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Indonesia's $100B Mineral Pivot to Advance Green Mineral Policy: Strengthening ESG Standards in Sustainable Green Mineral Supply Chain with Five ESG Reforms

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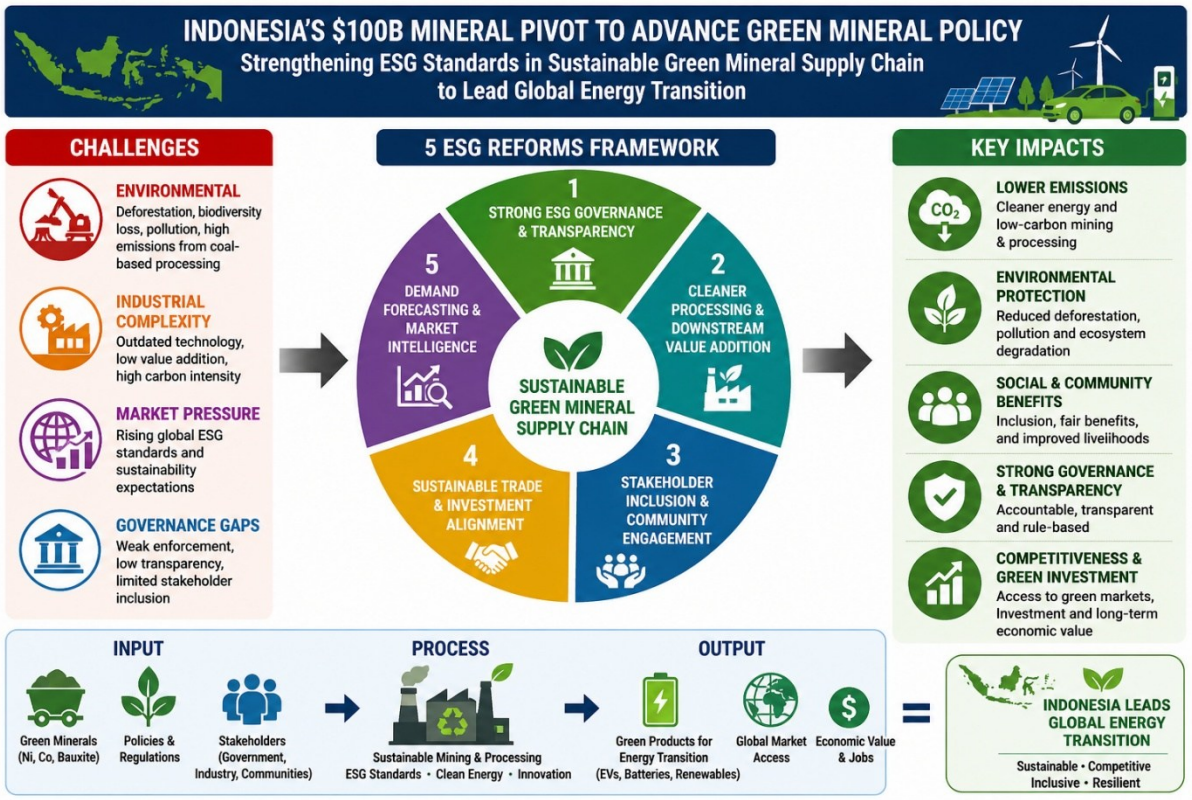
GRAPHICAL ABSTRACT



HIGHLIGHTS

- Indonesia faces environmental, industrial, and governance gaps in mining
- ESG policies improve competitiveness in global battery supply chains
- Five-pillar framework integrates governance, industry, and stakeholders
- Cleaner processing reduces emissions in mineral value chains
- Policy alignment strengthens sustainable investment and market growth

ABSTRACT

Green minerals such as nickel, cobalt, and bauxite are central to the global energy transition, supporting the deployment of electric vehicles, renewable energy systems, and low-carbon technologies. However, rapid expansion of mineral extraction without robust environmental, social, and governance (ESG) safeguards risks undermining sustainability objectives and investor confidence. Indonesia, which contributes a substantial share of global nickel supply, occupies a strategic position in emerging battery value chains, yet its continued reliance on coal-based processing raises concerns regarding lifecycle emissions and long-term competitiveness in ESG-sensitive markets. This study examines Indonesia's evolving green mineral strategy through qualitative policy analysis, stakeholder mapping, and benchmarking against international frameworks, including the Initiative for Responsible Mining Assurance (IRMA), the Extractive Industries Transparency Initiative (EITI), and OECD Due Diligence Guidance. The analysis identifies key structural challenges spanning environmental degradation, industrial complexity, shifting global market expectations, and governance gaps. In response, a five-pillar policy framework is proposed, focusing on: (1) strengthening ESG governance and transparency; (2) advancing downstream

value addition through cleaner processing pathways; (3) enhancing stakeholder inclusion and community engagement; (4) aligning trade and investment policies with sustainability requirements; and (5) improving demand forecasting and market intelligence to support long-term planning. Drawing on indicative case evidence from major nickel-producing regions, the study highlights the environmental and social pressures associated with current mining practices and explores policy scenarios under different energy and regulatory pathways. The findings suggest that improved ESG alignment, combined with a gradual transition toward lower-carbon processing and more coherent governance, could enhance Indonesia's ability to attract sustainable investment, reduce environmental risks, and strengthen its position in global mineral supply chains. Overall, the paper contributes an integrated policy framework that contextualizes global ESG standards within Indonesia's mineral sector, offering insights for resource-rich economies seeking to balance industrial development with environmental stewardship and evolving market expectations.

Keywords: Sustainable mineral governance; Indonesia nickel industry; ESG in mining supply chains; Green mineral policy; Energy transition minerals; Low-carbon mineral processing

1. Key Issues in Indonesia's Transition Mineral Sector: Mineral Boom Risks Undermining Indonesia Net-Zero Goals - Forest Lost and Nickel Smelters Powered by New Coal Plants

Indonesia's mineral sector faces four interconnected challenges threatening its sustainable growth: significant environmental damage from nickel mining, complexity due to outdated industrial processes, global market shifts demanding higher ESG compliance, and critical governance gaps undermining regulation enforcement (Figure 1). Addressing these systematically is vital for Indonesia to remain competitive, attract green investment, and fulfill its net-zero ambitions.

