring, tenure, and financing are routinely documented in isolation rather than integrated, with only six of 101 studies achieving full alignment across them. That foundation has its own limits, however. Reliance on peer-reviewed literature in English or Indonesian underrepresents grey literature such as corporate plans and community records, and the evidence base itself remains concentrated in mature coal and tin regions, leaving nickel comparatively thin. A further limit lies in the coding itself. Because activity-level coding measures authority within specific tasks rather than participation timing across the mining life cycle, documented engagement counts reflect an upper bound on shared roles rather than confirmed upstream authorship.

However, these limitations do not undercut the review's central finding on nickel. Closing that evidence and governance gap requires future research to prospectively track nickel regions from operation to closure across regional scales, while policy must condition closure approvals on identified end-users, recognized decision rights, secure land tenure, long-term financing, and enforceable handovers. Ultimately, research and policy must shift from documenting how communities adapt to post-mining landscapes toward explaining how socially legitimate, ecologically functional, and durable trajectories can be jointly authored before Indonesia's nickel frontier repeats the compliance-driven patterns established in coal and tin.

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