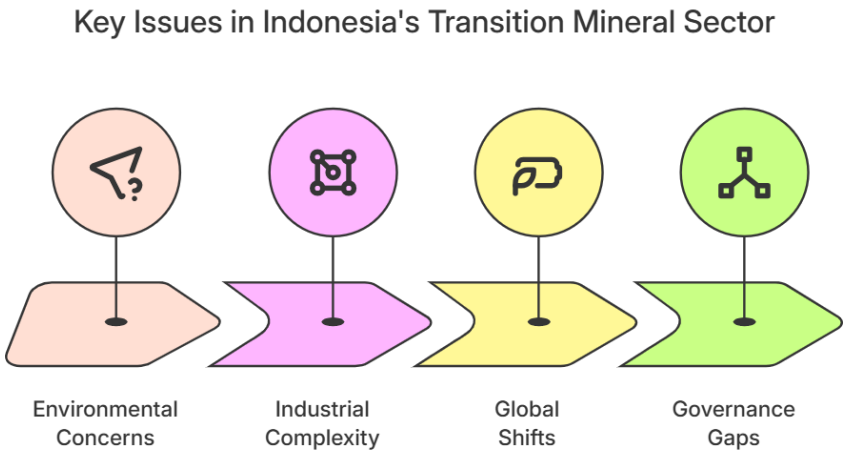


Figure 1. Resolving Indonesia's four critical mineral challenges could unlock sustainable value and green investment opportunities.

1.1. Environmental Concerns

Indonesia's push to supply battery metals has come at a heavy ecological price. Large-scale nickel projects have destroyed tropical forest and polluted waterways. For example, the Weda Bay Industrial Park in Halmahera cleared over 5,300 hectares of

forest and “polluted the rivers and sea,” forcefully displacing Indigenous communities [1]. IUCN reports that deforestation around new nickel plants is roughly double the national average, harming coastal ecosystems and coral reefs [2]. Mining wastes and tailings dams have repeatedly failed, releasing toxic heavy metals into rivers and threatening public health [3]. Such impacts – on forests, fisheries and freshwater – directly undermine the region’s rich biodiversity and local livelihoods. It is important to note that nickel mining is extremely land-intensive, “leading to deforestation, displacement of communities, and potential contamination of soil and water” [4].

- **Deforestation and Biodiversity Loss.** Indonesia’s nickel boom is slicing through primary forest, especially in Sulawesi and the Moluccas. The Halmahera project alone cut 5,331 hectares of forest [1], threatening species-rich habitats. IUCN notes that twice as much forest vanishes near processing plants as elsewhere [2].
- **Pollution of Water and Air.** Smelters and mining operations dump untreated waste into rivers and coastal waters, killing fish and eroding water quality. For example, villagers report poisonous “red water” from tailings dam failures at Morowali Industrial Park, exposing hundreds to toxins [3]. Air pollution from coal-powered refineries adds toxic dust and greenhouse gases. Innovative remediation approaches, such as ligand-based composite materials for selective heavy metal removal [5], demonstrate the potential for low-cost technologies to mitigate water contamination from mining operations.
- **Community Displacement and Social Impact.** Large projects often proceed without free, prior and informed consent. Locals around Weda Bay say companies coerced land sales at the point of a gun [1]. An investigative report found communities forcibly “displaced” and left without legal recourse [6, 7]. Such rights abuses further degrade traditional livelihoods (farming, fishing) and spark conflicts, deepening the social toll of mining.

1.2. Industrial Complexity

Indonesia’s transition-mineral strategy also faces tangled industrial and regulatory challenges. The country has imposed an export ban and is building dozens of smelters to capture more value, but many facilities use outdated, coal-heavy technologies [8-10]. For instance, the Weda Bay smelter complex is served by over a dozen new coal-fired power plants [6], making “clean” battery nickel among the world’s most carbon-intensive. Weak regulation has allowed multiple dam collapses at Indonesian nickel sites, indicating poor industry standards [3]. It is thus important to analyze “processing technologies” and “regulatory landscapes” that is central to understanding these dynamics.

- **Fragmented Regulations.** Indonesia’s mining laws have flipped several times, creating uncertainty. Recent amendments even allow universities and religious bodies to get mining permits without auction [11], raising concerns about conflicts of interest. Although Law No. 3/2020 shifted licensing toward the central government to improve oversight, local permits are still common – over 10,000 small-scale licenses were granted by districts, often with minimal controls. Such fragmentation makes coherent policy enforcement difficult [12].
- **Outdated Processing Technologies.** Most domestic refining remains relic of the past. Nickels are processed via high-pressure acid leach (HPAL) smelters

that burn coal, rather than cleaner methods. New tailings facilities have failed catastrophically [3], showing that engineering standards lag global best practices. Advanced refining (for EV-grade nickel sulfate) is only just emerging, so Indonesia risks surrendering the highest-value segments of the value chain.

- **Limited Domestic Value Capture.** Despite policy mandates to "downstream" minerals [13, 14], much Indonesian nickel still flows abroad as semi-processed ore. Export bans have boosted smelter output (metal ore mining grew ~20–22% per year in 2020–2022) [14], but local manufacturing of batteries or finished components are still relatively new. In practice, technology and capital are often provided by foreign (especially Chinese) firms, so Indonesia may reap royalties more than high-value knowledge or products.
- **Barriers to Upgrading.** The sector struggles to upgrade due to skill gaps and infrastructure limits. Power shortages, logistics bottlenecks and an uneven regulatory mix (e.g. overlapping rules from mining, environment and investment agencies) slow new projects. For example, Indonesia recently imposed a moratorium on new smelters to avoid an ore surplus [15], but this also complicates investment plans. In short, navigating the policy and technical confusion to move beyond bulk processing is a major hurdle.

1.3. Global Shifts

Worldwide demand for "green" minerals is reshaping Indonesia's trade and investment landscape. As global EV adoption surges, nickel's importance in batteries has shot up [2, 4]. Indonesia today supplies roughly half of the world's mined nickel [4, 6], making it a swing producer for clean-tech supply chains. Yet buyers and financiers are also demanding ethically sourced, low-carbon supply: U.S. and EU policies (tax credits, carbon-adjusted tariffs) will favor suppliers with high ESG standards. Global OEMs like Tesla, Volkswagen and Ford, which source Indonesian nickel, are under pressure to ensure their minerals come with minimal deforestation and pollution [6]. Therefore, it is essential to "keep up with demand trends" in EV batteries and stainless steel [2], reflecting these global pressures.

- **Surging EV Battery Demand.** Forecasts predict global nickel demand rising ~60% by 2040 on clean-energy demand [2, 6]. This puts Indonesia in a lucrative spot – if it can meet buyers' expectations.
- **Ethical and Decarbonization Requirements.** Major markets now insist on transparent supply chains. The EU battery regulations and U.S. incentives effectively penalize carbon-intensive or deforestation-linked ores. NGOs and investors note Indonesia's coal-dependent smelters and forest loss, urging companies to demand sustainable practices [4, 6]. Indonesia's competitiveness hinges on improving its ESG record; otherwise, European and North American buyers may seek alternatives.
- **Trade and Price Volatility.** Indonesia's export bans and smelter build-out have flooded the market, driving prices down and prompting export moratoria [15]. This policy backfire (a WTO challenge argued it was not truly "downstreaming" [13]) illustrates how Indonesia's global strategy must balance growth with market stability. In sum, global shifts favor Indonesia's resources but penalize its current practices. Adapting to these expectations will be crucial.

1.4. Governance Gaps

Indonesia's mineral transition is also hampered by governance limitations. Agencies often send mixed signals: for instance, the president champions zero-emission tech, yet regulations let smelters build new coal plants to power nickel refineries [16]. Mining law amendments are sometimes rushed (e.g. a 2025 package passed in one day [11]), undermining scrutiny. Coordination between national and provincial authorities remains weak – while the 2020 law centralised mining permits [12], regional governments still control many issuance and monitoring functions. Stakeholder engagement is very limited: communities report that projects proceed without proper consultation, violating consent norms [1].

- **Policy Inconsistency.** Climate pledges and industrial policies frequently clash. For example, a 2022 presidential regulation promoting "nationally strategic" industries has effectively allowed unlimited captive coal plants alongside refineries [16]. Civil society warns that such loosened standards contradict national climate goals [6, 11]. Frequent legal changes (new Mining Law, Omnibus Law updates) create uncertainty and erode trust.
- **Fragmented Authority.** Oversight of mining and environment is split among multiple ministries and levels of government [17, 18]. The Energy Ministry, Environment Ministry, Investment Board and local governments all have roles, often without strong coordination. As a result, monitoring is spotty: for example, Indonesia's mining law assigns land-licensing roles in principle to Jakarta [12], but in practice thousands of local "IUP" permits proliferated, many unexamined by national regulators.
- **Weak Public Participation.** Laws require community consent, but implementation is poor. Reports from Halmahera show that villagers were "not informed" about projects and had no real negotiation power [1]. It is important to analyze "stakeholder" dynamics, underscoring this gap. Without robust grievance mechanisms or NGO involvement, communities have little voice, fueling conflict and human rights concerns.
- **Enforcement and Transparency.** Corruption and rent-seeking persist. Amendments that allowed universities and religious organizations to enter mining raised alarms about insiders gaining favors [11]. Regulators often lack capacity or will to enforce environmental standards – as seen in repeated dam collapses [3] and unmitigated deforestation. Reform advocates argue for much stronger institutions and accountability if Indonesia's mineral wealth is to support a true green transition [6, 11].

Beyond regulatory fragmentation, the political economy of Indonesia's mineral sector shapes how ESG standards are applied—or circumvented—in practice. Large-scale Chinese investment, which has financed and operates many nickel smelters, often comes with vertically integrated supply contracts and project timelines negotiated at the national level, bypassing local oversight. This can weaken enforcement of environmental and social safeguards if host agencies are under pressure to maintain investment flows. Elite capture further complicates reform, as politically connected conglomerates and figures with military or security backgrounds hold significant stakes in mining ventures and associated infrastructure. In some cases, these actors influence permit allocation and regulatory decisions, creating conflicts of interest and shielding non-compliant operations from penalties. Such dynamics underscore that

ESG enforcement is not solely a technical challenge but also a political one, requiring governance reforms that address vested interests and improve transparency in ownership and decision-making.

2. Policy Recommendations: Green Mining Reform Could Unlock $100B in Added Value - 5 Bold Policy Moves to Make Indonesia's Mineral Strategy ESG-Compliant and Globally Competitive

The $100B represents a strategic estimate of the potential cumulative economic value that Indonesia could unlock by 2040 through sustainable industrialization of its transition mineral sector. This projection is grounded in several converging trends: Indonesia's nickel-related exports alone surged to over $33 billion in 2022, up from just $1 billion in 2015, indicating rapid value growth driven by downstream investment in EV batteries and processing [19-21]. With global demand for key minerals like nickel, cobalt, and bauxite expected to rise four- to six-fold by 2040, according to the International Energy Agency (IEA), Indonesia is well-positioned to capture a significant share of the expanding clean energy supply chain [22-24]. Additionally, aligning with ESG standards could unlock billions in green finance and foreign direct investment, further boosting the sector's long-term value. If Indonesia successfully scales value-added processing, green branding, and policy alignment, the combined export revenue, industrial output, and sustainable finance flows could realistically approach or exceed $100 billion by 2040.

This $100B estimate is based on a composite methodology integrating (i) historical growth rates of nickel-related exports (2015–2022) and International Energy Agency projections for mineral demand through 2040, (ii) modeled downstream value addition from expanding domestic refining and battery manufacturing capacity, (iii) projected foreign direct investment inflows assuming sustained fiscal incentives and regulatory stability, and (iv) potential "green premiums" of 5–10% for ESG-certified minerals in line with EU and U.S. clean energy market trends. Price assumptions draw on consensus nickel price curves from CRU and World Bank forecasts, while investment estimates use a blended growth model referencing UNCTAD FDI data for extractive industries. The calculation represents a cumulative value potential rather than an annual figure, illustrating the long-term economic opportunity if the recommended reforms are implemented in full.

Indonesia's mineral strategy centers on five interconnected policy reforms designed to drive sustainable and inclusive growth (Figure 2). By strengthening ESG governance, boosting industrial capabilities, enhancing stakeholder engagement, aligning trade policies with sustainability, and continuously monitoring market dynamics, Indonesia can unlock billions in green investments, significantly cut environmental impacts, and secure its competitive advantage in global green mineral markets.

Figure 2. Five bold policies could deliver a sustainable mineral industry for Indonesia, cutting emissions and attracting global ESG investments.

2.1. Strengthen ESG Governance in Mineral Supply Chains

To ensure mining is sustainable, Indonesia should mandate strict ESG compliance in mineral contracts and licenses. For example, policies can require alignment with international standards like the OECD Due Diligence Guidance and IRMA certification, and integrate EITI-style transparency (e.g. public reporting of revenues, licensing, and beneficial owners [25]). Specific measures could include:

- **Mandatory ESG Reporting & Audits.** Require mining and processing companies to publish third-party audited ESG data (e.g. emissions, tailings management, labor practices) on a publicly accessible platform. Incentivize compliance through tax breaks or expedited permitting, and impose penalties for non-compliance. Stakeholders urged "mandatory ESG disclosure and a ban on marine tailings disposal" to secure a sustainable supply chain [25].
- **FPIC and Community Monitoring.** Institutionalize Free, Prior and Informed Consent (FPIC) for Indigenous and local communities before new projects proceed, and establish community-led monitoring mechanisms (e.g. training local monitors, citizen scorecards). Commitments to land rehabilitation funds and benefit-sharing should be enforceable conditions in permits [25].
- **Public Transparency Platforms.** Expand digital tools (e.g. the Minerba One Data system) to track mineral flows and mine-site data in real time, enabling civil society and investors to audit compliance. Disclosure of contracts and mining data (following EITI's multi-stakeholder model) will build trust. Indonesia's multi-stakeholder EITI group – hosted by the Energy Ministry and comprising government, industry and civil society – is a good model [26].

Emerging digital technologies can significantly strengthen ESG compliance by enabling continuous, data-driven oversight. Similar bio-inspired and AI-driven approaches have already demonstrated superior forecasting capabilities in renewable energy applications, such as wind power prediction [27], suggesting their potential applicability in ESG monitoring for mining supply chains. Indonesia could pilot AI-powered ESG dashboards that integrate satellite imagery, IoT sensor data, and public reporting to track key indicators such as deforestation rates, tailings dam stability, water quality, and labor conditions in near real time. For example, satellite-based forest loss alerts—already deployed in palm oil monitoring—could be adapted to mining zones, triggering immediate investigations when land clearing exceeds permitted limits.

Machine learning algorithms could also be trained on historical compliance data to predict high-risk sites for environmental or social violations, allowing regulators to prioritize inspections. Evidence from other domains, such as cancer diagnostics, shows that hybrid meta-heuristic algorithms can greatly improve prediction accuracy [28], suggesting their potential application for anticipating ESG compliance risks in mining projects, though not yet validated in mining ESG contexts. By integrating these tools with platforms like Minerba One Data and making selected datasets publicly accessible, Indonesia can improve transparency, foster investor confidence, and enhance the capacity of both regulators and civil society to monitor ESG performance.

2.2. Boost Downstream Industrial Capabilities

Indonesia should aggressively attract investment in mineral processing, batteries and EV components by using a mix of fiscal and non-fiscal incentives. A recent UNCTAD analysis notes that Indonesia's nickel strategy succeeded "not only from our export ban on nickel ore, but also a combination of different fiscal and non fiscal incentives to attract investment on the refining and processing of nickel" [29]. To replicate this success across other minerals, policy tools can include:

- **Targeted Tax/Investment Incentives.** Extend and tailor tax holidays (up to 100% corporate tax relief for 10–20 years), VAT/duty exemptions on imported capital goods, and local tax abatements for investors building smelters, precursor plants or battery factories. Link incentives to concrete outcomes, e.g. staged payments when production or export targets are met.
- **Special Economic Zones & Industrial Parks.** Fast-track development of integrated mineral parks (as in Morowali, Weda Bay, KIPI, etc.) close to mine sites and ports to cut logistics costs [29]. Provide plug-and-play infrastructure (electricity, roads, port access) and one-stop-shop permitting to reduce entry barriers. Blend public equity or concessional loans (through state-backed funds or development banks) with private capital to de-risk large projects.
- **R&D and Skills Development.** Create public–private partnerships to fund R&D on advanced refining, battery chemistries and steelmaking technology. For instance, grant matching funds to universities and technical institutes for battery material research, and establish centers of excellence in collaboration with foreign partners. Expand vocational training and apprenticeship programs (e.g. via BLKs and polytechnics) to build local expertise in smelter operation, battery assembly, and EV manufacturing.

2.3. Enhance Stakeholder Coordination and Engagement

Indonesia needs a formal multi-stakeholder platform for critical minerals, ensuring government, industry, civil society and Indigenous representatives collaborate on policy. One model is Indonesia's EITI Multi-Stakeholder Group – chaired by the Energy Ministry – which brings together all these actors [26]. Recommendations include:

- **National Minerals Forum.** Establish a permanent "Green Minerals Council" under a coordinating ministry (e.g. Maritime/Investment or ESDM) that meets regularly with the private sector, local governments, NGOs and traditional community leaders. This forum would review policy implementation, share data (e.g. production figures, permits), and quickly resolve disputes. It should include youth and women's groups to ensure inclusive voice.
- **Capacity Building for Local Authorities.** Allocate resources for training district and provincial officials in environmental permitting, monitoring, and conflict resolution. For example, partner with UNDP or universities to conduct workshops on the new mining regulations, community grievance handling, and use of digital tools like the Minerba Monitoring System [25]. Strengthening subnational agencies will help prevent backlogs and ensure consistent enforcement.
- **Community Engagement & Benefit-Sharing.** Mandate that companies negotiate legally binding benefit-sharing agreements (e.g. royalties, local infrastructure funds) with affected communities. Ensure that FPIC is enforced by law (not just policy) so Indigenous groups can veto harmful projects [25]. Use local liaison offices or ombudsmen to keep communication channels open and to monitor that social commitments are met.

Beyond procedural FPIC, safeguarding Indigenous rights in mining regions requires strengthening land tenure security and accessible legal redress mechanisms. Many Indigenous communities in areas like Weda Bay and Halmahera lack formal land titles despite generations of stewardship, making them vulnerable to uncompensated displacement. Policy reforms should therefore prioritize participatory mapping and formal recognition of customary land (tanah adat) within national land registries. In addition, independent grievance mechanisms—supported by legal aid and community advocates—are essential to ensure that affected groups can challenge unlawful expropriation or environmental harm. Integrating Indigenous knowledge systems into environmental management plans can also improve ESG outcomes, as these communities often possess detailed ecological knowledge on forest conservation, watershed management, and biodiversity protection. Embedding such knowledge into permitting, monitoring, and reclamation processes would both honor cultural heritage and enhance the sustainability of mining operations.

2.4. Align Trade and Investment Policies with Green Goals

Indonesia's trade and investment rules should actively promote "green" minerals and curb dirty supply chains. Key policy options:

- **Sustainability Clauses in Contracts.** Require that all new mining and processing contracts include enforceable environmental and social covenants (e.g. no deforestation, no dumping of untreated tailings, use of renewable energy). Tie export privileges (or tax breaks) to meeting ESG benchmarks. As one industry official noted, giving "preferential treatment for certified green

products" and linking "export benefits… to sustainability metrics" would reward producers that comply [30]. For example, exporters of nickel (or copper, cobalt, etc.) could get faster customs clearance or green tariffs if they meet a domestic "Green Nickel from Indonesia" certification.

- **Green Branding and Certification.** Develop an official "Green Nickel/Copper" label guaranteed by independent audit (as recommended by DNV and others [31]). This could be similar to carbon credit programs: for instance, exports of metals produced with ≥50% renewable energy could qualify for "green premium" pricing or be bundled into climate-finance deals. Publicize these schemes abroad so that global buyers and ESG investors can preferentially source Indonesian minerals.
- **International Trade Engagement.** Pursue bilateral agreements focused on sustainable minerals (e.g. the proposed US–Indonesia Critical Minerals agreement) that open market access for products meeting stricter environmental standards. Leverage trade policy to encourage clean energy exports (solar panels, EVs) from Indonesia, complementing the domestic push on batteries. Parallel advances in clean hydrogen technologies, such as CdS-based heterojunction photocatalysts for solar-powered water splitting [32], highlight how frontier innovations in renewable hydrogen production can complement Indonesia's green mineral strategy by expanding downstream clean energy markets.

2.5. Monitor Market Dynamics and Future Demand

Indonesia should create a dedicated observatory to inform policy with real-time market analysis. For instance:

- **National Research Unit.** Establish a technical team (within MEMR, Bappenas or a science institute) charged with tracking global trends in EV batteries, solar PV, smart grids, hydrogen, and low-carbon steel. This unit would regularly gather data (e.g. from IEA, industry reports, commodity price services) and model future demand scenarios. As the IEA projects, global demand for EV battery minerals could quadruple by 2040 [25], so forewarning will help planners adjust strategy.
- **Data-Sharing Platforms.** Expand one-data initiatives (like the Minerba One Data portal) to integrate new analytics and forecasts. For example, publish an open-access dashboard where anyone (government, investors, academia) can view current production, capacity, prices and demand forecasts. Incorporate modeling tools (demand–supply simulation, price elasticity models) that allow stakeholders to run "what-if" scenarios under different policy paths. This transparency will attract investment by giving confidence in Indonesia's planning and reducing market uncertainty.
- **Regular Reporting.** Mandate that this research unit issue periodic outlook reports (e.g. annual "Green Minerals Outlook") synthesizing global and domestic market intelligence. Distribute summaries to industry associations and financial regulators. By staying ahead of technological shifts and international policy changes (like carbon border taxes), Indonesia can adapt incentives and ensure its mining sector remains competitive.

In summary, the recommendations draw on Indonesia case studies and global best practices, including stakeholder dialogue findings and analyses of Indonesia's industrial incentives, as well as international frameworks (EITI, OECD, IRMA, IEA).

3. Expected Impact of Indonesia's Transition Mineral Green Industrial Strategy: Greening Indonesia's Minerals Could Cut 58% of Deforestation Impacts and Unlock Billions in Green Finance by 2040

Implementing Indonesia's green industrial strategy for transition minerals promises multiple reinforcing impacts, starting with enhanced investor confidence through robust ESG standards (Figure 3). This strategy supports substantial growth in domestic industrial value addition, significantly reduces environmental degradation—including cutting deforestation impacts by 58% [33] —and aligns strategically with Indonesia's ambitious 2060 net-zero emission target.

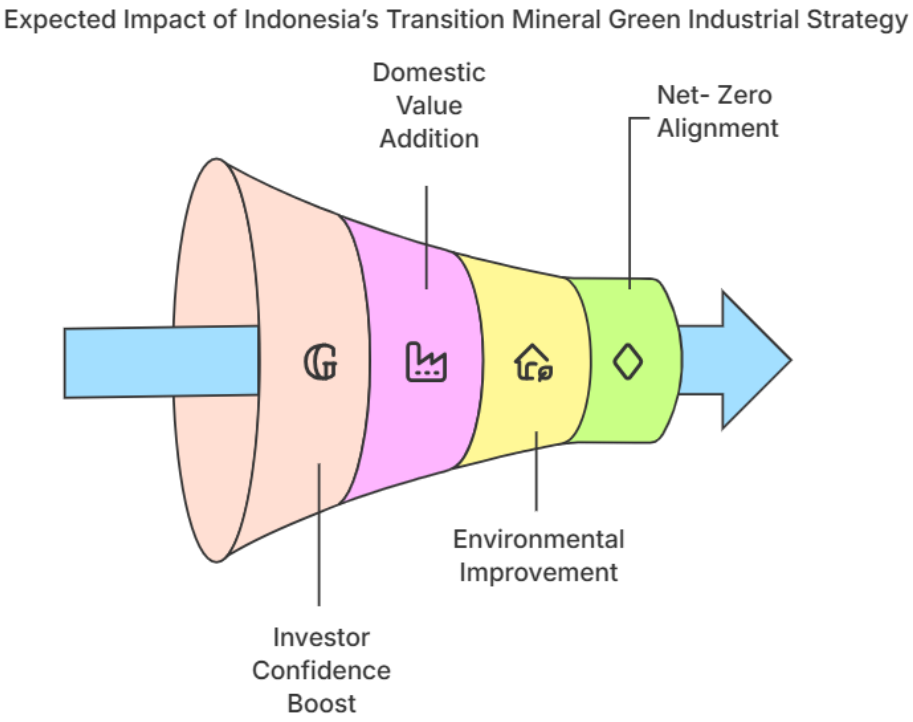


Figure 3. Indonesia's green mineral strategy can unlock billions in investment, cut environmental damage by 58%, and accelerate net-zero commitments.

3.1. Greater investor confidence and access to green finance

Enhanced ESG governance, transparency and stable regulations will make mining projects more attractive to investors [34-36]. Clear sustainability reporting (e.g. mandatory ESG disclosures) and aligned standards (such as OJK's green taxonomy and sustainable finance action plans [37]) signal lower risk and longer-term commitment. For example, industry observers note that "ever-changing – even arbitrary – regulations" have discouraged investment in Indonesia's mineral sector [38], whereas pursuing policy stability and international ESG frameworks can reverse this trend. Recent moves to allow "green-enabling" projects – such as ICMA's guidance that mining for renewable-energy materials can qualify under green bonds [39]– could open new funding channels. Stronger governance and coherence (e.g. consistent

permitting, predictable local content rules) are expected to boost foreign and domestic flows into sustainable mining and processing ventures.

- **Qualitative outcomes.** Increased capital inflows into mineral projects; more engagement by green/ESG funds and development banks; improved company creditworthiness. Investors may perceive Indonesian projects as lower-risk if they meet global ESG benchmarks. Access to green finance instruments (green bonds, sustainability-linked loans or sukuk) should grow as projects demonstrate compliance with green standards and climate commitments [38, 39].
- **Example indicators.** Volume of ESG-labeled bond issuances in mining; amount of green finance deployed (USD) into mining and downstream projects; number of mining firms obtaining ESG/green certifications; changes in investor surveys or indices (e.g. FDI Confidence Index) rating Indonesian mining.

3.2. Increased domestic value addition in the mineral supply chain

Policy incentives like export bans and investment tax breaks are intended to shift output from raw ore to higher-value products. Indonesia's raw-ore export bans (first on nickel in 2020, later on bauxite) aim to force onshore refining and processing. For instance, the 2009 Mineral Mining Law "required mining companies to domestically add value through processing and refining" before export [40]. To complement this, the government now offers fiscal and non-fiscal incentives for battery and smelter projects (tax holidays, import-duty exemptions, subsidized power, etc.[41]). In practice, new smelters and EV battery plants (in partnership with Korean and Chinese firms) have started production. These projects can also bring technology transfer and training: for example, the Morowali Industrial Park's companies responded to local pressure by investing in worker training and communications [38]. Over time, Indonesia is expected to capture a larger share of value by building domestic refining (metals to chemicals) and component industries (battery cells, precursors, recycling).

- **Qualitative outcomes.** Growth of Indonesian-owned refineries and battery factories; higher-skilled jobs and engineering know-how; a more diversified export mix (e.g. cathode materials instead of ore). The strategy should create an integrated local supply chain (miners, smelters, chemical processors, pack assemblers). Successful technology transfer and capacity building will expand the local skilled workforce and foster homegrown technology in mining and processing.
- **Example indicators.** Share of mineral output processed domestically (vs. exported as ore); number/value of new smelters, refinery and battery facilities built; employment in downstream industries; export revenues of processed mineral products; proportion of mining inputs sourced locally. Other metrics could include the percentage of contracts requiring local content or the number of joint ventures with capacity-building provisions (technical training, R&D centers).

3.3. Reduced environmental degradation and improved social license to operate

Stricter environmental safeguards and genuine community engagement are expected to prevent the severe ecological and social harms seen in some Indonesian mining

projects. Indonesia's mining boom has come with major deforestation and pollution – a recent study found Indonesia alone caused ~58% of tropical mining-driven forest loss from 2000–2019 [33]. Enforcing robust standards (for example on tailings storage, water quality, and land use) will reduce deforestation and contamination of waterways. Encouraging or requiring Free, Prior and Informed Consent (FPIC) and benefit-sharing with local and indigenous communities can prevent conflicts. In past projects, communities suffered from issues like water pollution, forest loss and land expropriation without fair compensation [6, 42]. Adopting international best practices (e.g. IFC Performance Standards, OECD Due Diligence) should mitigate these impacts. In turn, obtaining social consent means mining developments proceed with fewer delays or protests and generate local support through shared infrastructure or jobs.

- **Qualitative outcomes.** Cleaner water and land near mine sites; preserved forest cover (protected natural areas remain intact). Companies will be seen as more legitimate by local communities if FPIC is upheld. This yields a stronger "social license": projects are less likely to be stopped by protests or legal action. Locals may receive more benefits (community development programs, fair royalties) and fewer health impacts. Mining companies gain reputational benefits and secure their operating permits more smoothly.
- **Example indicators.** Area of forest or critical habitat conserved versus baseline; number of environmental incidents (e.g. spills, tailings breaches) per year; compliance with emission and effluent standards; number and quality of FPIC/consent agreements completed; counts of local complaints or conflicts related to mining. Social metrics could include surveys of community satisfaction and number of jobs or training programs provided to nearby residents. Health/environment indicators might track water quality (heavy metal levels), air pollution, or fishery yields in mining regions.

3.4. Stronger alignment with Indonesia's 2060 net-zero target

Decarbonizing the mineral sector – for example by powering smelters and mines with renewables – will help Indonesia meet its net-zero goals. Indonesia has pledged to reach net-zero emissions by 2060 (or earlier) as part of its development strategy [43]. However, many existing processing facilities run on coal-fired power, making nickel and aluminum refining carbon-intensive. Redirecting policy to support low-carbon processing (e.g. use of hydro or solar power, electrified equipment, or efficiency measures) will reduce mining-sector emissions. For instance, analyses note that Sulawesi's nickel industry could be supported by the island's renewable potential (estimated ~45 GW of solar, wind, hydro and geothermal, enough to meet most projected demand [44]). Indonesia's Just Energy Transition Partnership (JET-P) and other climate commitments prioritize renewables and early coal phase-out [43], which should extend to the mining sector. By greening the value chain, Indonesia not only cuts local emissions but also markets "green nickel" and other minerals to climate-conscious buyers abroad. Breakthroughs in photocatalytic renewable fuel production [45], for instance, illustrate how Indonesia can integrate mineral governance reforms with advances in clean fuel technologies to reinforce its net-zero strategy.

A preliminary feasibility scan of transitioning Morowali's smelter cluster to renewable power within the next five years suggests both technical potential and significant policy hurdles. Morowali Industrial Park's current captive coal capacity could be partially

displaced by integrating nearby hydropower potential (estimated at ~1.2 GW) and large-scale solar PV (up to ~400 MW on available non-forested land) if grid upgrades and storage systems are deployed. Based on International Energy Agency benchmarks, such a transition could reduce smelter-related Scope 2 emissions by up to 45% by 2030. However, realisation requires synchronized investments in transmission infrastructure, long-term offtake agreements, and regulatory clarity on renewable wheeling and tariffs. Pilot projects, such as hybrid hydro–solar systems in North Sulawesi supplying industrial loads, demonstrate that partial decarbonisation of high-load industrial parks is achievable in Indonesia when backed by concessional finance and strong government facilitation. Embedding such pilots into national industrial decarbonisation plans would provide the empirical evidence base for scaling renewable-powered smelters across the country.

From an operational perspective, the optimum condition for decarbonizing mineral processing may involve aligning three factors: (i) a renewable energy share in smelter power supply of at least 80%, (ii) grid and storage capacity sufficient to ensure a minimum 95% annual load factor for industrial demand, and (iii) synchronized policy support—such as wheeling regulations, fiscal incentives, and expedited permitting—to minimize transition delays. This configuration balances emission reduction goals, capital efficiency, and supply reliability, and can serve as a benchmark for assessing the readiness of industrial parks to transition toward low-carbon operations. It is important to note that these targets are subject to grid expansion, storage deployment, and regulatory feasibility

- **Qualitative outcomes.** Lower carbon intensity of mineral production (e.g. tonnes CO_2 per tonne metal). Greater use of clean energy in mining operations and increased energy efficiency. This translates into progress toward national climate goals and can attract climate finance. Indonesia can brand its mineral exports as low-carbon (a global value-add), and this supports its overall energy transition. Over the long term, a decarbonized mineral industry helps avoid future stranded assets (e.g. coal plants) and aligns investments with future climate regulations.
- **Example indicators.** Scope-1 and Scope-2 CO_2 emissions from mining and processing; percentage of mining energy (power, fuel) sourced from renewable sources; number of mining projects using carbon-intensive fuels versus cleaner alternatives. Other measures might include the share of “green” or climate-aligned investments into the sector, and the carbon footprint of exported minerals. Tracking energy intensity (GJ per tonne of output) and annual emissions reductions (absolute or per unit output) will reveal progress toward the 2060 net-zero target [43, 44].

In summary, authoritative analyses of Indonesia’s mining sector and sustainability policies were used, including policy briefings and research on Indonesian mining reforms. These reflect both local context and global best practices.

4. Policy Framework Matrix: A 10-Point Policy Matrix to De-Risk ESG, Localize Value Chains, and Unlock Indonesia's $100B Mineral Opportunity by 2040

To translate Indonesia's green mineral vision into measurable outcomes, an integrated policy framework is critical. This section introduces a structured matrix as shown in Table 1 that operationalizes strategic reforms across ten interconnected policy domains: Regulatory Framework, Financial Incentives, Stakeholder Engagement, Research and Development (R&D) Support, Capacity Building and Training, Sustainability Standards, Monitoring and Evaluation, Public Awareness and Education, Infrastructure Development, and Integration with National Energy Plans. Each domain is assessed along five strategic lenses: Challenges, Strategy, Impact, Implication, and Action Plan.

This matrix equips policymakers, industry leaders, and development partners with a systems-level view of how to prioritize reforms, allocate resources, and coordinate multi-sectoral interventions. For instance, the Regulatory Framework domain reveals inconsistent ESG enforcement and outdated permitting practices, recommending alignment with international frameworks such as the OECD Due Diligence Guidelines, IRMA, and EITI. These are supported by proposed actions such as mandatory ESG disclosures, citizen scorecards, and integrated digital monitoring platforms. Meanwhile, the Financial Incentives column highlights barriers in accessing green finance and attracting downstream investments. Recommended solutions include tailored tax holidays, blended financing mechanisms, and outcome-based subsidies tied to ESG performance, with the goal of mobilizing billions in clean capital by 2040.

In the R&D Support and Capacity Building domains, the framework emphasizes the importance of building local innovation ecosystems and workforce readiness for high-value activities such as battery chemistry, mineral recycling, and green metallurgy. These are backed by proposals for public–private R&D grants, technical training centers, and university–industry partnerships. On the infrastructure front, the matrix proposes the expansion of SEZs and mineral parks with grid-integrated renewables and low-emission logistics.

Each row in the matrix contributes toward a cohesive strategy to reduce environmental degradation, enhance Indonesia's climate ambition, and secure long-term economic resilience. By linking upstream governance reforms with downstream industrialization and community engagement, the policy matrix becomes a dynamic decision-support tool—one that ensures no critical leverage point is overlooked.

Critically, the framework is designed to support Indonesia's broader goals: reducing mining-related deforestation (which accounted for 58% of global tropical forest loss from 2000–2019), achieving net-zero emissions by 2060, and capturing a $100 billion share of the global green mineral market by localizing value chains, improving ESG credentials, and positioning Indonesia as a credible supplier to climate-conscious economies.

Table 1. How Indonesia's policy matrix can transform green minerals into a global ESG-compliant powerhouse by 2040.

	Challenges	Strategy	Impact	Implication	Action Plan
Regulatory Framework	Fragmented and outdated mining laws; inconsistent enforcement; lack of ESG mandate	Update regulations to align with IRMA, EITI, OECD; mandate ESG in permits	Stronger ESG governance; reduced legal risk; improved international reputation	Government must build legal coherence and cross-ministry ESG enforcement	Revise mining laws and licensing rules to include mandatory ESG and IRMA alignment
Financial Incentives	Low investor interest in downstream projects without clear incentives; high capital cost	Offer tax holidays, import duty exemptions, green bonds for certified projects	Increased domestic processing; rise in FDI; higher-value mineral exports	Fiscal planning needs to accommodate long-term investment incentives	Launch incentive scheme for ESG-compliant processing plants and EV battery factories
Stakeholder Engagement	Limited collaboration among government, industry, civil society, and communities	Establish permanent Green Minerals Council and EITI-style platforms	More inclusive decision-making; fewer project conflicts; faster permit resolution	Stakeholder coordination must be institutionalized and funded	Convene multi-stakeholder council quarterly; publish conflict-resolution dashboards
Research and Development Support	Insufficient funding for R&D in green processing technologies and battery materials	Fund R&D partnerships between universities and industry for battery innovation	Technology transfer; rise in domestic IP and skilled workforce	R&D and IP policy must support industrial decarbonization goals	Offer matching R&D grants and tax credits for clean processing innovation
Capacity Building and Training	Local governments lack expertise in ESG, permitting, and conflict resolution	Train local officials via UNDP/university workshops; deploy digital monitoring tools	Improved permit enforcement; better compliance at subnational levels	Budget allocations needed for district-level training and digital tools	Roll out ESG training modules to all provincial mining offices and BLKs

	Challenges	Strategy	Impact	Implication	Action Plan
Sustainability Standards	Weak compliance with global ESG norms; absence of national green certification	Introduce national Green Nickel/Copper labels; enforce environmental covenants	Higher investor trust; premium pricing for green-certified exports	Certification bodies and ESG audit systems must be scaled up	Establish green mineral certification authority; link benefits to compliance
Monitoring and Evaluation	Limited real-time tracking of mining activities; weak public data transparency	Expand Minerba One Data system; require regular company ESG reporting	Greater transparency; improved investor confidence; data-driven policy	Data platforms must be made accessible and interoperable	Deploy real-time monitoring tools and ESG data portals integrated with EITI
Public Awareness and Education	Low public understanding of green minerals and sustainable mining practices	Include mining in school curriculum and launch public campaigns on green minerals	More public support; stronger community oversight and legitimacy	Requires education ministry and media collaboration	Launch national green mining awareness campaign with local champions
Infrastructure Development	Poor logistics and infrastructure in mining zones; high cost of utilities and transport	Develop SEZs with plug-and-play infrastructure near mining clusters	Lower logistics cost; faster project execution; industrial clustering	Infrastructure agencies must prioritize mineral zones in planning	Expand SEZs with grid access and roads; offer blended finance for infra gaps
Integration with National Energy Plans	Disconnect between mineral policy and national energy/climate goals	Integrate green mineral strategy into Just Energy Transition Partnership and RPJMN	Aligned emission targets and mineral production; lower carbon footprint	Bappenas and MEMR must jointly develop scenario-linked policies	Mainstream green minerals in Indonesia National Energy and Climate Plan

5. Conclusion: Transforming Indonesia's Mineral Wealth into a $100B Green Legacy - Urgent ESG Reforms Can Prevent High-Emission Lock-In and Drive Inclusive Growth

Indonesia's transition mineral sector represents both a critical engine for economic modernization and a frontline battleground in its environmental and social sustainability journey. Without structural reform, the nation risks locking itself into a future of high-emissions, resource-dependent growth characterized by ecological degradation, social unrest, and declining competitiveness in a global market increasingly governed by ESG standards.

However, with the right policy mix—anchored in accountability, innovation, and inclusion—Indonesia can pivot toward a new development paradigm where the mineral sector not only drives GDP growth but also delivers climate action, technological upgrading, and equitable benefits for communities. The proposed strategy challenges stakeholders to move beyond short-term extractive logic and embrace long-term stewardship of mineral wealth.

Indonesia's path toward transforming its mineral wealth into sustainable economic growth depends on five strategic pathways: robust ESG governance, enhanced domestic value addition, stakeholder engagement, and proactive alignment of trade and investment with sustainability goals as well as monitoring and adapting to global market dynamics (Figure 4). Together, these strategic actions can significantly mitigate environmental and social impacts, attract substantial green investments, and establish Indonesia as a leader in the global transition to clean energy. To fully realize this vision, immediate actions and ongoing commitments include:

- **Strengthening ESG Governance:**
    - Mandating strict adherence to international standards like IRMA, EITI, and OECD guidance to improve transparency, accountability, and trust.
    - Implementing mandatory ESG disclosures and third-party audits to foster investor confidence and unlock access to green finance.
- **Accelerating Domestic Value Addition:**
    - Providing tailored fiscal and non-fiscal incentives (tax holidays, import duty exemptions) to stimulate investment in smelters, battery factories, and advanced refining capabilities.
    - Enhancing local skill development and technology transfer through strategic public–private partnerships in R&D and vocational training.
- **Promoting Inclusive Stakeholder Engagement:**
    - Establishing formal multi-stakeholder platforms and forums to facilitate dialogue and coordinated policy implementation.
    - Institutionalizing Free, Prior, and Informed Consent (FPIC) processes and enforceable community benefit-sharing agreements.
- **Aligning Trade and Investment with Sustainability Goals:**

- Introducing enforceable environmental and social clauses in mineral trade and investment contracts to reinforce sustainable practices.
- Developing globally recognized green certifications and branding to ensure market competitiveness and attract premium pricing from ESG-conscious buyers.

- **Monitoring and Adapting to Global Market Dynamics:**
  - Establishing specialized observatories and research units to continuously monitor market trends, technological advancements, and policy shifts, ensuring proactive and adaptive policymaking.
  - Regularly publishing transparent data and comprehensive market outlook reports to guide investment and policy decisions.

If implemented with urgency, clarity, and coordination, this comprehensive strategy can elevate Indonesia to a global model for green industrial transformation. Such reforms will not only ensure sustainable management of the country's vast mineral resources but will also turn Indonesia's mineral abundance into a lasting, sustainable legacy benefiting current and future generations.

Figure 4. Indonesia's 5-path ESG strategy could unlock $100B in sustainable value, strengthen global competitiveness, and accelerate green growth.

All in all, this study introduces a five-pillar governance and policy framework as a contextualized synthesis for Indonesian literature on sustainable mineral governance in the Global South. The analysis demonstrates that Indonesia's $100 billion mineral pivot, if guided by ESG integration, green trade alignment, and low-carbon innovation, can unlock new pathways for sustainable competitiveness. Compared with existing studies that primarily emphasize resource dependency or industrial policy, this work highlights the strategic role of renewable-powered mineral processing and ESG-linked

finance as innovative levers for global market positioning. These findings converge with recent studies on ESG compliance in extractive industries, while extending the discussion by situating Indonesia's case within the broader EV battery supply chain. In conclusion, Indonesia's experience provides a replicable governance model for other resource-rich nations seeking to reconcile economic growth with environmental stewardship, thereby advancing both scholarly debate and policy innovation in sustainable mineral governance.

Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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P.A.P.: Conceptualization, Methodology, Investigation, Writing – original draft.
A.F.M.: Validation, Formal analysis, Writing – review & editing.
H.G.M.: Supervision, Validation, Writing – review & editing.
D.S.: Resources, Investigation, Project administration.
P.P.: Visualization, Formal analysis, Writing – review & editing.
I.V.: Conceptualization, Supervision, Writing – review & editing.

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